FEDERAL RESERVE BANK OF ST. LOUIS

REVIEW

NOVEMBER/DECEMBER 2003 | VOLUME 85, NUMBER 6

Review is published six times per year by the Research Division of the Federal Reserve Bank of St. Louis and may be accessed at our new web address: < **research.stlouisfed.org/publications/review** > . Single-copy subscriptions are also available free of charge. Send requests to: Federal Reserve Bank of St. Louis, Public Affairs Department, P.O. Box 442, St. Louis, MO 63166-0442, or call (314) 444-8808 or 8809.

Contents

Volume 85, Number 6

Fed Transparency: How, Not Whether

William Poole

Central bank transparency is a topic discussed almost as much as policy actions themselves. Market participants have always wanted to know the implications of policy actions for the likely future course of monetary policy, but the longstanding practice of central bank secrecy has frustrated their search. In recent years, monetary policymakers have disclosed much more than they did in the past, partly because of growing interest in being more accountable and partly because of recognition that policy actions will be more effective if the market understands them better.

Discussion of transparency has gone well beyond the financial pages. The past decade has seen numerous professional papers on transparency issues. In this literature, transparency is taken to mean *public disclosure*, and much of the discussion has centered on questions such as: How specific should central banks be about their policy objectives? Should they announce the weights they apply to their inflation and output stabilization objectives in conducting monetary policy? Should central banks disclose their economic forecasts? Should transcripts of the policy debate be published and, if so, how soon? Should policymaking meetings be televised?

My intent today is not to review the entire range of transparency debates but instead to concentrate on issues relating to the effects of monetary policy information on markets and on the effectiveness of monetary policy. I certainly do not believe that political accountability issues are unimportant, but my chosen topic is large enough to more than fully exhaust the time available today.

Before proceeding, I want to emphasize that the views I express here are mine and do not necessarily reflect official positions of the Federal Reserve System. I thank my colleagues at the Federal Reserve Bank of St. Louis—especially Robert Rasche, senior vice president and director of research, and Daniel Thornton, vice president and economic advisor—for their assistance and comments, but I retain full responsibility for errors.

My plan is to proceed by first outlining my model of how the economy works. That view is, I believe, the essential starting place for a discussion of transparency. I will then discuss two cases in which, depending on what view you have, market participants did not interpret Fed statements correctly or the Fed did not communicate clearly. Under either interpretation, there was some miscommunication.

I will use "transparency" as shorthand for *accurately conveying accurate information including all the information market participants need to form opinions on monetary policy that are as complete as possible*.

FUNDAMENTALS OF MACROECONOMIC EQUILIBRIUM

Analysis of policy communication logically begins with a description of the economic interaction between the central bank and the markets. I've provided my view of this interaction on several occasions; here I provide just enough of a sketch of this view to enable me to discuss communication issues.[1]

At a highly abstract level, I believe that the appropriate model of the economy is that markets behave in an efficient, fully informed way. Equilibrium requires that market participants form accurate expectations about the behavior of the central bank. The economy will function most efficiently if central bank policy has two features. First, the central bank must have clearly understood, appropriate, and

William Poole is the president of the Federal Reserve Bank of St. Louis. This article was adapted from a speech of the same title presented at the Global Interdependence Center, Federal Reserve Bank of Philadelphia, August 21, 2003. The author thanks colleagues at the Federal Reserve Bank of St. Louis for comments: Robert H. Rasche, senior vice president and director of research, and Daniel L. Thornton, vice president and economic advisor, provided especially valuable assistance. The views expressed are the author's and do not necessarily reflect official positions of the Federal Reserve System.

[1] William Poole, "Synching, Not Sinking the Markets," presented before the Philadelphia Council of Business Economics, Federal Reserve Bank of Philadelphia, 6 August 1999; < www.stls.frb.org/general/speeches/1999_08_06_99.html > . William Poole and Robert H. Rasche, "Perfecting the Market's Knowledge of Monetary Policy," *Journal of Financial Services Research*, December 2000, *18*(2/3), pp. 255-98.

feasible objectives. Second, the central bank must have a highly regular and predictable policy rule or response pattern that links policy actions to the state of the economy, including all information relevant to assessing the economy's probable future course. Pushing the idea of a full rational expectations equilibrium one step further, there should be a political equilibrium in which the central bank pursues objectives broadly accepted in society. Without broad political support, monetary policy objectives are subject to change through normal democratic processes and such change, or the prospect of it, adds to uncertainty about future monetary policy.

With regard to objectives, the Federal Open Market Committee (FOMC) has stated repeatedly that one of its objectives is a low and stable rate of inflation. Although the FOMC has not quantified that target, for present purposes it is useful to discuss communications issues as if the FOMC had announced a specific target. Put another way, with regard to market behavior I believe that the difference between an explicit target and one inferred from FOMC decisions is minimal today and has been for some years.

The FOMC also has the objective of maximum possible stability of output and employment. Taken together, low inflation and output stability along the economy's growth path are believed to contribute to maximum possible economic growth over time. Because of its importance to output and employment stability, it is also useful to point explicitly to the objective of financial stability. Stabilizing policy responses to severe market disruptions such as a stock market crash or a liquidity crisis further contribute to fostering maximum possible economic growth.

The FOMC implements policy by setting the intended federal funds rate. As is well known, a central bank cannot achieve a stable outcome for the economy if it pegs the interest rate at an inappropriate level for any length of time. Thus, the central bank must change its interest rate target from time to time to achieve its objectives.

In my abstract model of the economy, the market and the central bank have the same information base; neither has an informational advantage. As new information arrives, the appropriate interest rate to achieve policy objectives may change. Given my assumption that the market and the central bank have the same information, all players respond the same way to the arrival of new information. The central bank determines the appropriate policy response knowing that the market also has the same information and understands its implications for the economy and for policy actions.

At a highly abstract level, I believe that this model accurately describes the way the U.S. economy has been working in recent years. As we add more and more detail to the model, we find areas in which the equilibrium is not complete. Thus, my view is that the economy has been converging toward a full rational expectations macroeconomic equilibrium, but is not all the way there as yet. In particular, over the past quarter century there has been enormous progress in improving the clarity of the Fed's objectives and in the Fed's discipline in pursuing the objectives. With regard to the inflation objective, there is a world of difference between today's situation and that prevailing in the 1970s.

There has also been enormous progress in provision of more accurate and timely information about policy actions. The FOMC announces its policy actions on the afternoon of the conclusion of each regularly scheduled meeting and promptly after any interim meeting. The Fed is more open in many other ways as well; for example, the FOMC now releases a policy statement at the conclusion of its meeting and dissents, if any, are also disclosed at that time.

My fundamental conception of the Fed's communication challenge is to further the progress toward a more complete rational expectations equilibrium. Put another way, my question is this: How might the Fed modify its communications strategy so that the market can converge on a rational expectations equilibrium with less error than we observe today?

MISCOMMUNICATION—TWO CASES

It is instructive to consider examples in which communications were less clear than they might have been and to analyze how such problems might be avoided in the future. Communications successes are also worth studying. There is a growing literature along these lines, such as analysis of the market effects of the change in FOMC practice in February 1994 to immediate disclosure of policy decisions at the conclusion of FOMC meetings.

Accurate communication is far more difficult than it seems at first glance. Complete accuracy requires that speaker and listener interpret actions and words the same way. In a normal conversation, individuals have an opportunity to clear up ambiguity by raising questions about intended meaning. It is possible to ask for clarification, or ask again, before

acting. What central bank officials (and, of course, other officials as well) say, however, can have immediate market impact; market participants may act before ambiguities or miscommunication can be corrected. This fact imposes special burdens on central bankers.

To illustrate how difficult the communications process is in the central bank context, let me relate to you an exercise I go through at the end of each FOMC meeting. Before the decisions of the meeting are made public, I estimate—"guess" is a much better word—the market reaction to the policy action and press release that are made public at 2:15 p.m. after the meeting. Then I listen to the radio or a cable news channel to determine how the bond and stock markets respond. Ordinarily, but not always, I get the direction of the market responses correct, but my estimates of the magnitudes of the market reactions are often wide of the mark. My personal experience is that I find it exceedingly difficult to predict how people will interpret policy actions and the nuances of the press release. I suspect that other FOMC participants perform similar exercises, though I have not asked any of them.

I've sometimes thought I should keep a formal record of my market predictions, but have not yet decided to do so. It could be a sobering exercise for all FOMC members to maintain such a record. Communication is obviously imperfect if the speaker—the FOMC in this case—cannot predict accurately how listeners will respond.

Now consider two specific examples of FOMC communications that I believe were misread. The first is the evolution in the announcement of the "tilt" in the directive, and the second is the communication last May about "an unwelcome substantial fall in inflation." I emphasize that I'm offering my personal interpretation of these cases; other FOMC members may have different interpretations.

In the early 1980s the FOMC began to vote on language pertaining to possible future policy actions. This language was alternatively called the "tilt," "bias," or "symmetry" of the policy directive. The language was generally regarded as applying to possible policy action through the period ending at the next FOMC meeting. Historically, the FOMC did not release this language until the minutes of that meeting were published (subsequent to the next regularly scheduled FOMC meeting). That meant that the statement, when released, had no information value about the probable direction of policy actions because the statement referred to a period already past.

In an effort to be more transparent, the Committee decided in December 1998 that it would release the tilt language immediately with its policy action at the conclusion of a meeting when it expected the information to be particularly important. The minutes of that meeting, released in late January 1999, contain a paragraph on the Committee's discussion of a disclosure policy. A key passage from the minutes reads as follows:

> Nonetheless, the members decided to implement the previously stated policy of releasing, on an infrequent basis, an announcement immediately after certain FOMC meetings when the stance of monetary policy remained unchanged. Specifically, the Committee would do so on those occasions when it wanted to communicate to the public a major shift in its views about the balance of risks or the likely direction of future policy. Such announcements would not be made after every change in the symmetry of the directive, but only when it seemed important for the public to be aware of an important shift in the members' views.

At the conclusion of the meeting in May 1999, the FOMC for the first time released a statement that included the "tilt" in the policy directive. The formal statement referred to "the federal funds operating objective during the intermeeting period." Many members of the FOMC believed that the market overreacted to the May tilt statement and to subsequent tilt statements as well. The statements did attract considerable attention, and market analysts began to speculate about changes in the intended funds rate at future FOMC meetings based on the tilt, or symmetry, announced by the FOMC.

The market reaction to the statement released immediately after the May 1999 FOMC meeting should not, perhaps, have been a surprise to the Committee. The Committee had said, after all, in its the minutes of the December 1998 meeting that it would make such an announcement "when it wanted to communicate to the public a major shift in its views..."

In an attempt to clarify its communications, the FOMC established a subcommittee to review both its policy directive and the public announcement following FOMC meetings. Communications practice changed in two respects. First, the FOMC would issue a statement after every meeting. That step eliminated the possibility that the mere exis-

tence of a statement would be treated as an unusual event signaling a major change in policy.

The second step was a new "balance-of-risks" statement that assessed the outlook for price stability and sustainable economic growth in the foreseeable future. Despite the FOMC's stated intention that its new "balance-of-risks" was not to be interpreted as an indictor of future FOMC actions, the evidence suggests that it was one of the pieces of information that market analysts did use to form expectations of a likely near-term policy action.[2] My perception, however, is that the balance-of-risks language did not come to have a completely settled meaning in the market.

For my second example, consider the statement following the FOMC meeting last May that referred to "an unwelcome substantial fall in inflation." In subsequent commentary in the financial press, this statement was interpreted to mean one or more of the following things: (i) A cut in the intended funds rate at the June 2003 meeting was likely. (ii) Any increase in the intended funds rate within the next year was highly unlikely. (iii) The FOMC would implement "unconventional monetary policy actions" such as aggressively purchasing long-term Treasury bonds. Interpretation (iii) gained force and a major rally in long-term Treasury markets ensued, driving the 10-year Treasury rate to a more-than-40-year low of 3.13 percent.

Speaking strictly for myself, I believe there are two important points that the statement of May 6 tried to communicate that didn't really come across. First, inflation has now receded to a level where for the first time in 40 years inflation risks are symmetric: From the current inflation rate neither sustained increases nor sustained decreases are desirable. Second, in the words of my FOMC colleague Governor Bernanke, "FOMC behavior and rhetoric have suggested to many observers that the Committee does have an implicit preferred range for inflation. Most relevant here, the bottom of that preferred range clearly seems to be a value greater than zero measured inflation, at least 1 percent or so."[3] On several occasions in the past I have stated that my preferred inflation target is zero inflation, properly measured. Since I believe that the major price indices employed today are subject to some upward bias and measurement error, the goal "zero inflation, properly measured" translates into a low, positive measured rate of inflation. In my judgment, 1 percent measured inflation for the consumption price index is in the neighborhood of price stability as I define it.

To me, though, an announcement that inflation is now down to an appropriate long-run target should not by itself have led to a sharp decline in the 10-year bond rate. What I think happened was that the market, seeing that the intended federal funds rate was down to 1 percent, thought that the Fed was running out of room to implement policy through setting a target federal funds rate. If the Fed were to switch to setting a target for long-term interest rates, then such a policy would reduce or eliminate for a time downside price risk on long-term Treasury bonds. That would justify bidding the 10-year bond price up (the rate down), because the price risk would become one-sided—bond prices could go up but not down, or at least not down by very much very soon. Over time, however, the market came to believe that the FOMC was not contemplating the need for an unconventional policy in the near term, and bond prices fell. Indeed, bond yields backed up to a level above where they had been just before the May FOMC meeting.

DISCLOSURE STRATEGY

Given my emphasis on the economic purpose of disclosure, I see no room for merely satisfying curiosity about what goes on in FOMC meetings. The general nature of what goes on in meetings can easily be inferred by reading meeting transcripts, which are released with a five-year lag. The appropriate communications goal, in the context of how the economy functions, should be to minimize market uncertainty about monetary policy. It is important to emphasize that uncertainty about future monetary policy actions cannot be eliminated because those actions depend critically on information that cannot itself be predicted. What needs to be minimized, therefore, is uncertainty about central bank responses to new information.

I'm going to concentrate my discussion on the policy statement issued at the conclusion of each FOMC meeting, but some of my comments have broader applicability. The communication at the conclusion of each FOMC meeting is a critical one because market participants are primed to react to

[2] Robert H. Rasche and Daniel L. Thornton, "The FOMC's Balance-of-Risks Statement and Market Expectations of Policy Actions," Federal Reserve Bank of St. Louis *Review*, September/October 2002, *84*(5), pp. 37-50.

[3] Ben S. Bernanke, "An Unwelcome Fall in Inflation?" presented before the Economics Roundtable, University of California, San Diego, 23 July 2003, in La Jolla, California; < http://www.federalreserve.gov/boarddocs/speeches/2003/20030723/default.htm > .

news of a policy action and its rationale. The statement is necessarily short and it sets the stage for FOMC members to provide subsequent, more thorough discussions of policy. I'll concentrate on two aspects of the statement. The first is the extent to which the statement should provide a forecast in some form of future policy actions, and the second is the structure of the statement itself.

Given my rational expectations macroeconomic model and my desire to create a more complete equilibrium—an equilibrium in which expectations errors are minimized—the central communications issue is to explain to the market the nature of the policy rule that determines how new information feeds into policy actions designed to achieve as closely as possible the central bank's policy objectives. Achieving clarity with respect to policy objectives is actually quite simple compared with explaining the nature of the policy rule.

The fundamental problem is that there is no policy rule by which we can calculate the appropriate policy action from observed data. There is instead a regularity to policy of the sort "you know it when you see it."

Sometimes we observe a striking change in some particular variable, such as the unemployment rate, that all but demands a policy response. Most of the time, though, policy actions flow from an accumulation of data, most of which point in the same direction. It just is not easy to describe "you know it when you see it." I would be absolutely delighted if researchers could provide a quantified policy rule, at least as a base case. The rule suggested by John Taylor is helpful, but very incomplete. I think it unfortunate that we have not seen in the professional literature an evolution of a policy rule that builds substantially on the work begun by Taylor. But the problem is a very difficult one; for one thing, it is necessary from time to time to discount changes in an important economic variable because of suspected anomalies in the statistics themselves.

Thus, we have to live with the unfortunate fact that the monetary policy world is one of "I'll know it when I see it." We need to keep that fact in mind when designing communications policy.

Explaining a policy action—elucidating the considerations that led the FOMC to decide to adjust the intended funds rate, or to leave it unchanged—is worthwhile. Over time, the accumulation of such explanations helps the market, and perhaps the FOMC itself, to understand what the policy regularities are. It is also important to understand that many—perhaps most—policy actions have precedent value. If the FOMC takes action A in circumstances X, the next time circumstances X arise the FOMC should also take action A, or have good reason not to do so. One of the advantages of public disclosure of the reasons for policy actions is that the required explanation forces the FOMC to think through what it is doing and why.

Discussing future policy actions is a different matter. In my view of the world, future policy actions are almost entirely contingent on the arrival of new information. For that reason, I believe that an FOMC forecast, or tilt, toward a specific future policy action is more likely to be misleading to the market than helpful. It is true that at the conclusion of a meeting I have a sense of the probabilities of various future policy actions, and I suspect that other FOMC members think about the policy process the same way. I might believe, for example, that new information would be very unlikely to lead me to want to raise the intended funds rate at the next meeting but might, in combination with information already known, make the case for cutting the intended rate. And I might assign a probability to a future cut of 0.5, or 0.3, or some other value. But even in this situation I would not want to rule out an increase in the intended rate, for I can certainly imagine new information that would compel an increase.

Question: Could the FOMC as a practical matter decide on the probability and convey that probability accurately to the market? My own view is that only rarely could the FOMC agree on what the probability should be, and even then it would be extremely difficult to convey that probability to the market. Moreover, if the probability is high, it seems to me that in most cases it would make more sense to simply take the policy action at the current meeting rather than broadcast it as likely at the next meeting.

The old "tilt" language caused problems, I think, precisely because different FOMC members had different interpretations of what probabilities attached to what words. And I think the market view was, at least sometimes, that if the FOMC chose to change the bias, it must be doing so to announce a significant probability of future policy action. I think some observers also tend to react as follows: If the probability is high, why shouldn't the FOMC act now? If the probability is low, why talk about it? If the probability is in a middle range, will disclosing the tilt help the market to price securities more efficiently—that is, more in line with the true likelihood of future policy action?

Furthermore, the tilt language was sometimes used in an effort to reduce the number of dissents in the FOMC. In this case, the language may have provided inaccurate information, because the majority may not have believed that there was any significant probability of future policy action in the direction indicated.

Another problem is that of acting consistently with guidance about the probable direction of future policy. Sometimes new information arrives that is clearly compelling in the direction of *not* acting in accordance with the guidance. A forecast of a policy action, made before the new information arose, may then have created a dilemma for a central bank. The central bank then either breaks what the market regards as a commitment or lives up to the commitment at the cost of ignoring new information calling for a different policy action. However, more often information will be indecisive; once guidance is announced, the burden of proof tends to shift toward showing why the forecasted action is inadvisable, whereas without guidance the burden of proof tends toward justifying an action.

All in all, then, I've come to the view that FOMC language forecasting future policy actions is probably counterproductive in most circumstances. I do not, however, rule out the desirability of forecasting future policy in some cases given that the rational expectations model from which I am reasoning is clearly an abstraction. What I think we need to do is to analyze the circumstances under which the abstract model provides misleading guidance with respect to communications strategy.

It is true that policy works in part by changing expectations and therefore the term structure of interest rates; that is the basic argument favoring disclosure of future policy direction. However, the crux of the matter is this: If the market fully understands the policy rule, or policy regularity, and has the same information the FOMC has, then an FOMC forecast of future policy direction is useless information because it is redundant. If the market and the Fed have the same information, then the market can determine the probabilities that new information will arrive pointing toward future policy actions. Understanding policy objectives and the policy rule, the market can put itself inside the Fed's head and make the same guesses the Fed can make.

If information on the Fed's thinking about its future policy direction is not redundant, then that fact alone does not necessarily call for the Fed to forecast future policy actions. The issue for me is quite different. If the market doesn't see what I see, why not? What is the market missing, and what do we make of the fact? Perhaps the better course would be to disclose the underlying information the market is apparently missing, or call attention to information the market is neglecting. That to me is a better strategy than hinting at an unconditional policy direction, because the essence of what the market needs to know is not the intended federal funds rate in six weeks. What the market needs to know is the policy response function by which the central bank acts in a consistent way over time and one that is efficient in fostering success in achieving policy objectives.

This discussion assumes that the market is missing something. But, could the problem be that the market sees something I do not? How can I be so sure that I know the appropriate direction for future policy actions? If it is the Fed that is missing something and not the market, then disclosing a policy tilt will clearly be misleading, or the odds are that it will turn out to be misleading.

Historically, the FOMC (and other central banks) went to great lengths to avoid providing guidance about future policy direction. Indeed, one of the arguments that the Fed used in the defense of secrecy in the Merrill case in 1975 was that the immediate release of the information in the directive or in FOMC deliberations would produce expectations that would destabilize financial markets. That argument is incomplete at best. Some disclosures clearly stabilize rather than destabilize markets; secrecy can create incorrect market guesses about what the Fed is doing. One such case arose on Thanksgiving eve 1989, when the Open Market Desk intervened to supply reserves for technical reasons. At this time there was no announcement of the intended funds rate. The intervention was widely interpreted by market participants as a signal that the FOMC had reduced its target for the federal funds rate from around 8.50 to about 8.25 percent. It took several trading days before the market sorted out the confusion. On this occasion secrecy produced unnecessary volatility in financial markets. Numerous other examples provide convincing evidence, in my view, that, in general, disclosure of actual policy actions is stabilizing rather than destabilizing. But it is not appropriate to generalize from the value of immediate disclosure of policy actions to disclosure of "everything."

To discuss the format of the policy statement at the conclusion of each FOMC meeting, I'll start with an observation. Suppose the statement is confined

to one page. With even those few words, the richness of language and the importance of word order in conveying meaning yield the result that the statement contains an enormous range of possibilities. The multiplicity of possible meanings is made even larger since each statement is read against the backdrop of the previous one. Thus, what is relevant is not just word choice and order but changes from the previous statement.

As an aside, the importance of statement changes can make it difficult to improve the statement over time. To avoid misinterpretation of changes, it is best if a changed approach or format can be announced in advance so that the change in approach is clearly separated from a change in policy.

If the statement is to convey policy intent accurately and with minimal ambiguity—surely desirable characteristics in terms of minimizing expectational errors in the market—then the number of possible meanings must be narrowed in some way. One way would be for the FOMC to chose among a relatively few standard phrases, at least in language providing a summary statement of the policy stance.

Some will regard this approach as providing "boilerplate" language with little real meaning. My own judgment is that it is better to provide boilerplate with clear meaning than rich language with a multiplicity of possible meanings. It just is not true that lots of words equals lots of disclosure and greater transparency.

Because the market responds immediately to policy actions and statements, it is important that the FOMC not find itself in the position of having to clarify its statements to correct misinterpretations; explaining the explanation can add to uncertainty and raise questions about future policy statements, which market participants might come to expect to be clarified or interpreted. The best way to avoid these problems is to narrow the range of phrases used in the statement.

As I explained earlier, my view is that the statement should concentrate on explaining the policy action and its rationale, and not hint at future policy actions. Given information available at the time of a meeting, I believe that the standing assumption should be that the policy action at the meeting is expected to position the stance of policy appropriately. The purpose of the statement should be to explain why the policy action, or lack of action, has positioned policy appropriately given the information available.

As a matter of logic, the current balance-of-risks language creates some ambiguity. If risks are assessed as unbalanced, why was policy not adjusted further to create a balance going forward? A possible answer is that an unbalanced risk assessment foreshadows future policy action. But the "tilt" interpretation of an unbalanced risk assessment seems at odds with the rationale for substituting the balance-of-risks language for the previous tilt language. What would be clearer, I think, would be to use the balance-of-risks language to explain that information since the previous meeting indicated that risks were becoming unbalanced in a particular way, and for that reason the FOMC adjusted the intended federal funds rate.

Separating growth risks from inflation risks, as in the May statement, makes a lot of sense. When employment change and inflation data are plotted in a scatter diagram, all four quadrants contain lots of observations. Sometimes employment and inflation rise together, or fall together. However, just about as often the two variables move in opposite directions. Because all four quadrants are populated, a summary policy judgment has to be communicated indicating the FOMC's weighting of the risks. It is relatively easy to explain that a policy tightening was occasioned by a rising risk of higher inflation and stronger employment growth; but when employment growth and inflation are headed in opposite directions, the summary policy language needs to indicate that the FOMC acted, or didn't, because it gave more weight to the inflation risk than the employment risk, or vice versa. The issue is not, by the way, that inflation risk is more or less important than employment risk, but rather that current information might suggest that recent employment changes, say, are transitory.

This discussion makes clear that a minimally accurate summary statement explaining a monetary policy action is still pretty complicated. The FOMC must weigh inflation risks, employment risks, and form a judgment balancing or weighting the two risks. Beyond that, from time to time special factors will intrude, such as the tragic events of 9/11 or unusual liquidity crises.

CONCLUDING OBSERVATIONS

Transparency is a worthy goal, but improving transparency is hard work. My thinking is still evolving, but one thing I know is that the more I consider the issue the harder it seems.

I've tried to present a framework for thinking about how to improve transparency. I start with a view of the world based on a standard rational

expectations macroeconomic model. An efficient equilibrium requires that the markets understand what the central bank is doing. The communications challenge for the central bank is to explain more thoroughly and completely what it is doing. That means, above all, explaining how new information feeds into policy actions. I have a lot of skepticism about forecasting future policy actions because they properly flow from new information that is not itself predictable.

Accurate communication requires settled meanings for words. For any given word, we can consult a dictionary and we usually discover that each English word has several meanings, which can be quite different. There is no dictionary in which we can look up the several meanings of a paragraph. The meaning of a policy statement—preferably only one—must be established by the central bank, through consistent practice over time and through more extended discussion of what the language means.

I think it fair to say that systematic study of the *how* of transparency is in its infancy, and I hope that my remarks here spark others to analyze these issues.

Burgernomics: A Big Mac™ Guide to Purchasing Power Parity

Michael R. Pakko and Patricia S. Pollard

One of the foundations of international economics is the theory of purchasing power parity (PPP), which states that price levels in any two countries should be identical after converting prices into a common currency. As a theoretical proposition, PPP has long served as the basis for theories of international price determination and the conditions under which international markets adjust to attain long-term equilibrium. As an empirical matter, however, PPP has been a more elusive concept.

Applications and empirical tests of PPP often refer to a broad "market basket" of goods that is intended to be representative of consumer spending patterns. For example, a data set known as the Penn World Tables (PWT) constructs measures of PPP for countries around the world using benchmark surveys that include hundreds of individual items that encompass all of the expenditure components of a nation's gross domestic product.

Many of the principles and limitations of the theory of PPP can be illustrated using a less comprehensive collection of goods. Since 1986, *The Economist* has published an annual tongue-in-cheek comparison of the prices of the McDonald's Big Mac™ sandwich in various countries around the world, evaluating prevailing exchange rates on the basis of international price differences.[1] A similar index has also been developed by the financial firm UBS, as part of a general comparison of prices and incomes around the globe.[2] These lighthearted studies of international hamburger prices have predictably been popular examples of the principles of PPP and have even given serious scholars food for thought.[3]

The attractive feature of the Big Mac as an indicator of PPP is its uniform composition. With few exceptions, the component ingredients of the Big Mac are the same everywhere around the globe. (See the boxed insert, "Two All Chicken Patties?") For that reason, the Big Mac serves as a convenient market basket of goods through which the purchasing power of different currencies can be compared. As with broader measures, however, the Big Mac standard often fails to meet the demanding tests of PPP. In this article, we review the fundamental theory of PPP and describe some of the reasons why it might not be expected to hold as a practical matter. Throughout, we use the Big Mac data as an illustrative example. In the process, we also demonstrate the value of the Big Mac sandwich as a palatable measure of PPP.

THE LAW OF ONE PRICE AND PPP

A strong version of the PPP theory has as its foundation the *law of one price*. Abstracting from complicating factors such as transportation costs, taxes, and tariffs, the law of one price states that any good that is traded on world markets will sell for the same price in every country engaged in trade, when prices are expressed in a common currency.

For instance, consider the price of sesame seeds—one of the basic ingredients of the Big Mac—in Britain and the United States. Letting $p_{ss}^{£}$ and $p_{ss}^{\$}$ represent the prices of sesame seeds in Britain (in pounds) and the United States (in dollars), respectively, then the law of one price can be expressed as follows:

$$p_{ss}^{£} = e \times p_{ss}^{\$}, \tag{1}$$

where e is the pound/dollar exchange rate. If sesame seeds cost \$6 per bushel in the United States and the pound/dollar exchange rate is 0.5, then the law of one price states that the price of sesame seeds in Britain should be £3. If sesame seeds sold for a price higher than £3, an astute trader could buy sesame seeds in the United States and sell them in Britain at a profit. This type of activity—known as *arbitrage*—

---

[1] Big Mac™ is a registered trademark of the McDonald's Corporation.

[2] The UBS survey is published only every three years. For the most recent version, see UBS (2003).

[3] See Click (1996), Cumby (1997), Lan (2001), Ong (2003), and Parsley and Wei (2003).

Michael R. Pakko is a senior economist and Patricia S. Pollard is a research officer at the Federal Reserve Bank of St. Louis. This article is an update and extension of an earlier paper, Pakko and Pollard (1996). Heidi Beyer provided research assistance.

TWO ALL CHICKEN PATTIES?

The Big Mac was created in 1967 by Jim Delligatti, a McDonald's franchise owner in Pennsylvania. In 1968 the Big Mac was launched in McDonald's restaurants throughout the United States, and it is now possible to purchase the sandwich in 120 countries around the globe. In each of these countries, the Big Mac is generally made according to the same recipe—two all beef patties, special sauce, lettuce, cheese, pickles, onions on a sesame seed bun.

In India, however, where no beef products are sold at McDonald's, the recipe for the Big Mac was altered. One can consume the "Maharaja Mac" with chicken patties replacing the beef patties. India, where the Maharaja Mac has been available since 1996, is not included in the Big Mac survey.

In Islamic countries the Big Mac is made with halal beef, and in Israel the Big Mac is made with kosher beef, even though the inclusion of cheese in the recipe makes it a non-kosher sandwich. Although it is possible to purchase a Big Mac in a kosher McDonald's, the lack of cheese would exclude it from the survey.

The first McDonald's outside the United States was opened in Canada in 1967. The most recent country in which one can satisfy a craving for a Big Mac is Mauritius, located in the Indian Ocean off the coast of southern Africa. The world's busiest McDonald's is located on Pushkin Square in Moscow. It seats 700 customers, has 27 cash registers, and serves 40,000 customers per day.[1]

[1] Information based on McDonald's press releases. See < www.media.mcdonalds.com/secured/news/russia/russia.html > and < www.licenseenews.com/news/news167.html > .

would tend to drive the price of sesame seeds higher in the United States and lower in Britain, with the process continuing until the law of one price prevailed.

Absolute PPP

The law of one price generalizes to PPP under special circumstances. Consider price indices (consumer price indices, for example) for the United States and Britain, which are constructed by combining the prices of several different commodities. Typically, these indices are weighted averages of the individual prices. If the same goods are included in each index and if the price indices are constructed identically, then, according to the law of one price, the overall price levels $P^{\$}$ and $P^{£}$ will be related in the same way as each of the individual commodities:

$$P^* = e \times P^{\$}, \tag{2}$$

where P^* is the price level measured in the foreign currency and e is the foreign currency price of a dollar (foreign currency units per dollar). If PPP holds, then equation (2) can be rewritten as

$$\frac{P^*}{P^{\$}} \times \frac{1}{e} = 1. \tag{3}$$

The expression on the left-hand side of equation (3) is referred to as the real exchange rate—the exchange rate adjusted by relative price levels.

The conditions under which the law of one price generalizes to yield PPP—as summarized in equation (2)—are clearly quite restrictive. For the law of one price to directly imply PPP, the same goods must be included in the price indices for each country.[4] Consequently, testing the absolute version of PPP requires careful construction of price indices so that a *common* market basket of goods is measured. One example of such a comparison is embodied in the PWT data set, which is based on the United Nations International Comparisons Program.[5] The PWT presents price measures that are based on a common market basket of approximately 150 detailed categories of goods.

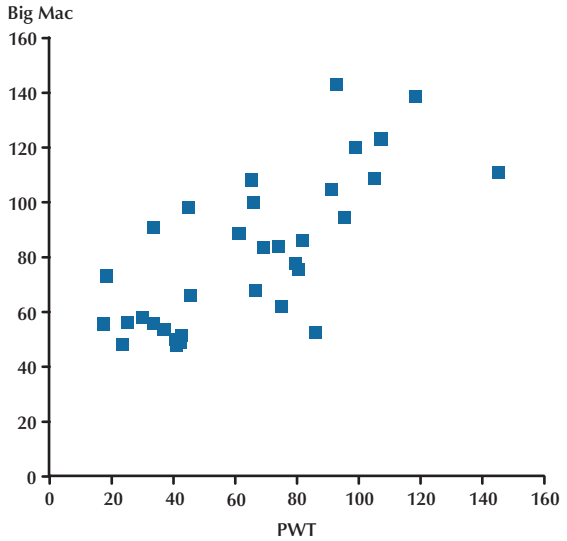
The first column of Table 1 shows a measure of PPP for various countries (relative to the United States) based on the PWT for 2000, the latest year for which data are available. The figures reported in Table 1 are constructed by multiplying equation (3) by 100, so a value equal to 100 means that PPP holds. In this case the dollar-equivalent prices in the country under consideration are the same as the prices in the United States. A value greater than 100 means that dollar-equivalent prices in the country under consideration are higher than prices in the

[4] The same base year must also be used for the price indices.

[5] The data used in this paper are from the PWT version 6.1; see Heston, Summers, and Aten (2002). The data are available at < pwt.econ.upenn.edu > .

Figure 1

PPP from the PWT and Big Mac (2000)



United States. We can interpret this as the U.S. dollar having lower purchasing power in that country relative to the United States or as the local currency being overvalued relative to the dollar. A value of less than 100 indicates that dollar-equivalent prices are lower than prices in the United States—the local currency is undervalued.[6] Clearly, absolute PPP does not hold strictly for the currencies of countries reported in Table 1.

Another common market basket of goods is the ingredients that make up the Big Mac sandwich. Sold in 120 countries around the world, the Big Mac is a standardized bundle of goods. (See the boxed insert, "A New Jingle?") Most of the ingredients that go into a Big Mac are individually traded on international markets, so we might expect that the law of one price would hold, at least approximately. The second column of Table 1 shows indicators of PPP based on Big Mac prices in 2000. Note that a similar pattern emerges for the Big Mac measure as for the PWT measure of PPP. (The correlation between these two price measures is 0.73.) The positive relationship between PWT price indices and Big Mac prices is illustrated by the scatterplot in Figure 1. There are only four countries for which the two price measures indicate differing qualitative conclusions regarding overvaluation or undervaluation. The currencies of Britain, France, Israel, and South Korea were undervalued based on the PWT data and overvalued based on the Big Mac data. The Argentine peso was undervalued based on the PWT but was at parity based on the Big Mac data.

A total of 481 individual observations, collected over the 18-year period 1986-2003, are available

Table 1

Indicators of PPP, 2000

Country	PWT	Big Mac
Argentina	66	100
Australia	75	61
Brazil	45	66
Britain	98	120
Canada	79	77
Chile	45	98
China	23	48
Colombia	33	91
Czech Republic	33	55
Denmark	107	123
France	91	104
Germany	95	94
Greece	69	83
Hong Kong	86	52
Hungary	42	48
Indonesia	18	73
Israel	92	143
Italy	81	86
Japan	145	111
Malaysia	41	47
Mexico	61	88
New Zealand	66	67
Philippines	25	56
Poland	42	51
Russia	17	55
Singapore	80	75
South Africa	37	53
South Korea	65	108
Spain	74	83
Sweden	105	108
Switzerland	118	138
Thailand	30	58
Turkey	40	50

[6] The terms *overvalued* and *undervalued* refer to the value of the currency relative to the value implied by PPP.

A NEW JINGLE?

To aficionados of classic television commercials, the ingredients of a Big Mac sandwich are indelibly etched into memory in the form of a jingle. In terms of the United Nations' Standard International Trade Classifications (SITC), Revision 3, the jingle might sound a little different:

Ingredient	SITC code	SITC description
All beef patties	011.12	Meat of bovine animals, fresh or chilled, boneless
Special sauce	098.49	Other sauces and preparations therefor; mixed condiments and mixed seasonings
Lettuce	054.54	Lettuce and chicory (including endive), fresh or chilled
Cheese	024.20	Processed cheese, not grated or powdered
Pickles	056.71	Vegetables, fruit, nuts, and other edible parts of plants, prepared or preserved by vinegar or acetic acid
Onions	054.51	Onions and shallots, fresh or chilled
Sesame-seed bun	222.50	Sesame (Sesamum) seeds
	046.10	Flour of wheat or of meslin

from *The Economist* Big Mac surveys.[7] Among these observations only 8.7 percent show deviations of 5 percent or less from PPP, and only 17.9 percent of the observations show deviations of 10 percent or less. These statistics indicate that, for most observations, there are significant deviations from PPP. For example, the data indicate that in 2003 the Danish krone was overvalued by 51 percent against the U.S. dollar, whereas the Swiss franc was overvalued by 70 percent against the dollar. In contrast, in 2003 the Chinese yuan was undervalued by 56 percent against the U.S. dollar and the Thai baht was undervalued by 49 percent against the U.S. dollar.

Figure 2 provides a graphical analysis of absolute PPP over time for selected countries, comparing actual exchange rates (relative to the U.S. dollar) with the ratio of countries' Big Mac prices relative to Big Mac prices in the United States.[8] The latter measures the exchange rate implied by Big Mac PPP. If the exchange rate implied by PPP (the price ratio) is above the actual exchange rate, e, then in order for PPP to hold, the foreign currency price of a dollar must rise—that is, the foreign currency must depreciate. In this case the foreign currency is overvalued relative to the dollar.[9] If the exchange rate implied by PPP is below the actual exchange rate, then in order for PPP to hold, the foreign currency price of a dollar must fall—that is, the foreign currency must appreciate. In this case the foreign currency is undervalued relative to the dollar.

Figure 2 demonstrates not only that departures from PPP are common, but also that for most currencies the direction of the deviation is maintained throughout the sample period. Currencies that have been consistently undervalued include the Australian dollar, the Czech koruna, the Hungarian forint, the Hong Kong dollar, and the Thai baht. The Danish krone has been consistently overvalued, as has the British pound since 1989.

After accounting for average levels of overvaluation and undervaluation, there is evidence of convergence toward PPP. Figure 3 shows the average deviation of the dollar from PPP, based on averages of the data in each annual survey. The dollar was undervalued on average from 1986 through the first half of the 1990s. Gradually this deviation from PPP declined and by 1997 the dollar reached parity. After 1997 the dollar became overvalued, reaching a peak

[7] The full data set is available at <research.stlouisfed.org/publications/review>.

[8] Throughout this article, we evaluate PPP relationships between foreign currencies and the U.S. dollar. Conceptually, however, the Big Mac data can be used to determine whether or not PPP holds between any two currencies in the survey. As an example, the boxed insert "The Big Mac and the Euro Area" discusses PPP relationships using the German mark as the base currency.

[9] For a country that fixes the value of its currency against the U.S. dollar, an overvalued currency is often seen as an indicator of an unsustainable exchange rate. The boxed insert "Currency Crises and the Big Mac" explores the usefulness of the Big Mac index as a currency crisis indicator.

Figure 2

Absolute Purchasing Power Parity

Currency Units/U.S. $

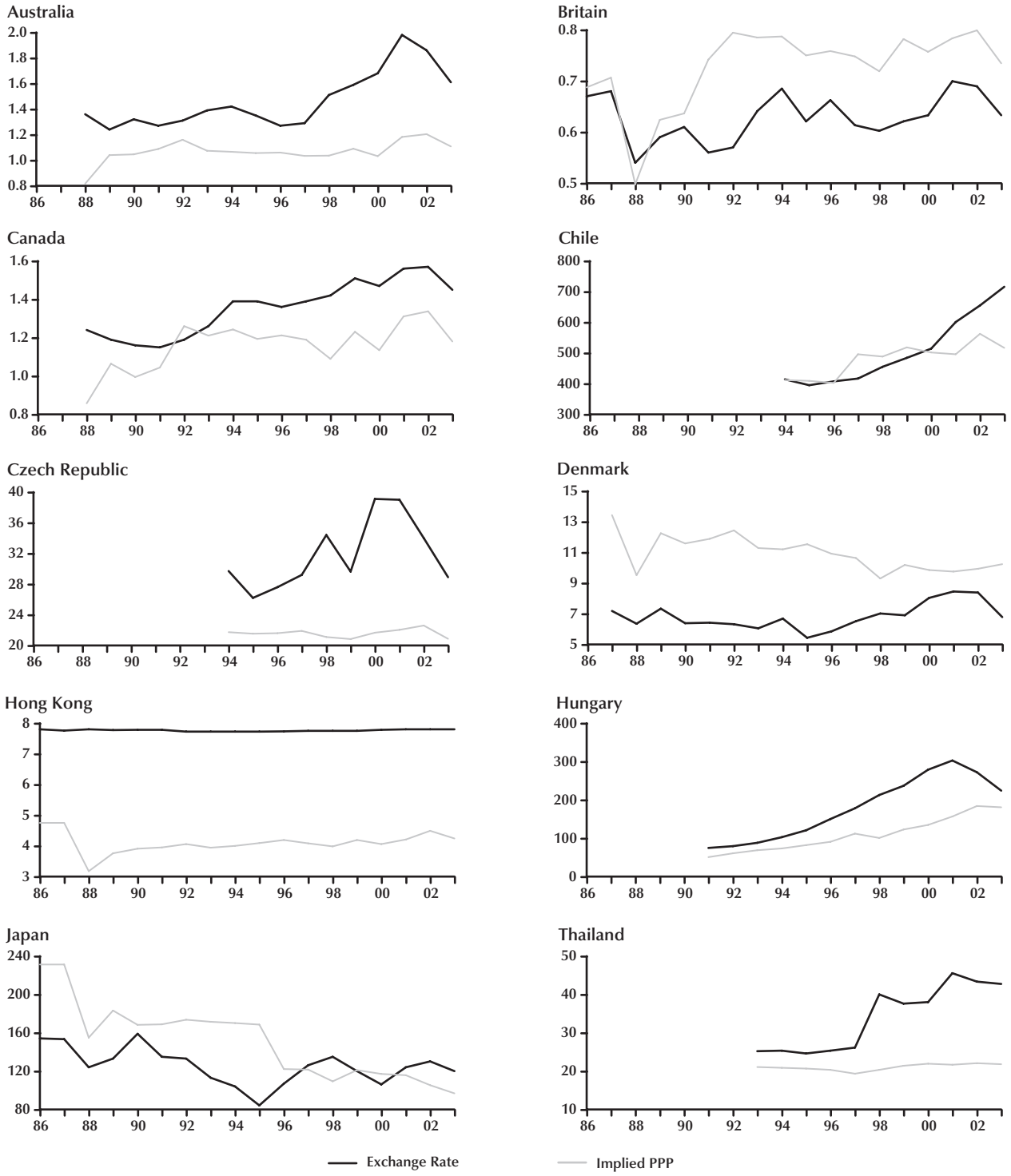
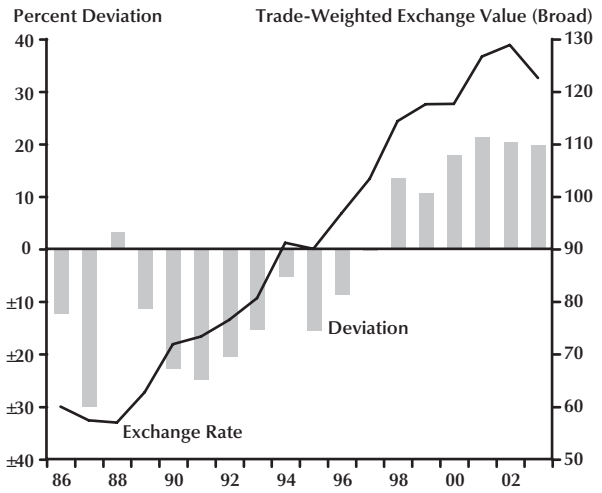


Figure 3

Average Deviation of U.S. $ from PPP



of 22 percent in the 2001 survey. The actual value of the dollar relative to a broad set of currencies follows the deviation of the dollar from PPP. As the figure shows, the value of the dollar rose throughout the 1990s, peaking in 2002.

In an econometric study of PPP using Big Mac price data, Cumby (1997) found statistical evidence that deviations from PPP are, in fact, temporary. He found that the adjustment toward PPP tends to take place through both exchange rates and local currency prices.

Relative PPP

Another condition for the law of one price to generalize to PPP is that weights assigned to the goods in the price indices must be the same across countries. Usually, these weights are based on actual consumption or production shares. So, for example, if more lettuce per capita is consumed in the United States and more pickles per capita are consumed in Britain, then the price of lettuce will be relatively more important in a U.S. price index, whereas the price of pickles will be more important in a British index. Even if lettuce and pickle prices are always identical in the two countries, a rise in the world price of pickles will have a larger impact on the British price index than on the U.S. index.

Most studies of PPP, therefore, are based on relative PPP, which does not require either the same basket of goods or the same weights applied to these goods in the price index. This relative version of PPP states that changes in price levels will be related to changes in exchange rates. Specifically, equation (2) can be transformed to express a relationship in growth rates as follows:

$$\%\Delta e = \%\Delta P^* - \%\Delta P^{\$}. \tag{4}$$

Equation (4) says that the percentage change in the exchange rate between two countries is equal to the difference in their inflation rates. For example, if U.S. inflation is 5 percent per year while inflation in Britain is 3 percent per year, then the relative version of PPP states that the dollar will depreciate by 2 percent per year. Relative PPP is a less strict condition than absolute PPP, requiring only that deviations from PPP not worsen.

Measures of relative PPP in relation to the U.S. dollar for selected countries are presented in Figure 4, which shows a measure of the difference between the Big Mac inflation differential ($\%\Delta P^* - \%\Delta P^{\$}$) and the change in the exchange rate ($\%\Delta e$). We would not necessarily think that relative PPP would hold on a year-to-year basis, but it is more likely to be observable in terms of an average relationship over many years. Consequently, relative PPP is suggested by the measures shown in Figure 4 whenever the spread between the inflation differential and the exchange rate change tends to center on zero, rather than to exhibit persistent deviations away from zero. For several countries, this appears to be the case. For example, the currencies of Australia, Britain, Canada, and Hong Kong all appear to have approximately maintained relative PPP against the dollar since 1991—despite the fact that absolute PPP clearly has not held for these currencies (see Figure 2). On the other hand, the Japanese yen and Danish krone have shown less evidence of maintaining relative PPP against the dollar.

As a long-run test, relative PPP is somewhat difficult to evaluate for the Big Mac because data are limited for many countries and there are only a few years of observations. The data suggest, however, that PPP does not generally hold in the short run, for either the absolute or the relative versions of the theory. Furthermore, for many currencies, deviations from PPP against the U.S. dollar appear to be sustained over a period of several years. The next section provides some explanations for these deviations from PPP.

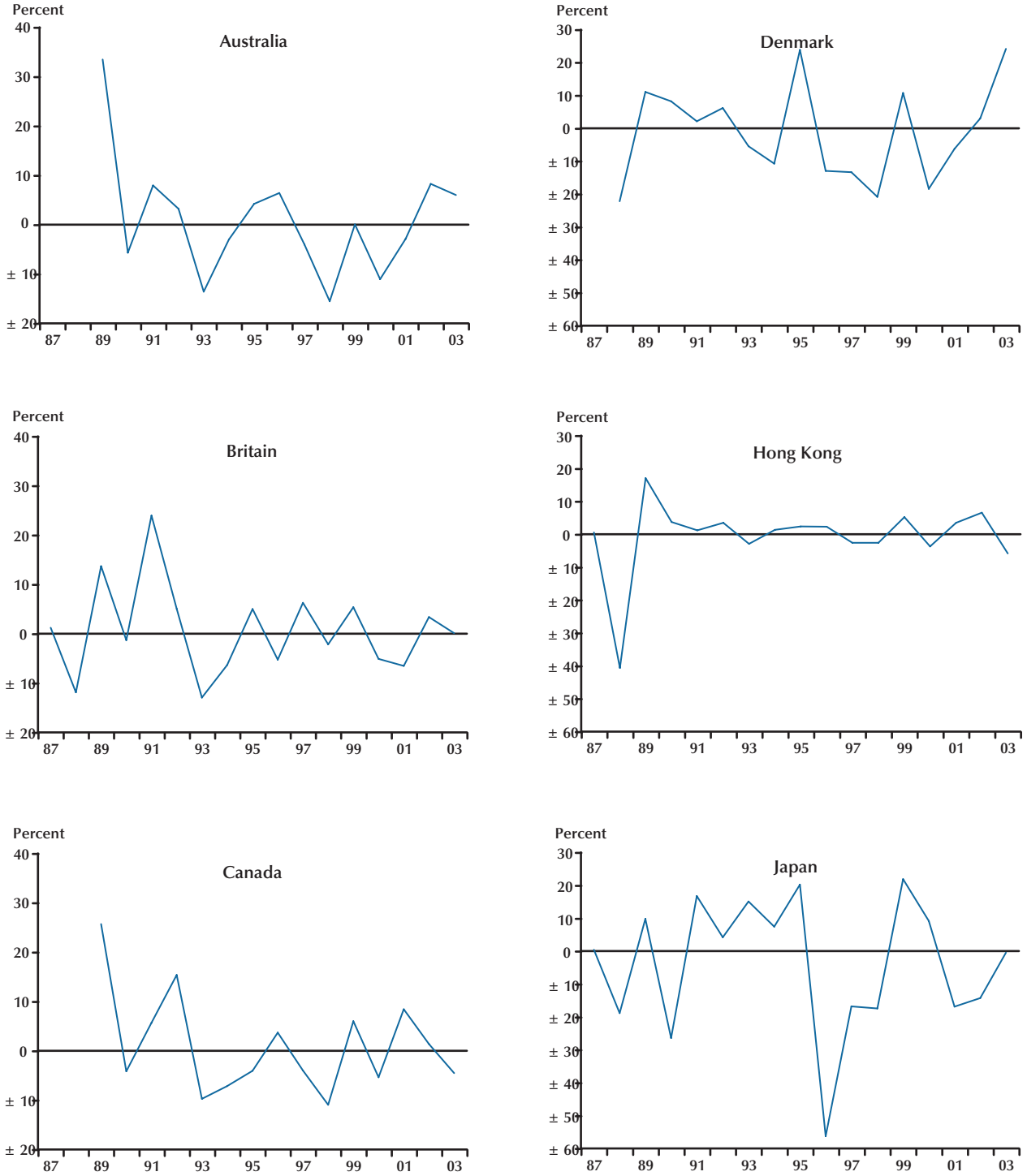
WHY DOES PPP FAIL?

In 2002 it cost $2.49 to buy a Big Mac in the United States, $3.80 in Switzerland, and $1.27 in

Figure 4

Relative PPP

(Inflation Differential Less Exchange Rate Change)



China. Thus a Big Mac devotee could buy one and a half of the sandwiches in the United States for every one he could purchase in Switzerland. He could buy only one-half a Big Mac in the United States for every one he could enjoy in China.

One wouldn't expect Swiss and U.S. consumers to import Big Macs from China to take advantage of the lower prices—a Big Mac sandwich shipped halfway across the globe would probably not arrive in a very appetizing form. Nevertheless, because the components of a Big Mac are traded on world markets, the law of one price suggests that prices of the components should be the same in all markets.

If the Big Mac is no more than the sum of its ingredients, then trade should equalize the price of a Big Mac across borders; or, at the least, differences between prices should narrow over time. Instead, the dollar price of a Big Mac in the three countries diverged by even more in 2003 than in 2002. In 2003 it cost $1.20 to buy a Big Mac in China, $2.71 to buy a Big Mac in the United States, and $4.60 to buy a Big Mac in Switzerland.

How do we explain these deviations from PPP? Once again, the Big Mac can serve as a useful example of why there tend to be systematic departures from PPP. We consider three main explanations: the existence of barriers to trade, the inclusion of non-traded elements in the cost of a Big Mac, and pricing to market.

Barriers to Trade

One simple reason why PPP, at least in the absolute sense, fails to hold is that it is costly to move goods across borders. Transportation costs, government-imposed trade barriers, and taxes all limit the extent to which differences in prices across countries will result in the international movement of goods.

Transportation Costs. Although the cost of shipping the sesame seeds needed for the Big Mac buns may be minimal, shipping perishable ingredients such as beef, cheese, and lettuce is more costly. Transportation costs, therefore, may drive a wedge between the prices of the same good in different markets.

In 2002, a Big Mac cost $2.38 in the euro area, 11 cents less than the price in the United States. Although this price difference appears to violate PPP, shipments of Big Macs (or, more appropriately, the ingredients of a Big Mac) from the euro area to the United States would not necessarily occur. Only if the cost of shipping a Big Mac was less than 11 cents (or 5 percent) would trade occur. As a result, we might expect absolute PPP to hold only approximately, with prices diverging within a range determined by the transport costs.[10] Hummels (2001) estimates that transportation costs add 7 percent to the price of U.S. imports of meat, 6 percent to the import price of dairy products, and 16 percent to the import price of vegetables.

Trade Restrictions. A more important factor than the presence of natural barriers to trade is the existence of tariffs and other legal restrictions on trade. Nearly every country restricts the importation of agricultural goods through the use of tariffs and/or quotas in order to protect its domestic farm sector. Tariffs, which represent a tax on imported goods, and quotas, which limit the amount of a good that can be imported, both raise the price of imports.

In one of the early works on PPP, Cassel (1921) noted the effects of trade restrictions, stating, "If trade between two countries is more hampered in one direction than in the other, the value of the money of the country whose export is relatively more restricted will fall, in the other country, beneath the purchasing power parity."[11] Cassel emphasized the effect of export restrictions on PPP because these restrictions were used extensively during World War I. He noted, however, that import restrictions have the opposite effect. Thus, given two countries, the one with the greater restrictions on imports will see its currency overvalued on a PPP basis. If there were no other factors causing deviations from PPP, the Big Mac data would tell us which countries had high agricultural barriers to trade relative to the United States. That is, countries with high barriers to trade relative to the United States would have overvalued currencies relative to the dollar, whereas those with lower trade barriers than the United States would have undervalued currencies.

Both Japan and Korea maintained high barriers to the importation of beef for many years in the Big Mac survey period. Until 1991 Japan imposed both quotas and tariffs on imports of beef. In 1991 the quota was replaced with a tariff (a process known as tariffication). The tariff was gradually reduced from 70 percent in 1991 to 38.5 percent in 2000.[12]

[10] Parsley and Wei (2001) and Wei and Parsley (1995) find that transportation costs are an important factor in explaining deviations from PPP in the member countries of the Organization for Economic Cooperation and Development.

[11] Cassel (1921, p. 39).

[12] See Dyck (1998).

From 1989 through 1994 Korea imposed a 30 percent tariff on beef imports in addition to imposing quantitative restrictions. In 1995 Korea began replacing its beef quota with a tariff. In 2001 the import quota was eliminated and the tariff rate was set at 41.2 percent. The tariff will decline to 40 percent by 2004. These trade barriers place a significant wedge between the price of beef in world markets and the domestic price of beef in Japan and Korea. These high barriers to trade may partly explain why the Japanese yen and the Korean won were overvalued against the dollar until the late 1990s.

The United States is not without its own restrictions on beef imports. The U.S. limits the amount of beef that can be imported duty-free from all countries except Canada and Mexico. Imports beyond the quota limit face a 26.4 percent tariff rate. In April 2002, McDonald's began buying some imported beef from Australia and New Zealand for its U.S. operations. The quota, however, limits the extent to which McDonald's can use imported beef to offset hamburger price pressures.[13] In addition, the higher barriers to trade in beef in the United States may partly explain why the U.S. dollar has been consistently overvalued relative to the Australian and New Zealand dollars.

Taxes. An additional factor that may help explain the deviations from PPP is tax differences across countries. The Big Mac prices reported by *The Economist* are inclusive of sales or value added taxes. Thus, holding all other factors constant, countries with higher taxes on a Big Mac relative to the United States would appear to have overvalued currencies relative to the dollar. Changes in tax rates can also give rise to apparent shifts in Big Mac parities. For example, in 1991 Canada imposed the Goods and Services Tax, a national 7 percent sales tax. Between 1990 and 1991, the price of a Big Mac rose from C$2.19 to C$2.35. As a result, the Canadian dollar moved from being undervalued by 14 percent against the U.S. dollar to being undervalued by only 9 percent. It would be misleading, however, to say that the United States and Canada were brought closer to PPP by the imposition of this new tax.

[13] Australia and New Zealand may export 378,214 and 213,402 metric tons of beef, respectively, to the U.S. duty free (United States International Trade Commission, 2003, Chap. 2). According to *AgJournal* (2002) Australia reached this limit in 2001 (the year prior to McDonald's decision to purchase imported beef) and New Zealand met 97 percent of its quota.

Non-Traded Goods

According to the theory of PPP, if there are no barriers to trade, then the dollar price of a good should be the same in the United States, Hungary, and Japan. The price of a Big Mac in any country, however, reflects more than the price of its ingredients. To sell its products, McDonald's has to buy or lease space for a restaurant and purchase utilities to heat, cool, and light the restaurant, as well as to run everything from the grills to the cash registers. Real estate and utilities are examples of what economists call non-traded goods. Though the title to a piece of property, for example, can be traded, the location of the property cannot be traded. Thus, although it may be cheaper to rent space for a restaurant in Beijing than in San Francisco, it is useless to do so if one wants to serve lunch to customers in San Francisco. To the extent that rent and utilities determine the cost of a Big Mac, deviations from PPP may simply reflect these cost differences across countries.

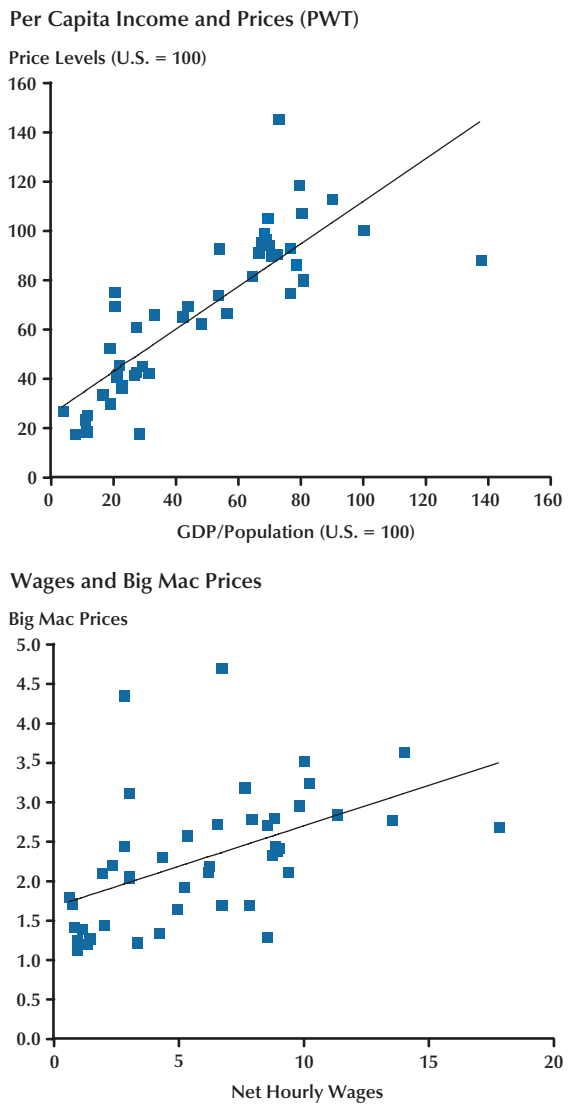
The price of a Big Mac also reflects a service component—that is, the cost of preparing the Big Mac and serving the customer. These aspects require the use of workers, who in economic terminology are also non-traded goods. McDonald's workers, like all workers, are restricted in their ability to move across borders to take advantage of wage differentials. Ong (1997) estimates that non-traded goods (wages, rent, etc.) account for 94 percent of the price of a Big Mac.

Productivity. Balassa (1964) and Samuelson (1964) formalized the idea that non-traded goods systematically affect the deviation from PPP because of differences in productivity across countries and sectors. They argued that because non-tradables are included in price indices (such as the Big Mac index), high-income countries will have overvalued currencies relative to low-income countries.[14] The Balassa-Samuelson argument is based on the idea, supported empirically, that per capita income levels broadly reflect differences in labor productivity. Thus high-income countries have more productive labor forces than low-income countries. Furthermore, the differences in productivity are greatest in the traded goods sector. The higher productivity in the traded goods sector in high-income countries

[14] Some studies such as Engel (1999) find that convergence to PPP does not occur even if one looks at only traded goods. Obstfeld and Rogoff (2000) argue that this is because even traded goods have a large non-traded component.

Figure 5

Income and Prices



is reflected in higher wages in all sectors, as firms in both the non-traded and traded goods sectors compete for workers. The higher wages paid to service sector workers in high-income countries relative to low-income countries results in higher prices for services in the former. The higher prices for services translate into higher price levels in high-income countries, even if prices for traded goods are identical across countries. Thus the currencies of these countries will appear overvalued relative to the currencies of low-income countries.

Turning to Big Macs, it is unlikely that there are large differences in the productivity of workers cooking burgers regardless of the country of location of the McDonald's.[15] There are, however, large differences in the wages earned by these workers. For example, according to a study by Ashenfelter and Jurajda (2001), a typical McDonald's crew worker in the United States earned $6.50 per hour in 2000 while his or her counterpart in China earned $0.42 per hour and a similar McDonald's worker in Poland earned $1.15 per hour. This difference in wage costs may partly explain why the yuan and the zloty have been consistently undervalued against the dollar as measured by Big Mac prices.

In fact, according to the Balassa-Samuelson theory, holding all other things constant, the dollar should be overvalued against the currencies of low-income countries. Table 2 divides the Big Mac survey countries into groups based on the International Monetary Fund's development classification. The currencies of the developing countries, with the exception of the Latin American countries, follow the prediction of the Balassa-Samuelson theory. These currencies have been constantly undervalued against the U.S. dollar. The behavior of the Latin American currencies, however, has been mixed. The currencies of the countries in transition (the former Communist countries) have generally been undervalued relative to the U.S. dollar, as expected.

The Balassa-Samuelson theory is less useful in explaining differences across countries with more similar per capita incomes. As shown in the bottom half of Table 2, the U.S. dollar has been consistently overvalued against the currencies of five other advanced economies—Canada, Hong Kong, Singapore, Australia, and New Zealand.[16] The U.S. dollar has been almost always undervalued against the currencies of Britain, Denmark, Sweden, and Switzerland.

More generally, we would expect to see a positive relationship between price levels and per capita income when comparing countries. Figure 5 plots two measures of this relationship. The upper panel uses the data from the PWT data for 2000 to compare PPP price levels with per capita gross domestic product—both relative to the United States.[17] The

[15] This requires that the training, the technology used to produce Big Macs, and the working conditions are similar across countries.

[16] Curiously, the currency unit for all of these countries is a "dollar."

[17] The upward sloping line in the graph is the fitted line from the following regression: $p = 20.9 + 0.90 \times pcgdp$, where p is the relative PPP price level and $pcgdp$ is the relative per capita gross domestic product. The t-statistic for $pcdgp$ is 11.64.

Table 2

Currency Valuation

	Data period	Local currency relative to the U.S. dollar		
		Undervalued	Overvalued	Parity
Developing countries				
Asia				
China	92-03	92-03		
Indonesia	95, 98-03	95, 98-03		
Malaysia	93-03	93-03		
Philippines	98-03	98-03		
Thailand	93-03	93-03		
Latin America				
Argentina	92-03	98, 01-03	92-97, 99	00
Brazil	92-03	92, 94, 99-03	93, 95-98	
Chile	94-03	96, 00-03	95, 97-99	94
Colombia	99-03	99-01, 03	02	
Mexico	93-03	95-03	94	93
Peru	98, 01-03	98, 01, 03		02
Venezuela	92, 98-99, 02-03	03	92, 98-99, 02	
Other				
Saudi Arabia	98-03	98-03		
South Africa	96-03	96-03		
Turkey	99-03	99-01, 03	02	
Countries in transition				
Czech Republic	94-03	94-03		
Hungary	91-03	91-03		
Poland	94-03	94-03		
Russia	90-03	92-03	90-91	
Advanced economies				
Major economies				
Britain	86-03	88	86-87, 89-03	
Canada	86, 88-03	86, 88-91, 93-03	92	
Euro area	99-03	00-02	99, 03	
France	86-01	01	86-00	
Germany	86-01	00-01	86-99	
Italy	87-01	98, 00-01	87-97, 99	
Japan	86-03	97-98, 01-03	86-96, 00	99
Newly industrialized Asian economies				
Hong Kong	86-03	86-03		
Singapore	86-92, 94-03	86-91, 94-03	92	
South Korea	89-03	98, 01-02	89-97, 99-00	03
Taiwan	94-03	98-03	94-97	
Other advanced economies				
Australia	86, 88-03	86, 88-03		
Austria	94-98		94-98	
Belgium	86-98		86-98	
Denmark	87-03		87-03	
Ireland	86-93	88-90	87, 92	86, 91, 93
Israel	95-02		95-01	02
Netherlands	86-99		86-99	
New Zealand	95-03	95-03		
Spain	86, 88-01	98, 00-01	86, 88-97	99
Sweden	86, 88-03	01	86, 88-00, 02-03	
Switzerland	93-03		93-03	

THE BIG MAC AND THE EURO AREA

On January 1, 1999, 11 of the 15 members of the European Union adopted a common monetary policy, conducted by the European Central Bank, and a common currency, the euro. The figure examines the deviations from PPP relative to the German mark for three of the euro area countries and the three European Union countries that remain outside the euro area.[1]

As the upper panel of the figure indicates, deviations from PPP for the three prospective euro area members (France, Italy, and Spain) had declined substantially by 1997. Although there was some convergence with respect to the three nonmember countries (Britain, Denmark, and Sweden, as shown in the bottom panel), it is less obvious, particularly for Denmark.

The adoption of a common monetary policy had little noticeable effect on reducing deviations from PPP for the euro area members. There is scant evidence of further convergence for the euro area members after the starting date. One possible explanation is that monetary policies had converged in the years prior to the formation of the European Central Bank.

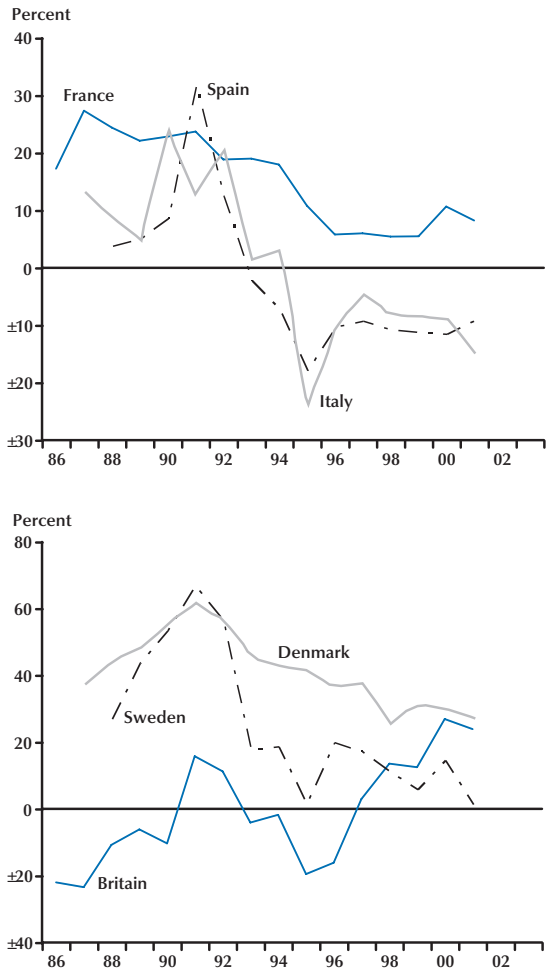
Although the euro was created in 1999, it did not exist as a physical currency until January 1, 2002. After this point, prices for Big Macs throughout the euro area were posted in euros. For European Big Mac aficionados, this should have made it easier to determine the best place to have a Big Mac attack. Unfortunately for the study of burgernomics, it is not possible to determine if the existence of euro pricing has led to convergence, because starting with the 2002 survey *The Economist* no longer reports prices for individual euro area countries.

Euroskeptics in Britain can look to the Big Mac to support their country's continued absence from the euro area. The pound continues to be overvalued by 20 percent or more against the mark (and the euro). Interestingly, the Swedish krona moved close to parity with the mark by 2001; however, in the past two years it too has diverged sharply from parity.

[1] Greece became the twelfth member of the euro area in 2001.

Figure B1

Deviation from PPP - Relative to German Mark



lower panel presents a similar comparison, plotting the relative hamburger prices against relative average net earnings for the same set of countries, using the UBS (2000) data.[18] As we might expect from a bundle of goods that includes both tradable and non-tradable components, the relationship between Big Mac prices and incomes closely parallels the relationship that exists for more inclusive measures of the overall price level. Using a more formal analysis, Click (1996) reaches the same conclusion. Deviations from PPP are driven by the Balassa-

[18] The upward sloping line in the graph is the fitted line from this regression: $pbm = 1.67 + 0.10 \times wage$, where *pbm* is the relative Big Mac price and *wage* is relative wage rate. The t-statistic for *wage* is 3.82.

Samuelson effect. He concludes, "the Big Mac simply costs more where income is higher."

Government Expenditures. Another explanation for why relative prices might deviate from the exchange rate considers differences in government expenditures across countries. Governments typically spend relatively more on non-traded goods than does the private sector (households and businesses). Suppose government spending (as a share of output) in the United States increases relative to government spending in other countries. The price of non-traded goods in the United States will rise as will the overall price level. If PPP held prior to this increase in spending, the dollar now will be overvalued relative to its PPP level. Studies have found that government spending does result in deviations from PPP, at least among the high-income economies.[19]

Current Account Deficits. Another role for non-traded goods in explaining deviations from PPP comes through the current account. Krugman (1990) argued that, as a country runs a current account deficit, its spending on traded goods increases relative to other countries. This results in a decline in the relative price of non-tradable goods in the deficit country. Thus, if PPP had held prior to the current account deficit, the country's currency would now be undervalued.[20]

Pricing to Market

The inclusion of non-traded goods in price indices is often considered the primary explanation for deviations from PPP. This is because, in the absence of barriers to trade, which for most goods are not substantial, the law of one price states that the price of tradable goods will be the same in all countries.[21] Another fundamental requirement for PPP to hold is that markets are perfectly competitive. If imperfect competition exists—so that firms have market power—then even in the absence of barriers to trade, goods prices may not be equal across countries. Some economists have argued that differences in tradable goods prices account for much of the deviation from PPP.

Differences in traded goods prices across countries can occur if firms are able to price to market—that is, charge different prices in different countries.[22] Economic theory states that a firm will maximize profits by varying prices in accordance with the elasticity of demand for a product. The elasticity of demand indicates how the quantity demanded of a product changes when the price changes. If the price of a good increases by 10 percent and the quantity demanded falls by less than 10 percent, the demand for this product is said to be inelastic. If the price increases by 10 percent and the quantity demanded falls by more than 10 percent, the demand for this product is elastic. Sales revenue rises following an increase in the price of a good whose demand is inelastic and falls following an increase in the price of a product whose demand is elastic. A firm would be able to maximize revenue, and hence profits, by pricing to market—charging a higher price for its product in a country where demand is inelastic relative to a country where demand is more elastic.

Firms that price to market in international markets may limit exchange rate pass-through—the extent to which changes in the exchange rate result in changes in import prices. If exchange rate pass-through was complete, the 14 percent rise in the Australian dollar against the U.S. dollar between 2002 and 2003 should have resulted in a 14 percent decline in the price of Australian beef sold in the United States. Incomplete exchange rate pass-through means that the price of imported goods does not rise (fall) by as much as the rise (fall) in the value of the foreign currency. When exchange rate pass-through is incomplete, then a wedge occurs between the prices of a good in the domestic and foreign markets, expressed in a common currency.[23] In countries where demand is relatively elastic, a firm may limit pass-through to maintain market share when the local currency depreciates and to increase its profit margin when the local currency appreciates.

The ability of a firm to price to market depends on the ease with which goods can be resold across countries. For example, because of differences in safety and pollution standards, as well as warranty restrictions, it is difficult for individuals to resell automobiles across borders. For other products, a

[19] Froot and Rogoff (1995) give a summary of this literature.

[20] There is, however, no consensus among economists on the role of the current account in explaining deviations from PPP. See Rogoff (1996) for more details.

[21] Obstfeld and Rogoff (2000), however, argue that trade costs are the key determinant of deviations from PPP.

[22] See, for example, Dornbusch (1987) and Krugman (1987).

[23] Feenstra and Kendall (1997) find that incomplete pass-through is a significant source of deviations from PPP in the floating exchange rate period.

firm may allow only authorized wholesalers to distribute its product in a country to prevent the importation of its product from a country with lower prices.

Clearly the Big Mac cannot be easily resold across borders. However, all of its components are easily resold. Thus, it would be fairly easy for someone to purchase the ingredients necessary to create a Big Mac (despite the secret recipe for the special sauce) and sell a competing sandwich. Although in some markets, most notably the United States, the Big Mac has close substitutes, in many countries the Big Mac has few substitutes. Perhaps this is because a Big Mac is more than the sum of its ingredients. People choose to frequent McDonald's for more than the burgers, and these factors may be reflected in price differences across borders.

Indeed, the typical American view of McDonald's as a place to get a fast, cheap meal does not hold throughout the world. In much of East Asia "'fast' refers to the delivery of food, not its consumption" (Watson, 2000, p. 130). According to Bak (1997), young Koreans view McDonald's as a place to socialize, without the high price of a typical café. Likewise, in many developing countries the Big Mac is not an inexpensive meal option. The $1.38 price of a Big Mac in Bangkok in 2003 may have looked like a bargain to an American accustomed to paying twice that much at home for the sandwich. For a typical Thai consumer, however, the Big Mac cost over three-quarters of his or her hourly wage. Table 3 shows, in a sample of countries, how long a worker must work to purchase a Big Mac. Using this criterion the cheapest Big Macs in 2003 were in Japan, where it took a worker only 10 minutes to afford a Big Mac. A worker in the Philippines could afford less than a bite after that amount of time working. It took nearly 2 hours for a worker in the Philippines to purchase a Big Mac.

How then can McDonald's flourish in low-income countries? Perhaps it is because

> …wherever McDonald's takes root, the core product—at least during the initial phase of operation—is not really the food but the experience of eating in a cheerful, air-conditioned, child-friendly restaurant that offers the revolutionary innovation of clean toilets.[24] (Watson, 2000, p. 122)

Yan (1997) argues that McDonald's in China attracts young urban professionals who see eating there as a way to connect with the outside world. For those who visit Beijing from the Chinese countryside, McDonald's is viewed as a tourist stop. Watson (2000) notes that these rural visitors bring their Big Mac boxes home as souvenirs. These factors may be reflected in the price differences of a Big Mac around the world.

CONCLUSION

Although the theory of PPP serves as a useful benchmark for thinking about long-term equilibrium in foreign exchange markets, it generally does poorly as a predictive tool. A great deal of research effort has been put into tests of PPP and in constructing price measures for consistent bundles of commodities across countries. It is interesting to find that the simple collection of items comprising the Big Mac sandwich does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures.

This is perhaps not surprising when we consider that the Big Mac is a composite of tradable commodities and non-tradable service content. Its ingredients are subject to various tariffs and nontariff trade barriers in countries around the world. Finally, though it may have close rivals in some markets, the Big Mac itself is produced by only one company; hence we might expect to find elements of imperfect competition. That many of its basic ingredients are tradable goods would lead us to believe that Big Mac prices around the world should be driven to equality by arbitrage. Its other characteristics make the Big Mac a good example of why the theory of PPP generally fails to hold except under special circumstances.

Even within the United States the price of a Big Mac varies across cities. The U.S. price of a Big Mac in *The Economist* survey is based on the average price in Atlanta, Chicago, New York, and San Francisco. Although *The Economist* does not publish data on individual U.S. cities, an example of the range of U.S. prices can be gleaned from the most recent UBS survey of prices and earnings. The survey covers four U.S. cities: Chicago, Miami, Los Angeles, and New York. The price of a Big Mac in 2003 ranged from $2.03 in Miami to $3.04 in New York. Although

[24] Although friendly service may be the expectation in the United States, it is not so universally. Watson (1997) notes that in some cultures consumers are suspicious of clerks who smile on the job. When McDonald's opened in Moscow in 1990, customers waiting outside were told, "The employees inside will smile at you. This does not mean that they are laughing at you. We smile because we are happy to serve you" (Watson, 1997).

Table 3

Working for a Big Mac

	Big Mac price U.S. $	Net hourly wage U.S. $	Minutes of work to buy a Big Mac
Argentina	1.42	1.70	50
Australia	1.86	7.80	14
Brazil	1.48	2.05	43
Britain	3.14	12.30	15
Canada	2.21	9.35	14
Chile	1.96	2.80	42
China	1.20	2.40	30
Colombia	2.13	1.90	67
Czech Republic	1.96	2.40	49
Denmark	4.09	14.40	17
Euro area	2.98	9.59	19
Hong Kong	1.47	7.00	13
Hungary	2.19	3.00	44
Indonesia	1.84	1.50	74
Japan	2.18	13.60	10
Malaysia	1.33	3.10	26
Mexico	2.18	2.00	65
New Zealand	2.22	6.80	20
Peru	2.28	2.20	62
Philippines	2.24	1.20	112
Poland	1.62	2.20	44
Russia	1.32	2.60	30
Singapore	1.85	5.40	21
South Africa	1.85	3.90	28
South Korea	2.70	5.90	27
Sweden	3.60	10.90	20
Switzerland	4.60	17.80	16
Taiwan	2.01	6.90	17
Thailand	1.38	1.70	49
Turkey	2.34	3.20	44
United States	2.71	14.30	11
Venezuela	2.32	2.10	66

NOTE: Wages are based on a weighted average of 12 professions.

Wage data for Brazil, Canada, Germany, Italy, and Spain are based on averages of wages in two cities in each country. Wage data for Switzerland and the United States are averages of wages in four cities. Wage data for the euro area is an average of wages in 15 cities in the region.

SOURCE: Big Mac prices, *The Economist* (April 26, 2003); net wages, UBS (2003).

CURRENCY CRISES AND THE BIG MAC

Over the past ten years, currency crises have struck various countries in the Big Mac database whose currencies were pegged to the U.S. dollar. These crises have spawned a host of studies to determine their causes. Some economists have argued that an overvalued currency is a good predictor of a currency crisis. Although there are more sophisticated ways to determine whether a currency is overvalued, PPP is often used as a guide.[1]

We use the Big Mac survey to examine the predictability of five recent currency crises—the Mexican crisis (1994), the Asian crisis (1997), the Russian crisis (1998), the Brazilian crisis (1999), and the Argentine crisis (2002).[2] The table on the next page shows the exchange rate, Big Mac prices, and the PPP measure for each currency relative to the dollar prior to the crisis and in the first survey after the crisis. Based on these data, the Big Mac appears to be a poor predictor of a currency crisis.

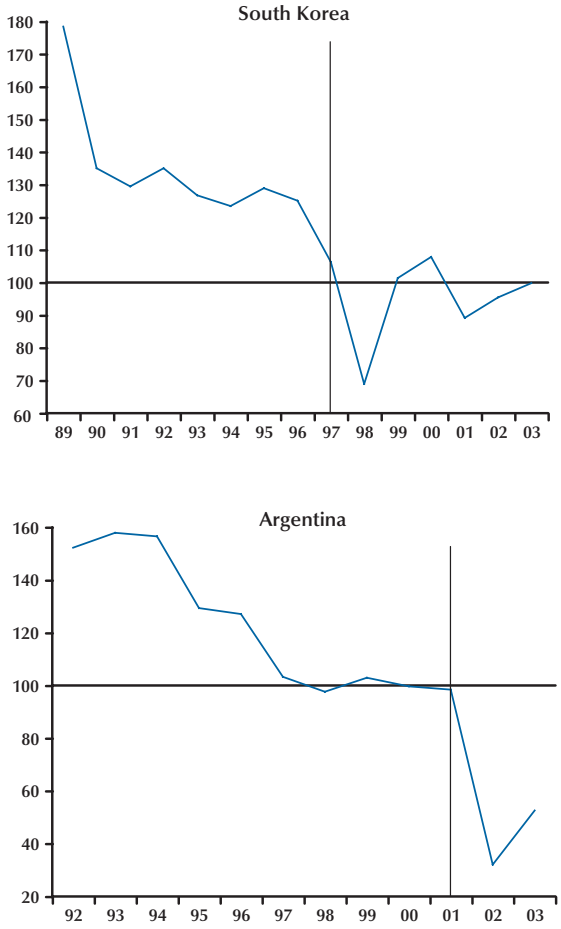
In only four countries was the local currency above parity. In none of these cases was there evidence of a strongly overvalued currency; the overvaluation ranged from 2 to 6 percent. In Korea's case, as shown in the top panel of the figure, the won had been substantially overvalued in the early 1990s, but was moving close to parity prior to the crisis. In contrast, in four other countries the local currency was substantially below parity, with the undervaluation ranging from 14 to 36 percent.[3] In the remaining case, Argentina, the currency was only 2 percent below parity.

Argentina is a particularly interesting case study. In mid-1991 Argentina adopted a fixed exchange rate, setting the value of the peso at one U.S. dollar. Initially, the peso was highly overvalued against the dollar, as shown in the figure, as the price of a Big Mac was much higher than in the United States. By 1997, however, Big Mac prices in the two countries had converged. The peso remained close to parity with the dollar through the 2001 survey.[4] In January 2002 the exchange

Continued on p. 25

Figure B2

PPP and Currency Crises



NOTE: The vertical line indicates the survey prior to the currency crisis.

[1] See Chinn (2000) for a discussion of these methods.

[2] Indonesia and the Philippines are excluded from our analysis of the Asian crisis because these countries were not in the Big Mac survey in 1997.

[3] Conversely, Chinn (1999) argues that the Thai baht and Malaysian ringgit were overvalued based on PPP estimates, while the Korean won and Taiwan dollar were undervalued.

[4] Perry and Servén (2003) argue that the Argentine peso was overvalued by 40 percent prior to the crisis.

Continued from p. 24
rate peg was broken and the peso fell sharply against the dollar. Between the 2001 and 2002 Big Mac surveys, the dollar had risen by over 100 percent against the peso. Despite the change in the exchange rate, the peso price of a Big Mac in Argentina remained unchanged. As a result, on a PPP basis the peso was undervalued by 68 percent against the dollar. By the 2003 survey, the peso price rose sharply, to 4.10 pesos, moderating the extent of the undervaluation.

The slow adjustment of goods prices despite large movements in the exchange rate is typical. As the table shows, in three of the nine countries, Big Mac prices were unchanged in the surveys immediately following the currency crisis. Only in the survey following the Russian crisis was the change in the local price of a Big Mac of similar magnitude to the change in the exchange rate. Across all nine countries the average rise in the foreign exchange value of the dollar was 58 percent, while the average rise in the local currency price of a Big Mac was 27 percent.

Currency Crises and the Big Mac

	Survey prior to crisis				Survey after crisis			
Country	Exchange rate	U.S. price Big Mac	Local price Big Mac	PPP	Exchange rate	U.S. price Big Mac	Local price Big Mac	PPP
Mexico	3.36	2.30	8.1	105	6.37	2.32	10.9	74
Thailand	26.1	2.42	46.7	74	40	2.56	52	51
Malaysia	2.5	2.42	3.87	64	3.72	2.56	4.3	45
Singapore	1.44	2.42	3	86	1.62	2.56	3	72
South Korea	894	2.42	2300	106	1474	2.56	2600	69
Taiwan	27.6	2.42	68	102	33	2.56	68	80
Russia	5.999	2.56	12	78	24.7	2.43	33.5	56
Brazil	1.14	2.56	3.1	106	1.73	2.43	2.95	70
Argentina	1.0	2.54	2.5	98	3.13	2.49	2.5	32

NOTE: The exchange rate is the local-currency price of the U.S. dollar. The U.S. price of a Big Mac is in dollars. The local price of a Big Mac is in local currency.

SOURCE: *The Economist,* various issues.

tariff barriers are nonexistent between Miami and New York, other factors that result in deviations from PPP across borders do exist—transportation costs and differences in sales taxes, prices of nontraded goods (wages, rents, and utilities), and competitive conditions.

Nevertheless, the $1.01 difference in high and low Big Mac prices across these U.S. cities is less than the range of differences for Big Mac prices across countries. A series of recent studies have shown that this observation holds across a range of goods.[25] There is still much to be learned about the role of international borders in driving deviations from PPP.

[25] See, for example, Cecchetti, Mark, and Sonora (2002), Crucini and Shintani (2002), Engel and Rogers (1996 and 2001), and Parsley and Wei (1996).

REFERENCES

Ashenfelter, Orley and Jurajda, Štěpán. "Cross-Country Comparisons of Wage Rates: The Big Mac Index." Unpublished manuscript, Princeton University and CERGE-EI/Charles University, October 2001.

AgJournal. "New Zealand Has Beef with Labels." 17 May 2002; < http://www.agjournal.com/story.cfm?story_id = 1981 > .

Bak, Sangmee. "McDonald's in Seoul: Food Choices, Identity, and Nationalism," in James L. Watson, editor, *Golden Arches East: McDonald's in East Asia*. Stanford: Stanford University Press, 1997.

Balassa, Bela. "The Purchasing-Power Parity Doctrine: A

Reappraisal." *Journal of Political Economy*, December 1964, *72*(6), pp. 584-96.

Cassel, Gustav. *The World's Monetary Problems*. London: Constable and Company, 1921.

Cecchetti, Stephen G.; Mark, Nelson C. and Sonora, Robert J. "Price Index Convergence Among United States Cities." *International Economic Review*, November 2002, *43*(4), pp. 1081-99.

Chinn, Menzie D. "Three Measures of East Asian Currency Overvaluation." *Contemporary Economic Policy*, April 2000, *18*(2), pp. 205-14.

_____. "Measuring Misalignment—Purchasing Power Parity and East Asian Currencies in the 1990s." IMF Working Paper No. 99/120, International Monetary Fund, September 1999.

Click, Reid W. "Contrarian MacParity." *Economics Letters*, November 1996, *53*(2), pp. 209-12.

Crucini, Mario J. and Shintani, Mototsugu. "Persistence in Law-of-One-Price Deviations: Evidence from Micro-Data." Working Paper No. 02-W22, Vanderbilt University, December 2002.

Cumby, Robert E. "Forecasting Exchange Rates and Relative Prices with the Hamburger Standard: Is What You Want What You Get With McParity?" Unpublished manuscript, Georgetown University, May 1997.

Dornbusch, Rudiger. "Exchange Rates and Prices." *American Economic Review*, March 1987, *77*(1), pp. 93-106.

Dyck, John. "U.S.-Japan Agreements on Beef Imports: A Case of Successful Bilateral Negotiations," in Mary E. Burfisher and Elizabeth A. Jones, eds., *Regional Trade Agreements and U.S. Agriculture*. Chap. 9. Market and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture, Agricultural Economics Report No. 771, November 1998.

Economist, various issues, 1986-2003.

Engel, Charles. "Accounting for U.S. Real Exchange Rate Changes." *Journal of Political Economy*, June 1999, *107*(3), pp. 507-38.

_____ and Rogers, John H. "Violating the Law of One Price: Should We Make a Federal Case Out of It?" *Journal of Money, Credit, and Banking*, February 2001, *33*(1), pp. 1-15.

_____ and _____. "How Wide Is the Border?" *American Economic Review*, December 1996, *86*(5), pp. 1112-25.

Feenstra, Robert C. and Kendall, Jon D. "Pass-through of Exchange Rates and Purchasing Power Parity." *Journal of International Economics*, August 1997, *43*(1/2), pp. 237-61.

Froot, Kenneth A. and Rogoff, Kenneth. "Perspectives on PPP and Long-Run Real Exchange Rates," in Gene Grossman and Kenneth Rogoff, eds., *Handbook of International Economics*. Volume 3. Amsterdam: North Holland Press, 1995.

Heston, Alan; Summers, Robert and Aten, Bettina. *Penn World Table Version 6.1*. Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.

Hummels, David. "Toward a Geography of Trade Costs." Unpublished manuscript, Purdue University, September 2001.

Krugman, Paul R. "Equilibrium Exchange Rates," in William H. Branson, Jacob A. Frenkel, and Morris Goldstein, eds., *International Policy Coordination and Exchange Rate Fluctuations*. Chicago: University of Chicago Press, 1990, pp. 159-87.

_____. "Pricing to Market when the Exchange Rate Changes," in Sven W. Arndt and J. David Richardson, eds., *Real-Financial Linkages among Open Economies*. Cambridge, MA: MIT Press, 1987, pp. 49-70.

Lan, Yihui. "The Long-Run Value of Currencies: A Big Mac Perspective." Unpublished manuscript, University of Western Australia, September 2001.

Obstfeld, Maurice and Rogoff, Kenneth. "The Six Major Puzzles in International Macroeconomics: Is There a Common Cause?" NBER Working Paper 7777, National Bureau of Economic Research, July 2000.

Ong, Li Lian. *The Big Mac Index: Applications of Purchasing Power Parity*. New York: Palgrave MacMilan, 2003.

_____. "Burgernomics: The Economics of the Big Mac Standard." *Journal of International Money and Finance*, December 1997, *16*(6), pp. 865-78.

Pakko, Michael R. and Pollard, Patricia S. "For Here or To Go? Purchasing Power Parity and the Big Mac." Federal Reserve Bank of St. Louis *Review*, January/February 1996, *78*(1), pp. 3-22.

Parsley, David C. and Wei, Shang-Jin. "Convergence to the Law of One Price without Trade Barriers or Currency Fluctuations." *Quarterly Journal of Economics*, November 1996, *111*(4), pp. 1211-36.

_____ and _____. "Explaining the Border Effect: The Role of Exchange Rate Variability, Shipping Costs, and Geography." *Journal of International Economics*, October 2001, *55*(1), pp. 87-105.

_____ and _____. "The Micro-Foundations of Big Mac Real Exchange Rates." Unpublished manuscript, May 2003.

Perry, Guillermo and Servén, Luis. "The Anatomy of a Multiple Crisis: Why Was Argentina Special and What Can We Learn From It?" Policy Research Working Paper 3081, World Bank, June 2003.

Rogoff, Kenneth. "The Purchasing Power Parity Puzzle." *Journal of Economic Literature*, June 1996, *34*(2) pp. 647-68.

Samuelson, Paul A. "Theoretical Notes on Trade Problems." *Review of Economics and Statistics*, May 1964, *46*(2), pp. 145-54.

UBS. *Prices and Earnings Around the Globe*. 2000 and 2003 Editions. Zurich: UBS, 2000, 2003.

United States International Trade Commission. *Harmonized Tariff Schedule of the United States*. Revision 2. 2003.

Watson, James L. "China's Big Mac Attack." *Foreign Affairs*, May/June 2000, *79*(3), pp. 120-34.

_____, ed. *Golden Arches East: McDonald's in East Asia*. Stanford: Stanford University Press, 1997.

Wei, Shang-Jin and Parsley, David C. "Purchasing Power Dis-Parity During the Floating Rate Period: Exchange Rate Volatility, Trade Barriers and Other Culprits." NBER Working Paper 5032, National Bureau of Economic Research, February 1995.

Yan, Yunxiang. "McDonald's in Beijing: The Localization of Americana," in James L. Watson, ed., *Golden Arches East: McDonald's in East Asia*. Stanford: Stanford University Press, 1997.

Banking Antitrust: Are the Assumptions Still Valid?

R. Alton Gilbert and Adam M. Zaretsky

The federal bank regulatory agencies and the U.S. Department of Justice (DOJ) scrutinize bank mergers and acquisitions for potential antitrust violations. To perform this antitrust analysis, the federal regulators make assumptions about the geographic scope of banking markets, the types of competitors that banks face in these market areas, and the nature of banking services. The authorities assume that the relevant geographic market is a local area where banks compete to offer financial services to households and small businesses. That market area is often approximated by a metropolitan area for mergers involving banks in urban areas and by a county for those involving banks in rural areas. The antitrust authorities assume that the relevant competitors are banks with offices in the same market area. They further assume that the relevant product for antitrust analysis is a cluster of financial services that is unique to banking. In some analyses, however, the focus is on competition among banks to provide individual categories of deposit and loan services. Antitrust agencies typically use a bank's deposits as the measure of output of financial services each bank provides.

The assumptions that underlie banking antitrust have been subject to criticism in recent years (Austin and Bernard, 2001; Jackson and Eisenbeis, 1997; Moore, 1998; Petersen and Rajan, 2002; Radecki, 1998, 2000; and Santomero, 1999). Some critics focus on assumptions about the relevance of local markets for antitrust analysis. They argue that financial innovation and changes in banking regulations, including nationwide branch banking since 1997, have undermined the relevance of using local areas for competitive analysis. Innovative financial firms are now able to offer services, such as loans and investment options, to customers in areas where the firms do not have offices. In addition, the threat of entry by out-of-market financial firms constrains the terms under which banks with offices in a given geographic area can offer services to local customers. Finally, studies indicate that banks with offices in many communities tend to offer financial services to all communities on the same terms. The results of these studies appear to undermine the assumption that the terms on which banks make their services available to customers depend to some extent on the structure of local market areas. Shull and Hanweck (2001) also criticize the focus on local markets in banking antitrust analysis, arguing that it is not constraining consolidation of the banking industry at the national level.

Critics also focus on the assumption that a cluster of banking services is the relevant product in antitrust analysis. They argue that the success of nonbank financial firms in providing services to households and small businesses has undermined the premises that commercial banks are the relevant competitors in antitrust analysis and that a bank's relevant product is a "cluster of banking services."[1]

The large literature on the topic of banking antitrust dates from the 1960s, when bank mergers in the United States became subject to the federal antitrust statutes. This article, by summarizing the results of empirical studies written or published since the early 1990s, assesses whether these more recent studies provide empirical support for the current assumptions that underlie banking antitrust analysis.[2]

CURRENT METHOD OF ANTITRUST ANALYSIS IN THE BANKING INDUSTRY

Antitrust analysis of bank mergers and acquisitions dates back to 1963, when the U.S. Supreme Court held that commercial banking, like other

R. Alton Gilbert is a vice president and banking advisor and Adam Zaretsky is an economist at the Federal Reserve Bank of St. Louis.
Neil R. Wiggins provided research assistance.

[1] See DeYoung, Hunter, and Udell (2003) for a description of these changes in the market for financial services to households and small businesses.

[2] For surveys of the earlier studies, see Rhoades (1982), Gilbert (1984), and Weiss (1989). See Rhoades (1996) for an examination of the implications of empirical studies for the methods of banking antitrust.

industries in the United States, is subject to the Sherman Antitrust Act of 1890 and the Clayton Act of 1914.[3] In its opinion, the Court noted that the test for anticompetitive behavior is whether the effect of a bank merger "may be substantially to lessen competition…in any line of commerce in any section of the country." To apply this test, the Court defined the "line of commerce" for the banking industry as the cluster of products and services—demand deposits, trust administration, and extension of various types of credit, for example—that banks uniquely provide to their customers. In other words, the Court determined that the products and services denoted by the term "commercial banking" compose a distinct line of commerce.

To define "section of the country"—that is, the relevant geographical market—the Court looked to where the effect of a merger on competition would be "direct and immediate." For banking, this effect occurs in the customers' local communities because individuals and firms typically conduct the bulk of their banking transactions at banks with local offices.

These two definitions—the relevant line of commerce is a cluster of products and services uniquely supplied by commercial banks, and the relevant geographical market is local—have guided banking antitrust analysis since the 1963 ruling. The federal banking regulators (Office of the Comptroller of Currency, Federal Deposit Insurance Corporation, Office of Thrift Supervision, and Board of Governors of the Federal Reserve System) have since adopted these definitions for their antitrust analyses.

Once a bank regulatory agency has identified the cluster of products and services and the local market, its final step is to determine whether the effect of the merger "may be substantially to lessen competition." In its ruling, the Supreme Court recognized that the answer to this question involved not only the immediate effects of a merger on competition, but also its anticipated future effects.[4] Such a prediction relies on the structure of the relevant market—that is, market concentration, the market shares of individual banks, and the number of market competitors. Banking antitrust is based on the assumption that the structure of a market influences how firms in that market will act, which, in turn, affects the firms' overall performance.[5] In other words, the merger's effect on these measures of "structure," particularly market concentration, is thought to be a reliable gauge of whether the merger will substantially lessen competition. Therefore, a proposed merger that increases market concentration considerably would likely fail this test, and the federal regulator would not approve it. The federal regulator might approve it, however, if other evidence exists to mitigate the proposal's anticompetitive effects on market structure. That said, the DOJ could challenge the decision and possibly sue to prevent the merger.

To minimize the chances that a decision will be challenged and to align the antitrust analyses of the federal regulators, the DOJ has periodically issued guidelines that define the circumstances under which an application is likely to exceed its antitrust standards and, therefore, warrant closer scrutiny. The federal banking regulators use these guidelines to help them identify the proposals that are likely to raise concerns about adverse effects of mergers on competition.

The DOJ's antitrust standards identify potentially anticompetitive mergers in terms of prescribed levels, and changes in levels, of a commonly used measure of market concentration, the Herfindahl-Hirschman Index (HHI). HHI is calculated by squaring each bank's share of deposits in a market and then summing these squared shares. The index number can range from zero (a perfectly competitive market) to 10,000 (a pure monopoly).[6] HHI is the preferred concentration index because it accounts for the market share of each bank in the market and gives greater weight to the firms with larger market shares. Other indices, such as the three-firm or four-firm concentration ratio, do not have both of these features.

According to the guidelines, a market can be broadly characterized as unconcentrated if HHI is less than 1000 points, as moderately concentrated if HHI is between 1000 and 1800, and as highly

[3] *United States v. Philadelphia National Bank*, 374 U.S. 321 (1963). See Shull (1996) for an historical perspective on banking antitrust.

[4] This is how the Court interpreted Congress's directive to "arrest anticompetitive tendencies in their 'incipiency'."

[5] The assumption of a link between market structure and the performance of firms in the market is commonly referred to as the structure-conduct-performance hypothesis.

[6] The perfectly competitive market would consist of many firms, each with about the same market share. As the number of firms in this market increases, each firm's share decreases until it approaches the limit of zero. The square of zero is zero, so the sum of those squares is still zero. The pure monopoly market would have only one firm that controls 100 percent of the market. The square of 100 is 10,000.

concentrated if HHI is above 1800.[7] These thresholds apply not only to banking, but to all industries in the United States. The DOJ distinguishes banking from other industries, however, by allowing it more latitude for *increases* in HHI. That is, the DOJ normally will not challenge a bank merger or acquisition unless the resulting increase in HHI is at least 200 points *and* the post-merger market HHI is at least 1800 (highly concentrated).[8] For other industries, an increase in HHI of at least 50 points in a highly concentrated market will trigger closer scrutiny by the DOJ. The additional cushion afforded the banking industry accounts for the competition banks now face from thrifts, credit unions, and other providers of financial services. In fact, thrifts—that is, savings and loan associations and savings banks—so resemble banks today in their financial service offerings that federal regulators routinely account for thrift deposits when calculating a banking market's HHI.[9] Deposits at thrifts are commonly included at 50 percent weight, however, because thrifts target their financial services primarily to consumers and not businesses, which commercial banks typically service.[10] Thrifts' focus on consumers dates back to before deregulation (1980), when they were restricted to accepting only savings deposits and to making predominantly residential real estate loans. Post-1980, changes in the law gradually allowed thrifts to expand their menu of offerings and services, enabling them to resemble and compete more directly with banks. These changes ultimately led the Federal Reserve Banks, in 1987, to incorporate thrift deposits (at half weight) into their market antitrust analyses.[11]

Deposits at credit unions are rarely included in banking antirust analyses. Being membership organizations, credit unions offer their financial services only to their members, and these services are usually quite limited when compared with those offered by banks and thrifts. As such, credit unions do not necessarily compete in the same product market as banks and thrifts. In certain cases, however, credit union deposits may be included in the analysis of a specific market (at fractional weighting) if substantial evidence supports their inclusion. One piece of such evidence would be that the share of deposits at credit unions in the market area greatly exceeded the national average. In addition, a particular credit union should have liberal membership rules (typically, at least 70 percent of market residents must be eligible for membership) and offices that are easily accessible to local residents.

Determining the change in HHI and its post-merger level is not the end of the story. If these numbers were to fall outside of the DOJ guideline thresholds, it would not automatically mean that the merger or acquisition would be denied. Such an outcome would indicate only that regulators would consider the concentration of the market to be high enough to permit the firms in the market to keep prices above the competitive level for a significant period. Such a case would require that a more-detailed economic analysis be conducted before a decision could be made. This analysis would seek to determine whether other factors, such as potential competition and economic conditions of the market, could mitigate the anticompetitive structural effect of the merger and, thereby, suggest that the HHI does not tell the whole story. An applicant might avoid the more-detailed analysis, however, if it were to choose or agree to divest to a third party some of its offices in the affected markets to get those markets' competitive structures to fall within guidelines.[12]

Having a post-merger HHI and an increase in HHI that exceed DOJ thresholds is not the only reason an application might receive closer scrutiny. A bank that would end up controlling more than 35 percent of the deposits in a particular market after a merger or acquisition would also trigger a more in-depth examination by the Federal Reserve, even if the HHI measures indicate no significant change

[7] DOJ, Antitrust Division, and the Federal Trade Commission, *1992 Horizontal Merger Guidelines* (revised April 8, 1997).

[8] See Cyrnak (1998, p. 704).

[9] Savings and loan associations, which may also be known as savings associations, S&Ls, building and loan associations, cooperative banks, or homestead societies, include both mutual and stock associations. Both mutual and stock savings banks are included.

[10] In some cases, deposits at thrifts may be weighted more or less than 50 percent, depending on the level of activity a particular thrift has in a region's commercial lending market. In addition, deposits of thrift subsidiaries of commercial banking organizations are included in the HHI calculation at 100 percent.

[11] The DOJ does not include any thrift deposits in its banking antitrust analyses, unless the proposal fails its competitive screen *and* individual circumstances warrant a particular thrift's inclusion at 100 percent weight. One example would be a ratio of commercial and industrial loans to total assets at thrifts in a market area that exceeds 2 percent.

[12] Most often, large banking organizations use divestiture of banking offices as a means of securing approval for a proposed merger or acquisition. See Pilloff (2002) and Webb (2001) for discussion of divestiture in antitrust analysis.

Sources of Data Used to Evaluate the Assumptions of Banking Antitrust

MEASURES OF MARKET STRUCTURE

Summary of Deposits

The Summary of Deposits contains deposit data for more than 85,000 branches/offices of institutions insured by the Federal Deposit Insurance Corporation, which collects deposit balances for commercial and savings banks as of June 30 of each year. The Office of Thrift Supervision collects the same data for savings institutions. These data are used for measuring concentration of deposits among depository institutions with offices located in each market area.

Loans Reported under the CRA

Beginning in 1996, all banks and savings institutions (savings banks and savings and loan associations) with total assets in excess of $250 million, or banks of any size that are subsidiaries of holding companies with assets of $1 billion or more, must report the number and amount of small business loans by location. Small business loans are defined as commercial and industrial loans of less than $1 million. Coding of these CRA data by geographic area makes it possible to measure the influence of lending by large depository institutions on banking concentration in market areas where these institutions do not have offices.

MEASURES OF BANK PERFORMANCE

Call Reports

Each quarter, each bank files a balance sheet and an income statement with its supervisor. These data are used for calculating *profit rates*, commonly measured as net income after tax as a percentage of total assets (called return on assets, or ROA).

Some studies use the call report data to calculate *the average interest rates that banks paid on various categories of deposits*. The interest rate paid on each category of deposits is derived by calculating interest paid as a percentage of average deposits. A major challenge involves calculating interest rates on time deposits, since a bank's outstanding time deposit liabilities may have been issued at various points in time in the past. Average interest rates paid calculated with data from the call report are likely to reflect more accurately the interest rates that banks were offering to depositors at the time of the call report for very short-term deposits, such as savings accounts, than for time deposits.

Monthly Survey of Selected Deposits and Other Accounts

Between April 1982 and September 1997, the Federal Reserve asked a sample of several hundred banks to report monthly on the interest rates they paid on specific categories of deposit accounts. In addition, the Fed asked these banks about the fee structures on these deposit accounts in annual supplements that were collected between 1989 and 1997. Since each bank in the sample filed one report, the authors who use these data for testing the SCP hypothesis have to make various adjustments for the fact that many of the banks in the sample had offices in more than one market area.[1]

Continued on p. 33

[1] Simons and Stavins (1998) use data on interest rates from the "Monthly Survey of Selected Deposits and Other Accounts" to test the SCP hypothesis for banks. They assume that each bank in their sample paid the same interest rate on deposits at each of its offices, although they did not have information to support this assumption.

in market concentration.[13] Indeed, a bank subject to the antitrust authority of the Federal Reserve can certainly control more than 35 percent of total deposits in any given market, but, in most of these cases, the high market share would not have resulted from a merger. For instance, a bank could have achieved a large market share through internally generated growth rather than through acquisitions; alternatively, a change in market definition may have increased the share of total deposits the bank controls in that market. If a merger or acquisition were to result in a bank controlling more than 35 percent of market deposits, the antitrust analysis would focus on whether any factors might mitigate the anti-competitive effects of that merger. An example of such a mitigat-

[13] See 12 CFR 265.11 and DOJ, "Bank Merger Competitive Review—Introduction and Overview" (1995), current as of September 2000.

Continued from p. 32

Bank Rate Monitor

Bank Rate Monitor is the name of a publication that conducts surveys of the interest rates that each office of large banks located in urban areas charges on various categories of loans and pays on various categories of deposits. Data from this source have important advantages over other sources of data for purposes of measuring bank performance. As a survey of the interest rates that banks offer on categories of deposits at various points in time, this source avoids problems inherent in the use of call report data to measure the interest rates that banks offer to pay on time deposits. Data from *Bank Rate Monitor* avoid the problem inherent in the data from the Monthly Survey of Selected Deposits and Other Accounts of interpreting reports by banks that have offices in more than one market area. In addition, the Monthly Survey of Selected Deposits and Other Accounts ceased in 1997, whereas *Bank Rate Monitor* continues to survey the interest rates that bank offices charge on loans and pay on deposits. *Bank Rate Monitor* data, however, are available for only relatively large depository institutions with offices in relatively large metropolitan areas.

Survey of the Terms of Lending to Business

This survey is conducted by the Federal Reserve. Once each quarter, the banks in the survey sample provide detailed information on each business loan made during a period of one week. This report is used to derive the average interest rate that banks in the sample charged on small loans to businesses. The survey does not include information that can be used to measure the size of the borrowers. These small, business loans are assumed to be made to small businesses.

National Survey of Small Business Finances

The survey, conducted by the National Opinion Research Center for the Board of Governors of the Federal Reserve System during 1987, 1993, and 1998, includes characteristics of firms and owners, the firms' use of financial services and financial service suppliers, and income and balance sheet items. The survey was renamed the Survey of Small Business Finances in 1998.

Survey of Consumer Finances

This Federal Reserve survey, which is conducted at intervals of three years, includes information on selected demographic characteristics of U.S. families, including their income, balance sheets, and use of financial services. Data from this survey are used to examine trends over time in the degree to which households obtained their financial services from depository institutions located in their communities.

ing factor could be that recent economic growth in the market has been strong enough to indicate that it is attractive for entry by other banks or thrifts.[14]

This process of antitrust analysis appears quite cut and dried. It relies, however, on several assumptions: Market concentration is the relevant dimension of market structure; market concentration is accurately and adequately measured; and the effects of a merger on market concentration translates consistently into anticipated effects on the pricing behaviors of the players in the market. In other words, the process assumes that the "structure-conduct-performance" (SCP) hypothesis correctly models the true market mechanism and that HHI, used to measure market concentration, reflects the relevant facets of market structure. Suppose, however, the hypothesis does not accurately model the true market mechanism. In that case, regulators could be using the hypothesis appropriately and drawing the correct conclusions from it, but still end up with unintended policy outcomes because the hypothesis is the wrong analytical model of banking competition in the first place. Several of the following studies directly test whether the SCP hypothesis holds for the banking industry.

In addition, the process of banking antitrust depends on HHI being a reliable measure of market structure. If HHI is not the relevant measure of market structure, the regulators and the DOJ may be missing important structural information that is not captured by HHI. This issue is also addressed in a number of the studies described in the following section.

[14] For other examples of mitigating factors, see Holder (1993).

EMPIRICAL RESEARCH

The literature has pursued various approaches to analyzing the assumptions that underlie banking antitrust. Some studies examine empirical evidence on the assumptions themselves. Other studies test hypotheses about the association between local market concentration and measures of bank performance, such as the profit rates of banks and the interest rates they charge on loans and pay on deposits. In still other articles, which investigate issues other than the validity of the assumptions of banking antitrust, the empirical results end up having implications for the relevance of local market areas for banking antitrust. The boxed insert of this paper describes the various surveys and other sources of data authors have used in such studies.

Evidence on the Validity of the Assumptions

Survey Data: Location of Banks and Their Customers. Several studies use survey data on the location of banks and their customers to assess the validity of the assumption that customers tend to obtain their financial services from firms with offices located in their communities. Kwast, Starr-McCluer, and Wolken (1997) use data from the 1992 Survey of Consumer Finances and the 1993 National Survey of Small Business Finances to examine the extent to which households and small businesses obtain financial services from local bank offices. The authors conclude that the data presented in their study support such an assumption.

Amel and Starr-McCluer (2002) use data from the Survey of Consumer Finances for the years 1989 through 1998 to examine trends over time in the degree to which households obtained their financial services from depository institutions located in their communities. They interpret their results as indicating that households with at least one bank-type account or loan continue, to a substantial degree, to obtain certain key financial services at local depository institutions.[15] The tendency to obtain services from local institutions is especially pronounced for transactions accounts. The data for 1998, however, tend to undermine the concept of a cluster of financial services that households demand from commercial banks. Except for checking accounts, Amel and Starr-McCluer's results demonstrate that the percentage of households obtaining their financial services from local banks has fallen substantially over time. For instance, the share of households that obtained money market accounts from local depository institutions declined from 78.4 percent in 1989 to 63.6 percent in 1998. The share of households that borrowed from local depository institutions declined from 73.3 percent in 1989 to 44.8 percent in 1998.

Petersen and Rajan (2002) use data from the 1993 National Survey of Small Business Finances to draw inferences about changes over time in the distance between small businesses and the firms that provide their lending and transactions services. Knowing the date the lending relationship began and the distance between the lender and the firm, the authors find that these distances have increased over time, from an average of 51 miles for lending relationships that began in the 1970s to an average of 161 miles for relationships that began in the 1990s. To obtain transactions services, on the other hand, small businesses continue to favor banks with offices in their communities. Petersen and Rajan argue that their results support wider geographic areas for markets in banking antitrust than have been used in the past. The authors acknowledge, however, that their results are subject to several possible biases. One such bias involves the survival of relationships over time. Results for the 1970s, for instance, are based on relationships between small businesses and lenders that began in the 1970s and remained in existence in 1993, the year of the survey.

Approaching the distance question from a different angle, Wolken and Rohde (2002) use data from the National Survey of Small Business Finances for 1993 and 1998. Distances between small businesses and their financial service providers varied substantially by category of service. In both 1993 and 1998, about 96 percent of small businesses obtained checking account services from financial institutions with offices located within 30 miles of the small businesses' headquarters. For those two years, the percentage of small businesses with lines of credit from financial institutions located within 30 miles of their headquarters was about the same: 85.1 percent in 1993 and 83.6 percent in 1998. Thus, small businesses continue to obtain these basic financial services from financial institutions located in their communities.

Although these four studies provide mildly

[15] Bank-type accounts or loans include checking, savings, money market (both money market deposit and money market mutual fund), brokerage, individual retirement, and Keogh accounts; certificates of deposit; trusts and other managed asset accounts; first and second mortgages; motor vehicle loans; home equity and other lines of credit; and other consumer loans. It does not include credit cards.

conflicting empirical support for the assumption that customers continue to receive many financial services from local depository institutions, their results are limited because they reflect only demand for financial services under existing prices. Survey data cannot help us understand how households and small businesses would respond to changes in these prices. The results also do not describe or help determine what share of financial services from local depository institutions is sufficiently high to support the current methods of banking antitrust.

Evidence of National Versus Local Markets for Banking Services. Jackson (1992) tests the hypothesis that the geographic scope of banking markets is national rather than local. In his regression analysis, the dependent variables are the monthly changes in interest rates on three categories of deposits from a sample of banks in 29 metropolitan statistical areas (MSAs). The independent variables include the current and lagged changes in the average monthly rate on the 6-month Treasury bill and a set of dummy variables for each MSA. The null hypothesis is that the sum of the coefficients on the dummy variables for an MSA, which represents how interest rates in the MSA adjust relative to a change in the national rate, is zero. If so, then the rate movements in the MSA match the movement in the national market. If the sum is significantly different from zero, then the interest rate adjustment on a particular type of deposit at banks in the selected MSA is different from that rate's adjustment in the national market. Jackson finds that in a significant number of MSAs the interest rate adjustments on money market deposit accounts (MMDAs) and super NOW accounts are statistically different from adjustments in the national market. In other words, banks do not compete in a national market for MMDAs and super NOW accounts. For 6-month certificates of deposit (CDs), however, the null hypothesis cannot be rejected, which implies that banks do compete for these CDs in a national market. Depositors with MMDAs and super NOW accounts have frequent contact with their banks, whereas customers who invest in 6-month CDs may limit contact with their banks to once every six months. Jackson's results are consistent with the use of local market areas rather than one national market in banking antitrust analysis for certain types of transactions accounts.

Jackson and Eisenbeis (1997), using the same data as Jackson (1992), employ cointegration analysis to determine whether the interest rates on the various deposit accounts are determined in local or national markets. Using the interest rate on 6-month Treasury bills to represent the national market, the authors test whether the deposit interest rates are cointegrated with the 6-month Treasury bill rate—that is, whether all of the series follow a common long-run trend. If they do, then the authors can conclude that the deposit interest rates are determined in a national market. Jackson and Eisenbeis find that MMDAs, super NOW accounts, and 6-month CDs are all cointegrated with the 6-month Treasury bill rate and, therefore, are all determined in the same national market.

Cointegration analysis, however, is not well-suited to test the hypothesis that banks compete for deposits in a national market because it can detect only the common long-run trend of the series. In the short run, the deposit interest rates banks pay in a local market could deviate substantially from the 6-month Treasury bill rate, thus suggesting they do not compete in the same market. The two series could still be cointegrated (follow a common long-run trend), though.

Are Banks with Offices in the Local Market Area the Relevant Competitors? Would the measure of concentration in a local market area be substantially different if it were adjusted for the financial services provided by firms that do *not* have offices in the market area? Cyrnak (1998) investigates this issue using data from the reports required of large banking organizations under the Community Reinvestment Act (CRA). He finds that the market concentration of loans to small businesses tends to be substantially lower if the relevant competitors include all banks that lend to small businesses in the local market area, whether the banks have offices in that local market area or not. The effect on concentration ratios of including the out-of-market lenders is especially pronounced for rural banking markets. Woosley, King, and Padhi (2000) extend Cyrnak's work by identifying those rural banking markets where including out-of-market CRA data would cause market concentration to fall below the DOJ's HHI guidelines. These studies raise questions about whether it is appropriate to limit the relevant competitors in antitrust analysis to the banks with offices located in local market areas.

Cyrnak and Hannan (1999) investigate whether the concept of a cluster of banking services is relevant for the pricing of bank loans for small businesses. In addition, they investigate whether the

relevant competitors for antitrust analysis are banks with offices located in the local market area. Their measure of bank performance is the interest rate on loans to small businesses, derived from the Survey of the Terms of Lending to Business. About 300 banks report information on each of their business loans originated during one week each quarter.

The authors develop three measures of market concentration:

1. HHI based on the deposits of banks with offices in the market area.
2. HHI based on small business loans by banks with offices in the market area.
3. HHI based on CRA data and an estimate of the amount of small business loans made by small banks with offices in each market area.

The authors find that the HHI measure based on the deposits of banks with offices located in the market area has more power to explain the interest rates charged on small business loans than do the other concentration measures. They conclude that their results support the current approach to banking antitrust, which is based on the HHI calculated for the deposits of banks with offices in each local market area.

Hannan (2003) uses CRA reports to examine the magnitude of loans that relatively large banking organizations made to small businesses located in market areas where the lenders do not have offices. Including lenders with large credit-card business (because small businesses might view credit cards as a substitute for bank loans), there was a large increase in the *number* of small business loans made by out-of-market lenders between 1996 and 2001. The effect of these lenders on the supply of loans to small businesses is much smaller when measured in terms of dollars of lending; it is even smaller if the known credit-card lenders are eliminated as out-of-market lenders. These observations indicate that considerable numbers of small loans from a few large banking organizations with substantial credit-card operations dominate the measures of out-of-market lending that we can derive from CRA data; that is, much of the out-of-market lending is credit-card related.

Hannan also finds that the share of small business loans from out-of-market banks tends to be higher in markets with a relatively high concentration of deposits at in-market banks. He concludes that his results are consistent with an erosion in the validity of the assumption that banking markets are local geographic areas; he argues, however, that it is not clear at this time whether the erosion would justify a substantial broadening of defined geographic markets for antitrust analysis.

Relevance of Money Market Mutual Funds for Banking Antitrust Analysis. Pilloff (1999c) investigates the degree to which shares of retail money market mutual funds (MMMFs) are substitutes for federally insured accounts at depository institutions. This issue has implications for banking antitrust because, if shares of MMMFs are close substitutes for deposit accounts, then depository institutions with offices in highly concentrated market areas would be less able to extract monopoly profits by paying relatively low interest rates on deposit accounts. Pilloff emphasizes three points in his argument why, for most households, MMMFs are not close substitutes for accounts at depository institutions. First, MMMFs require minimum initial investments that tend to be higher than the minimum initial deposit balances depository institutions require. Second, although MMMFs permit customers to write checks against their shares, the minimum check amounts usually exceed the amount of many routine household payments. Third, MMMFs are not federally insured like accounts at depository institutions, which adds a certain degree of risk.

Pilloff also uses survey data to support his argument that MMMFs are not close substitutes for deposit accounts. According to the survey, only 5.7 percent of households in 1995 owned shares of MMMFs, and almost all of these households also had accounts at depository institutions. Thus, even the small minority of households that held liquid assets with MMMFs did not find it in their interest to close all of their accounts at depository institutions.

Uniform Pricing by Banks with Offices in Many Communities. Another assumption of banking antitrust is that banks set each office's interest rates—those charged on loans and those paid on deposits—according to the concentration in the market area where the office is located. Radecki (1998, 2000), however, finds that banks with offices in several communities within a state offer the same interest rate at each office for a particular loan or deposit category. His data are from the *Bank Rate Monitor*, which reports the interest rates posted by the individual offices of a large number of banks located in many urban areas. Radecki therefore concludes that the geographic area for banking markets in antitrust analysis should be no smaller than a state.

Several staff of the Board of Governors have conducted a number of studies that focus on the implications of Radecki's findings for banking antitrust. For example, Heitfield (1999), using data from the *Bank Rate Monitor*, also finds that banks with offices located in several local market areas (multi-market banks) tend to post the same interest rate on the same type of deposit at each office. Heitfeld extends this analysis by examining the interest rates posted by banks that have all of their offices in one local market area (single-market banks). He finds significant variation across local markets in the interest rates that single-market banks offer on various categories of deposits; he reasons that this variation reflects local market conditions. He does not present results for interest rates on the loan categories in the *Bank Rate Monitor* survey that Radecki includes in his studies. Heitfeld concludes that the results of his study support the current practice of focusing on local market areas in banking antitrust.

Heitfield and Prager (2002) investigate whether the relevant geographic market areas for banking antitrust have expanded beyond the traditional local market areas of MSAs for urban banks and counties for rural banks. They use call report data to estimate the average interest rate each bank paid on NOW accounts, MMDAs, and savings accounts in 1988, 1992, 1996, and 1999. For each category of deposits, the authors regress the bank's interest rate on, among other independent variables, measures of concentration at the local and state levels. They find that the coefficients on the measures of local market concentration are negative and statistically significant in most equations and that the magnitude of the coefficients has not declined over time. In some of the equations, they also find that the coefficients on concentration at the state level are negative and significant. Heitfield and Prager conclude that, although measures of local market concentration remain useful indicators of the market power of banks, measures of market structure for broader geographic areas may be relevant for banking antitrust, too.

Hannan and Prager (2003) investigate whether concentration in local market areas affects the deposit interest rates that single-market banks offer. They find that it does. The authors also find that the interest rates that single-market banks pay on deposits tend to be lower in local areas where multi-market banks account for a greater share of market deposits. Furthermore, the relationship between local market concentration and deposit interest rates offered by single-market banks becomes weaker as multi-market banks account for larger shares of deposits in those market areas where both have offices.

Tests of the Structure-Conduct-Performance Hypothesis

According to the SCP hypothesis, the ability of banks in a local market area to set relatively high interest rates on loans or low interest rates on deposits depends on the structure of the market. Such behavior is assumed to be more effective in market areas where concentration is relatively high. Hannan (1991b) examines the theoretical foundation for this SCP hypothesis in banking. Table 1 summarizes several features of studies that test hypotheses about the effects of local market structure on various measures of bank performance.

Effects of Local Market Concentration on Bank Profits. Banks that are more effective in affecting the interest rates they charge on loans and pay on deposits will tend to have higher profits. Some studies test the hypothesis that there is a positive association between the profit rates of banks and local market concentration.

Rhoades (1995) tests the hypothesis that measures of market structure in addition to HHI influence the profit rates of banks. In regressions with the average profit rate of banks in market areas as the dependent variable, the coefficient on HHI is positive and statistically significant. He finds, however, that other indicators of market structure, including the number of banking organizations with offices in the market area and measures of the inequality of banks' market shares in local areas, are also significant.

Moore (1998) investigates whether, in response to financial innovations and changes in regulations, the influence of local market structure on bank profits has tended to decline over time. In his analysis, the measure of performance is net income after taxes divided by total assets (return on assets, or ROA) of all banks in the market area. The measure of market structure is HHI. Moore finds that the statistical significance of HHI has declined over time for rural market areas. With the ROA of each market in the sample as the dependent variable, the coefficient on HHI was positive and statistically significant for rural areas in 1986 and 1987, but not in 1996 and 1997. In similar regressions for urban markets, the coefficient on HHI was not statistically significant for any of these four years. Moore concludes that,

Table 1

Tests of the Structure-Conduct-Performance Hypothesis for the Banking Industry

Authors	Measures of bank performance	Measures of markets structure	Sample	Consistent with current practice of bank antitrust?
Effects of market concentration on the profit rates of banks				
Rhoades (1995)	Mean ROA of the banks in each market	HHI and other measures of market structure	1,684 urban and rural markets, 1990-92	Yes
Moore (1998)	ROA of individual banks	HHI	Urban areas and rural counties, 1986, 1987, 1996, and 1997	No
Pilloff (1999c)	ROA of individual banks	HHI and measures of multi-market contact	6,233 banks, 1992-95	Yes[a]
Pilloff (1999b)	ROA of individual banks with all offices in the rural banking markets included in the study	HHI and the presence of large banking organizations in rural market areas	1,728 institutions with offices in 762 rural banking markets, 1995-96	Yes
Pilloff and Rhoades (2002)	Mean ROA of banks in each market	HHI	National sample of urban and rural markets, 1975-98	Yes
Akhigbe and McNulty (2003)	Profit efficiency relative to the banks on the efficient frontier	HHI	35,807 observations, 1990, 1992, 1994, and 1996	Yes
Berger (1995)	ROA and ROE	HHI	4,800 banks, 1980-89	No[b]
Frame and Kamerschen (1997)	ROA	Market share of each bank in the sample	Quarterly data for 208 banks with all offices in one rural county in Georgia, 1990:Q4–1994:Q4	Qualified yes[c]
Effects of market concentration on the interest rates that banks pay on deposits				
Berger and Hannan (1989)	The interest rates that banks paid on MMDAs, NOW accounts, and time deposits of various maturities, from the MSSDOA	CR3	Quarterly data for 470 banks in 195 local banking markets, September 1983–December 1985	Yes[d]
Calem and Carlino (1991)	Interest rates paid by banks on MMDAs and 3- and 6-month CDs, from the MSSDOA	CR3	466 banks in 105 urban banking markets, October 1983–November 1987	Yes

Table 1, cont'd

Authors	Measures of bank performance	Measures of markets structure	Sample	Consistent with current practice of bank antitrust?
Sharpe (1997)	Interest rates paid by banks on MMDAs and 6-month CDs, from the MSSDOA	HHI	Monthly data on interest rates for 222 banks located in 105 markets, October 1983–November 1987	Yes
Hannan (1997)	Interest rates paid by banks on NOW accounts, MMDAs, and 3-month CDs, from the MSSDOA	HHI, measures of market share inequality, and number of banks in the market	About 300 urban banks, November 1993	No: coefficients on HHI not statistically different from zero
Prager and Hannan (1998)	Interest rates paid by banks on NOW accounts, MMDAs, and 3-month CDs, from the MSSDOA	HHI	468 banks: 26 in markets with substantial mergers, 30 in markets with less-substantial mergers, 412 in markets not affected by mergers; interest rate data for October 1991–August 1994	Yes: declines in interest rates over the sample period were larger at the banks in market areas with substantial horizontal mergers, as defined in the DOJ guidelines
Heitfield and Prager (2002)	Interest rates paid by banks on NOW accounts, MMDAs, and savings accounts, derived from call reports	HHI and CR3	Most banks in the United States, 1988, 1992, 1996, and 1999	Qualified yes: measures of concentration statistically significant at both the local and state level
Hannan and Prager (2003)	Interest rates paid by single-market banks (those with most of their deposits from offices in one market) on NOW accounts, MMDAs, and savings accounts, derived from call reports	HHI	7,700 single-market banks in 1,925 urban and rural areas (1996) and 6,502 single-market banks in 1,806 banking markets (1999)	Yes, except the results are consistent with a declining influence over time in the effects of local market structure on deposit interest rates
Effects of market concentration on the responsiveness of deposit interest rates to changes in market rates				
Hannan and Berger (1991)	Interest rates paid by banks on MMDAs, from the MSSDOA	HHI	Monthly data on deposit interest rates paid by 398 banks in 132 banking areas, September 1983–December 1986	Yes

Table 1, cont'd

Authors	Measures of bank performance	Measures of markets structure	Sample	Consistent with current practice of bank antitrust?
Neumark and Sharpe (1992)	Interest rates paid by banks on MMDAs and 6-month CDs, from the MSSDOA	HHI	255 banks in 105 urban markets, interest rates on deposits, October 1983–November 1987	Yes
Hannan and Liang (1993)	Responsiveness to the yields on Treasury securities of the interest rates paid by banks on MMDAs and 2- and 3-year CDs, from the MSSDOA	CR3	About 300 banks, 1983-89	Yes
Khan, Pennacchi, and Sopranzetti (1999)	Interest rates paid by banks on MMDAs and CDs with maturities of 3, 6, and 12 months, from the MSSDOA	HHI	Over 600 banks, November 1983–May 1994	Yes: banks located in market areas with higher HHI are more likely to set their deposit interest rates as integers or quarter integers[e]
Effects of market concentration on the interest rates that banks charge on loans				
Cyrnak and Hannan (1999)	Interest rates charged by banks on small business loans ($100,000 or less) in the STLB	Three measures of HHI[f]	228 banks located in 98 urban areas that participated in the STLB in May 1996	Yes
Hannan (1991a)	Interest rates charged by banks on business loans, from the STLB	HHI	8,250 business loans by 260 urban banks, from reports in different interest rate environments, 1984, 1985, and 1986	Yes
Hannan and Liang (1995)	Interest rates charged by banks on business loans less than $100,000, from the STLB	HHI	Over 300 banks' small business loans, August 1989, May 1990, and May 1991	Qualified yes: equations with the best fit use HHI calculated with zero weight for thrift institutions

Table 1, cont'd

Authors	Measures of bank performance	Measures of markets structure	Sample	Consistent with current practice of bank antitrust?
Hannan (1997)	Interest rates charged by banks on small business loans (less than $100,000), from the STLB	HHI measures of market share inequality and number of banks in the market	Loans reported by sample of banks in November 1983: 511 unsecured loans and 2,059 secured loans	Qualified yes: HHI does not reflect the only relevant measure of market structure; the number of banks in the market also affects loan rates
Berger, Rosen, and Udell (2001)	Interest rates charged by banks on loans to small businesses under lines of credit in 1993[g]	HHI and the asset size of organizations with offices in the market areas	520 small businesses that obtained credit from their banks under lines of credit in 1993	Qualified yes[h]
Kahn, Pennacchi, and Sopranzetti (forthcoming)	Interest rates charged by banks on consumer and auto loans: data from the *Bank Rate Monitor*	HHI	Weekly surveys of interest rates quoted by large banks in 10 urban areas, 1989-97	Yes: interest rates on consumer loans are higher in market areas with higher HHI[i]

NOTE: ROA, annual net income after taxes divided by average annual assets; ROE, annual net income after taxes divided by the book value of equity; HHI, Herfindahl-Hirschman Index (see section "Current Method of Antitrust in the Banking Industry"); CR3, percentage of deposits at banking offices in a market area at the institutions ranked first through third in terms of deposits at offices in the market area; MMDA, money market deposit account: a short-term deposit account at a depository institution on which customers may write a limited number of checks; NOW account, a transactions account available to individuals and non-profit organizations on which depository institutions may pay interest; CD, abbreviation for certificate of deposit, which is an interest-earning deposit account with a fixed maturity date; MSSDOA, Monthly Survey of Selected Deposits and Other Accounts (see boxed insert); STLB, Survey of the Terms of Lending to Businesses (see boxed insert).

[a]Pilloff (1999c) also finds that the coefficient on the measure of multi-market contact is consistent with the linked oligopoly theory.

[b]A positive association between profit rates and market concentration disappeared when measures of X-efficiency were added as independent variables.

[c]The empirical results are consistent with the hypothesis that the banks in the sample exercised market power. The measure of market structure, however, is the market share of the sample bank, not a measure of market concentration. The only aspect of market share that is relevant under the current banking antitrust procedures for banking involves closer scrutiny for cases in which a merger creates a bank with a market share of 35 percent or higher.

[d]Although the published results use CR3 as the measure of market concentration, the results are qualitatively similar using HHI.

[e]The model developed by Kahn, Pennacchi, and Sopranzetti (1999) implies that banks in less competitive markets are more likely to use integers to set the interest rates they offer to pay on deposits.

[f]The three measures of HHI in Cyrnak and Hannan (1999) are based on (i) the deposits of banks with offices located in each market area, (ii) the small business loans of banks with offices in the market areas, and (iii) the second measure of HHI adjusted for business loans to residents of each market area by large banks that do not have offices in the market area.

[g]Berger, Rosen, and Udell (2001) derive interest rates on loans from the National Survey of Small Business Finances, 1993.

[h]Berger, Rosen, and Udell (2001) find a dimension of local market structure not considered in banking antitrust: the total assets of banks with offices in the market area.

[i]In Kahn, Pennacchi, and Sopranzetti (forthcoming), results of analysis of the effects of mergers on consumer interest rates and the dynamics of consumer interest rates in response to changes in market areas are also consistent with the assumptions of banking antitrust.

because market concentration no longer seems to have a significant effect on bank profits, local areas are no longer the relevant market areas for antitrust.

Pilloff (1999a) estimates a regression in which the dependent variable is the ROA of individual banks and the independent variables include market HHI and measures of multi-market contact among the banks with offices in the market. His finding that the coefficients on HHI are positive and statistically significant supports the current approach to banking antitrust. Pilloff also finds that the coefficients on measures of multi-market contact among the banks in each market area are positive and statistically significant, providing empirical support for the linked oligopoly theory—that is, when the same banks compete with each other in several different markets, they will tend to limit their rivalry for customers in each of the markets.

Pilloff (1999b) examines the determinants of ROA among small, rural banks that have all of their offices in local markets, which are identified as counties. Pilloff estimates the effects of market HHI and the presence of the offices of large banking organizations on the ROA of small banks. While Pilloff finds that the presence of offices of large banks in rural markets tends to increase the ROA of small banks (a sign of reduced competition), he also finds that the coefficient on HHI is insignificant. The insignificant coefficient on HHI may reflect the inclusion of another independent variable, a measure of market size that tends to be correlated with market concentration.

Pilloff and Rhoades (2002), using data for a large number of rural and urban banking markets for the years 1975 through 1998, test the hypothesis that banks located in market areas with higher concentration tend to have higher profit rates. The authors regress the mean ratio of net income to total assets for banks in market areas (the dependent variable) on HHI and other measures of market structure, including the number of banking firms with offices in the market areas (the independent variables). The authors find that the coefficients on HHI are consistently positive and statistically significant at the 1 percent level. Other measures of market structure, including number of firms, have significant coefficients in some years, but not in others.

Akhigbe and McNulty (2003) examine the association between bank profits and local market concentration using a technique that estimates the profit efficiency frontier for given levels of loans, deposits, and other determinants of bank profits. They estimate each bank's deviation from the profit-efficiency frontier as a function of various explanatory variables, including market concentration (HHI). They find that the banks located in market areas with higher HHI (more concentrated) tend to be closer to the profit frontier.

These six studies examine whether the data support the hypothesis of a static, contemporaneous association between bank profits and market concentration. Amel and Liang (1997), in contrast, examine the evidence of a dynamic relationship between bank profits and market structure. They report evidence that lagged profit rates of local banks tend to induce entry by additional banks, which, in turn, reduces that market's concentration. De novo entry, however, would likely not affect a market's concentration too much because de novo banks tend to control only a small share of a market's total deposits for many years. Amel and Liang's results are especially interesting because their data are for the years 1977 through 1988, a period when barriers to entry into banking markets were higher than they are now.

SCP Versus Efficiency. A problem with using the relationship between bank profit rates and market concentration as a way to test the validity of the SCP hypothesis is that an alternative hypothesis, the efficient-structure hypothesis, leads to the same relationship. Because of this similarity, a more-detailed description of the two hypotheses will help place the related empirical studies in their proper context. The SCP hypothesis takes local market concentration as given and considers, for example, the implications of that concentration for the ability of banks to effectively collude on the terms of the services they offer to their customers. According to the SCP hypothesis, banks located in more concentrated market areas should be able to detect local banks cheating on collusive agreements, and enforce penalties for such cheating, more effectively than banks located in less concentrated market areas. The observed outcome would be that markets with higher concentration have banks that earn higher profits.

The efficient-structure hypothesis, rather than taking market concentration as given, considers the economic factors that help explain variation in concentration across markets. To illustrate how economic factors could influence market concentration, assume initially that all market areas have equal demand for banking services and that each bank has the same cost structure. In addition, assume that each bank is small relative to the demand for banking services in each market area. Under these

assumptions, each market has the same number of identically sized banks and the economic profits at all banks are zero. That is, each bank's profit equals the return it would have earned had it invested its capital in a firm in an industry other than banking.

Now suppose that some of the banks in some markets discover ways to change their cost structures such that at each level of output their total costs are lower than those of the other banks. The low-cost banks can then reduce their prices slightly (presumably by not as much as costs fell) to increase their market shares and, consequently, earn higher profits than the high-cost banks. And since the low-cost banks will be larger than other banks, market concentration will be higher in the market areas where the low-cost (high-profit) banks are located. The observed outcome again would be that markets with higher concentration have banks that earn higher profits.[16]

This analysis illustrates why evidence of a positive association between bank profits and market concentration is consistent with both the SCP and efficient-structure hypotheses. The analysis also demonstrates why evidence of an association between the *prices* of bank services and market concentration would tend to provide more relevant tests of the SCP hypothesis than evidence of an association between bank profit rates and market concentration.

Berger (1995) investigated whether empirical evidence of an association between local market concentration and bank profits would provide support for the SCP hypothesis or the efficient-structure hypothesis. He found that the positive association between bank profit rates and market concentration disappeared when a measure of the cost efficiency of banks was added to the regressions as an independent variable, which is consistent with the efficient-structure hypothesis. Thus, his empirical results do not support the current approach to banking antitrust. Berger emphasized that each of the equations in his study explains little of the variation in bank profit rates, with median R^2 across equations below 0.1, a finding similar to that in Pilloff and Rhoades (2002) and Pilloff (1999a).

Frame and Kamerschen (1997), following Berger (1995), included a sample of banks that operated in an environment with relatively high legal barriers to entry: banks with all of their offices located in rural Georgia counties during a period of the 1990s when these banks were protected from intrastate branching. In their profit equation, the measure of cost efficiency is not statistically significant, while the measure of market structure is statistically significant with and without the cost efficiency measure as an independent variable. The sign of the coefficient on the market structure variable is consistent with the SCP hypothesis. The results in Berger (1995) and Frame and Kamerschen (1997) imply that the interpretation of a positive association between profit rates and market concentration may depend on the level of barriers to entry.

The studies examining the association between bank profit rates and market structure do not provide consistent support for the current approach to banking antitrust. Analysis of the association between the prices of bank services and market structure may yield more conclusive tests of the SCP hypothesis for the banking industry.

Effects of Local Market Concentration on Interest Rates Paid on Deposits. The SCP hypothesis implies that banks located in market areas with relatively high concentration will tend to pay relatively low interest rates on deposits. Most of the studies that examine the effect of banking market concentration on deposit interest rates use data from the "Monthly Survey of Selected Deposits and Other Account." The boxed insert describes this survey.

In a widely cited article, Berger and Hannan (1989) examine the effects of local market concentration on the interest rates banks paid on MMDAs between September 1983 and December 1985. They find that the coefficient on local market concentration is negative and statistically significant at the 1 percent level. The size of this coefficient indicates that if the concentration of the least concentrated market were increased to that of the most concentrated market, the interest rate banks in that market paid on MMDAs would decline by about 50 basis points. The results of most of the studies listed in the section of Table 1 on deposit interest rates are qualitatively similar to those of Berger and Hannan (1989).

Prager and Hannan (1998) investigate the effects of bank mergers on deposit interest rates. Table 1 describes their sample of banks and measures of deposit interest rates. Market interest rates declined over their sample period. Declines in deposit interest rates were larger at banks located in markets where

[16] See Carlton and Perloff (2000, Chap. 8) for a discussion of the literature on the SCP and efficient-structure hypotheses.

mergers created substantial increases in HHI, as identified in the DOJ's guidelines, than at banks located in other market areas. The results in Prager and Hannan (1998) are consistent with the assumptions that underlie the current approach to banking antitrust analysis.

Two studies, Heitfield and Prager (2002) and Hannan and Prager (2003), use recent call report data to derive estimates of the interest rates that banks paid on various short-term deposits. To derive these estimates, the authors divided each deposit category's quarterly interest expense by its average quarterly deposit balance, a method that is more appropriate for short-term deposits than for long-term deposits because data for long-term deposits reflect deposits made over various dates in the past. Both studies find evidence to support the assumption that deposit interest rates tend to be lower in market areas with higher market concentration. Heitfield and Prager (2002) also find evidence that banks in states with higher state-level banking concentration rates tend to pay lower deposit interest rates. Hannan and Prager (2003) find evidence that industry consolidation through nationwide branch banking is weakening the influence of local market concentration on deposit interest rates.

Effects of Local Market Concentration on the Responsiveness of Deposit Interest Rates to Changes in Market Rates. The studies discussed in this section examine the influence of local market concentration on the dynamics of the interest rates that banks pay on deposits. This section discusses some of the details of each study because they have unique features. Table 1 presents additional information about these studies.

Hannan and Berger (1991) develop a theoretical framework to illustrate how local market concentration affects banks' deposit pricing in the face of changing market interest rates. In this model, banks in more concentrated markets exhibit more price rigidity than banks in less concentrated markets. The authors test the model empirically by estimating the probability that a bank, given its market's concentration, will adjust its deposit interest rate up, down, or not at all in response to a change in the market rate—in this case, the 3-month Treasury bill rate. They find that banks in more concentrated markets have a lower probability of increasing deposit rates when market rates rise. Market concentration has no effect on the probability of decreasing interest rates when market rates fall, however. In other words, banks in less competitive markets are less responsive to upward changes in Treasury bill rates than those in more competitive markets; but they are just as responsive to downward changes in Treasury bill rates. These results support the hypothesis that banks in a more concentrated market behave less competitively.

Neumark and Sharpe (1992) estimate the effects of market concentration on deposit interest rates with an asymmetric partial equilibrium model. The authors find that banks in markets with higher concentration paid lower equilibrium interest rates on MMDAs and 6-month CDs. Moreover, Neumark and Sharpe find that, when market interest rates changed, MMDA rates at banks in more concentrated markets tended to go up slower and down faster than at banks in less concentrated markets. Market concentration affected rates on 6-month CDs similarly, but not as strongly. The difference between the MMDA and 6-month CD results may reflect a tendency for bank customers to shop in wider geographic areas for longer-term investments. It may also reflect greater reluctance for banks to raise interest rates on MMDAs than on CDs, since an increase in the interest rate a bank pays on MMDAs affects its interest expense on all MMDAs, whereas an increase in the interest rate it pays on CDs affects only its marginal CD accounts—newly contracted CDs and rollovers—because the interest rates paid on CDs issued in the past remain unchanged.

Hannan and Liang (1993) test the hypothesis that banks are price takers in the markets for MMDAs, 2-year CDs, and 3-year CDs. For each of the more than 300 banks in the sample, they estimate a time-series equation for each deposit category, using monthly data between October 1983 and May 1989. In each equation, the authors regress the interest rate paid by the bank on the yield on Treasury securities with comparable maturity. If the coefficients on the Treasury security yields are less than 1, Hannan and Liang can reject the hypothesis that banks are price takers. For MMDAs, the coefficient is significantly less than 1 for almost all of the banks in the sample. For 2- and 3-year CDs, the coefficient is significantly less than 1 for most of the banks. The mean coefficient for MMDAs is less than, and statistically different from, the mean coefficients for 2- and 3-year CDs. These results are consistent with the view that banks exercise market power in their local market areas. It also implies that bankers have greater ability to exercise market power when pricing MMDAs than when pricing time deposits with 2- or 3-year maturities.

In the next step in their analysis, Hannan and Liang investigate whether the degree of market concentration affects the size of the coefficients described above. They find that when MMDA interest rates are the dependent variable, the coefficients on market interest rates tend to be lower among banks located in market areas with higher concentration. For interest rates on 2- or 3-year CDs, there is not a statistically significant correlation between the coefficients on market interest rates and banking market concentration. These results imply that the banks operating in more concentrated local markets exercise greater market power when pricing MMDAs, but, because competition for CDs occurs on a broader geographic scale, local market concentration does not influence their rates. The results in Hannan and Liang (1993) are consistent with the assumptions that underlie banking antitrust.[17]

Kahn, Pennacchi, and Sopranzetti (1999), taking a different approach, develop a theory of how banks set the interest rates they pay on retail deposits (in denominations of less than $100,000) that is based on customers' limited ability to recall numbers when comparison shopping. Because customers are assumed to recall only a limited number of digits, banks tend to quote deposit interest rates either in whole integers, such as 3 percent or 4 percent, or at a limited number of points between whole integers. The authors find empirical support for their theory. Deposit interest rates were more likely to remain unchanged after changes in wholesale market interest rates if banks had initially set the deposit rates at whole integers. In addition, banks in local markets with higher concentration were less likely to respond to changes in wholesale market interest rates and more likely to set deposit interest rates at integers or quarter-integers. The results of the articles cited in this section are consistent with the assumptions that underlie banking antitrust.

Effects of Local Market Concentration on Interest Rates Charged on Bank Loans. The SCP hypothesis implies that banks in market areas with higher concentration will tend to charge higher interest rates on loans.[18] An important challenge in estimating the effect of market concentration on loan rates involves holding constant lending risk and the effects of other loan terms. Although the studies discussed in this section attempt to do this, their estimates may still be biased because of imperfect adjustments for risk and loan terms.

One study on this issue, Cyrnak and Hannan (1999), is discussed above. Hannan (1991a) derives empirical tests for two of the assumptions of banking antitrust: first, markets are local; second, performance is influenced by market concentration. He tests the hypothesis that markets are local by estimating two equations. In one equation, the interest rates on business loans are determined in a national market; in a second equation, the interest rates on business loans are assumed to vary among metropolitan areas. The equation that incorporates local effects has more explanatory power for business loans than the equation that is based on a national market. Hannan also finds a positive association between the interest rates that banks charge on relatively small business loans and the concentration of deposits in the local banking market areas. Thus, he finds empirical evidence to support the two banking antitrust assumptions.

The objective of Hannan and Liang (1995) is to investigate the weight that deposits at thrift institutions should receive when calculating measures of market concentration. The dependent variable is the interest rate on business loans. Independent variables include market HHI, calculated under various assumptions about the weights assigned to deposits at thrifts; other measures of market structure; and other variables that reflect characteristics of the loans, the lending banks, and the market areas where the banks have their offices. In the regressions with zero weights for thrift institutions, the coefficients on HHI are positive and statistically significant. Assigning positive weights to thrift deposits when calculating market HHI makes the fit of the regression equations worse. These results do not support inclusion of thrift institutions in the HHI calculation for purposes of banking antitrust. Because routine antitrust analyses focus on deposits and not loans to small businesses, however, this empirical test does not necessarily rule out a positive weight for thrift deposits in those routine analyses.

Hannan (1997) uses interest rate data on individual business loans as the measure of bank performance. As independent variables, he uses HHI and other measures of market structure, along with other variables that reflect the characteristics

[17] Jackson (1997) discusses reasons why the relationship between market concentration and price rigidity may be nonlinear and presents evidence of such a nonlinear relationship for banking markets.

[18] In a theoretical model that incorporates asymmetric information about borrowers' likelihood of repaying a loan, Shaffer (2002) examines the relationship between the interest rates on bank loans and market concentration. He finds that there are conditions under which the SCP hypothesis is valid even if the empirical results indicate no association between measures of interest rates on loans and measures of market structure.

of the loans, lending banks, and market areas where the banks have offices. The regression coefficients on HHI are positive and statistically significant. The coefficients on the number of banking organizations in the market are negative and statistically significant. These results are consistent with giving greater weight to the number of banking organizations in market areas in banking antitrust analyses.

Berger, Rosen, and Udell (2001) expand on the conventional methods of examining how interest rates on loans to small businesses are determined by including a measure of the size structure of the market in their analysis. The size structure of the market represents the distribution of the banks with offices in the local area by the size of their total assets in all market areas. The authors posit that large regional or national banking organizations may compete differently from small, local institutions and that banks' competitive strategies may depend on the sizes of banks in a local market. Berger, Rosen, and Udell find several results to support their suppositions: First, small businesses pay lower interest rates when large banks dominate a market; second, size structure primarily affects the prices at large banks; and, third, size structure is statistically significant only in the markets in which small banks control relatively large shares of market deposits. These findings show that market size structure is important to bank pricing behavior and that banks compete less aggressively in markets dominated by small banks. One implication of this study, which supports the current approach to banking antitrust, is that local market areas are still relevant for bank behavior. Another implication, however, is that market size structure may also be relevant for antitrust analysis, a facet of markets not considered in current banking antitrust procedures.

Kahn, Pennacchi, and Sopranzetti (forthcoming) examine the association between banking market concentration and interest rates on consumer and auto loans. They find that local banking market structure does not affect auto loan rates. One explanation for this result is that interest rates on car loans are now predominantly determined by financing available through the auto manufacturers. The results are different for the interest rates on consumer loans. These interest rates tend to be higher at banks in more concentrated market areas. Moreover, interest rates on consumer loans tend to respond asymmetrically to changes in market interest rates. Banks increase consumer loan rates in tandem with market rates as they rise, but they reduce consumer loan rates more slowly than market rates as they fall. This asymmetric response is more pronounced for banks in more highly concentrated markets.

The results from studies cited in this section are consistent with some of the assumptions that underlie banking antitrust: Markets for banking services are local and local banks are the relevant competitors. Results in Hannan (1997), however, indicate that the number of banking organizations with offices in a market area should also receive some weight in antitrust analysis. Berger, Rosen, and Udell (2001) indicate that, in addition to local market concentration, the size structure of local market areas may affect the degree of competition among banks in those markets.

Monopoly Profits and the "Quiet Life." If relatively high market concentration facilitates collusion among banks, then banks located in more highly concentrated markets should face less pressure to minimize their operating costs. Such an inverse relationship between cost efficiency and market concentration is a version of the "quiet life" hypothesis, which is based on a statement by John Hicks that "the best of all monopoly profits is a quiet life" (Hicks, 1935, p. 8). Analysis of the quiet life hypothesis has a long history in the literature on banking antitrust (Rhoades and Rutz, 1982; and Edwards and Heggestad, 1973). Berger and Hannan (1998) test the hypothesis using data from the 1980s and find evidence that banks in more highly concentrated markets exhibit poorer cost efficiency than do other banks, all else equal. In fact, the authors show that if the concentration level in the most concentrated market were reduced to the minimum level observed in their sample, operating costs at banks in that market would be expected to decline between 8 percent and 32 percent. In addition, they conclude that the size of the additional operating cost due to market concentration (efficiency loss) is several times larger than the size of the additional revenues due to noncompetitive pricing of banking services (welfare loss).

Bergstresser (2001a) tests another version of the quiet life hypothesis: Banks with greater market power tend to assume less risk than other banks. He tests this version of the hypothesis by examining the association between the percentage of bank loans in a high-risk category (construction and land development loans) and local market concentration. The data are derived from bank call reports for the years 1980 through 1994. Bergstresser finds

that banks located in market areas with higher concentration tend to have lower shares of construction and land development loans in their loan portfolios. These results are consistent with the current approach to banking antitrust.

Other Evidence Relevant for Banking Antitrust

Effects of Local Banking Concentration on the Decision To Join a Credit Union. Emmons and Schmid (2000) examine how local banking market concentration influences the decisions of residents to join credit unions. They measure credit union participation as the percentage of potential members who actually choose to become members. They find a positive association between this measure of credit union participation in the current period and the lagged value of concentration in the banking markets where the credit unions are located. Their results can be interpreted as evidence that banks in areas of relatively high concentration offer their banking services at relatively unattractive terms, such as high interest rates on loans, low interest rates on deposits, or poor service. In response, a relatively high percentage of eligible households in these areas join credit unions.

Effects of Competition from Credit Unions for the Pricing of Bank Services. Three recent studies find that credit unions influence the interest rates that banks charge on loans and pay on deposits. Tokle and Tokle (2000), using interest rate data on small-denomination deposit accounts gathered from telephone surveys of banks in Idaho and Montana, estimate the effect local credit unions have on deposit interest rates at local banks. Their results indicate that the share of market deposits at credit unions has positive effects on deposit interest rates at local banks. Feinberg (2001), using *Bank Rate Monitor* data, finds that the share of market deposits at credit unions has a negative and statistically significant effect on new car loan rates at local banks. Hannan (2002), also using *Bank Rate Monitor* data, finds that various measures of credit union market penetration have positive and statistically significant effects on the interest rates that banks pay for deposits. The results of these three studies provide empirical support for the current practice of defining markets as local. The results raise questions, however, about the current practice of rarely including credit union deposits in local market concentration calculations.

Effects of Market Concentration on Economic Growth. Collender and Shaffer (2003) examine how various measures of local banking market structure, including market HHI, affect local economic growth. They measure economic growth as the change in per capita personal income at the county level for rural counties and at the MSA level for urban counties. They find that economic growth is slower in urban markets with higher concentrations of deposits. In contrast, they find that local market concentration has no effect on economic growth in rural areas.

Demonstrating that a bank merger would lead to slower economic growth in the local market is not necessary to establish a violation of antitrust standards. That said, the results in Collender and Shaffer have implications for the delineation of banking market areas in antitrust analysis: Had financial innovations and regulatory changes made local markets irrelevant for antitrust analysis, the authors would not have found any association between local economic growth and measures of local banking structure.

Local Market Concentration and Credit Availability to Borrowers without Credit Histories. Petersen and Rajan (1995), starting from the assumption that lenders have less information about new firms than about more established firms, develop a theory of the supply of bank credit to new firms. In this theory, Petersen and Rajan posit that credit availability to new firms depends on the degree of bank competition in local market areas. Banks located in areas with relatively limited competition know that, if they lend to new firms and the firms are successful, they are likely to keep these firms as customers in the future. In other words, banks that face limited competition view loans to new firms as risky investments that may yield long-term profits if the new firms survive. Banks located in areas with more intense competition, on the other hand, know that competitors eventually will bid away any long-term profits that banks might expect to gain from relationships with new firms that are successful. These banks, then, do not have reason to view risky loans to new firms as potentially yielding long-term profits.

Petersen and Rajan use data from the 1987 National Survey of Small Business Finances to develop an empirical test for their theory of credit availability to new firms. The following quotation presents the conclusions of their study:

> Young firms in concentrated markets receive more institutional finance than do similar firms in competitive markets. As firms get old, the difference in the relative firms borrowing from institutions disappears. Young firms who get institutional loans are more indebted in concentrated markets than in competitive markets, but this pattern reverses for older firms. Creditors seem to smooth interest rates over the life cycle of the firm in a concentrated market, charging a lower-than-competitive one when the firm is young and a higher-than-competitive rate when the firm is old. (p. 439)

Petersen and Rajan's results are consistent with the view that local market areas are relevant for banking antitrust.[19]

Bergstresser (2001b) applies the Petersen and Rajan (1995) framework to consumer lending. He posits that consumers without credit histories located in more concentrated banking markets should face fewer constraints when obtaining credit than similar consumers located in less concentrated markets. This theory, similar to that for new firms, is based on the idea that, in less competitive (more concentrated) areas, banks view loans to consumers with no credit histories as risky investments that are likely to yield long-run profits if these consumers pay their debts. In the more competitive (less concentrated) markets, borrowing constraints are higher for consumers without credit histories because, once these customers have established credit histories, competing banks will bid interest rates on their loans down to the competitive level.

To test this theory, Bergstresser estimates two equations using data from the 1983 Survey of Consumer Finances, which is the last of these surveys for which the MSA of each respondent is publicly available. In each equation, the observations are for individual households. In the first equation, the dependent variable is a dummy variable with a value of 1 if the household reports that it received less credit from banks than it requested, zero otherwise. One of the independent variables is the HHI of the MSA where the household resides. In various specifications, the coefficients on HHI are negative and statistically significant. That is, living in an area with relatively high banking concentration reduced the odds that consumers reported receiving less credit than requested.

In Bergstresser's second equation, the dependent variable is the interest rate that the household paid on a bank loan. Independent variables include the age of the head of the household and other control variables. This equation is estimated separately for households in areas with HHI above and below a threshold for relatively high concentration. In areas of high and low concentration, interest rates tend to decline with age, but the decline is smaller in the high concentration markets than in the low concentration markets. The difference in the rates of decline because of age between these two equations is statistically significant. The empirical results for both equations are consistent with the theory developed by Petersen and Rajan (1995). The results in Bergstresser (2001b) are consistent with the view that local market areas are relevant for banking antitrust.

The relevance of the Petersen and Rajan (1995) and Bergstresser (2001b) studies for banking antitrust analysis is limited, however, because both studies use data from the 1980s. Financial innovation and the relaxation of branching restrictions may have reduced the ability of banks in markets with relatively high concentration to derive long-term economic profits from relationships with new firms or with households without credit histories. Evanoff and Fortier (1988) emphasize that branching restrictions alter the nature of the relationship between local market concentration and bank performance.

Zarutskie (2003) extends the analysis of bank market structure and the availability of credit to new businesses into the 1990s by using income tax data for small U.S. corporations for the years 1987 through 1998. She finds that local banking market structure affects the likelihood a new firm will borrow from banks in a manner consistent with Petersen and Rajan's (1995) theory: In more concentrated markets, young firms are more likely to borrow from banks than from owners' savings. She also finds, though, that the effects of local market structure are weaker after 1995, the period when nationwide banking was permitted under federal legislation.

[19] The discussion of the following studies focuses on those that test the Petersen and Rajan (1995) theory empirically by using local market areas in the United States as the relevant market areas. Several other studies, some using international rather than just U.S. data, have also tested this theory, including Cetorelli and Gambera (2001) and Beck, Demirgüç-Kunt, and Maksimovic (forthcoming). Cetorelli (2003) uses data for regions in the United States, and Bonaccorsi and Dell'Aricca (forthcoming) use data for local market areas in Italy.

CONCLUSIONS

Antitrust analysis of bank mergers and acquisitions is based on assumptions about the geographic scope of banking markets, the nature of the product or products sold in banking markets, and the relevant competitors within the market areas. The market areas for banking services are assumed to be local: generally, metropolitan areas for cases involving banks in urban areas and counties for cases involving banks in rural areas. The relevant product is a cluster of financial services demanded from commercial banks, rather than individual financial services, such as various types of deposit accounts or types of loans. The relevant competitors are banks and thrifts with offices located in the same market area.

The studies surveyed in this article provide evidence that is consistent with some of the assumptions that underlie banking antitrust. The findings of these studies are consistent with the view that the relevant market areas for banking antitrust are local communities. In addition, the studies continue to yield evidence that banks located in market areas with relatively low concentration tend to offer their financial services at terms that reflect greater competition.

Several of the surveyed studies also provide evidence that is *not* consistent with the current practice of banking antitrust. One such study presents evidence that concentration at both the local and state levels affects the pricing of banking services. A study based on recent data indicates that banking consolidation is diminishing the effect of local market concentration on deposit interest rates. Other studies find evidence that local market concentration is not the only measure of market structure that affects the pricing of banking services. The sizes of the organizations with offices in local areas affect the pricing of banking services, and the degree to which these institutions compete with each other in other markets affects bank profits. In addition, evidence that large banks are lending to small businesses located in areas where the banks do not have offices raises questions about the assumption that local banks are the relevant competitors in banking antitrust analysis. Finally, several studies find evidence that the presence of credit unions in market areas affects how banks price financial services. This evidence brings into question the current practice of rarely including credit union deposits in market concentration calculations.

In conclusion, many of the studies written or published in recent years have found evidence supporting a number of the assumptions that underlie banking antitrust. The studies also show, however, that the effects of financial innovations and changes in bank regulation are starting to call into question some of the current practices in banking antitrust analysis.

REFERENCES

Akhigbe, Aigbe and McNulty, James E. "The Profit Efficiency of Small U.S. Commercial Banks." *Journal of Banking and Finance*, February 2003, *27*(2), pp. 307-25.

Amel, Dean F. and Liang, J. Nellie. "Determinants of Entry and Profits in Local Banking Markets." *Review of Industrial Organization*, February 1997, *12*(1), pp. 59-78.

_____ and Starr-McCluer, Martha. "Market Definition in Banking: Recent Evidence." *Antitrust Bulletin*, Spring 2002, *47*(1), pp. 63-89.

Austin, Douglas V. and Bernard, Craig D. "The Competitive Analysis in the Banking Industry No Longer Reflects Reality." Proceedings of the 37th Annual Conference on Bank Structure and Competition, *The Financial Safety Net: Costs, Benefits, and Implications for Regulation*, Federal Reserve Bank of Chicago, May 2001, pp. 624-47.

Beck, Thorsten; Demirgüç-Kunt, Asli and Maksimovic, Vojislav. "Bank Competition and Access to Finance." *Journal of Money, Credit, and Banking* (forthcoming).

Berger, Allen N. "The Profit-Structure Relationship in Banking—Tests of Market-Power and Efficient-Structure Hypotheses." *Journal of Money, Credit, and Banking*, May 1995, *27*(2), pp. 404-31.

_____ and Hannan, Timothy H. "The Price-Concentration Relationship in Banking."*Review of Economics and Statistics*, May 1989, *71*(2), pp. 291-99.

_____ and _____. "The Efficiency Cost of Market Power in the Banking Industry: A Test of the 'Quite Life' and Related Hypotheses." *Review of Economics and Statistics*, August 1998, *80*(3), pp. 454-65.

_____; Rosen, Richard J. and Udell, Gregory F. "The Effect of Market Size Structure on Competition: The Case of Small Business Lending." Working Paper 2001-10, Federal Reserve Bank of Chicago, October 2001.

Bergstresser, Daniel. "Market Concentration and Loan

Portfolios in Commercial Banking." Unpublished manuscript, MIT Department of Economics, November 2001a.

_____. "Banking Market Concentration and Consumer Credit Constraints: Evidence from the Survey of Consumer Finances." Unpublished manuscript, MIT Department of Economics, November 2001b.

Bonaccorsi Di Patti, Emila and Dell'Aricca, Giovanni. "Bank Competition and Firm Creation." *Journal of Money, Credit, and Banking* (forthcoming).

Calem, Paul S. and Carlino, Gerald A."The Concentration/Conduct Relationship in Bank Deposit Markets." *Review of Economics and Statistics*, May 1991, *73*(2), pp. 268-76.

Carlton, Dennis W. and Perloff, Jeffrey M. *Modern Industrial Organization*. Third Edition. Reading, MA: Addison Wesley Longman, 2000.

Cetorelli, Nicola. "Life-Cycle Dynamics in Industrial Sectors: The Role of Banking Market Structure." Federal Reserve Bank of St. Louis *Review*, July/August 2003, *85*(4), pp. 135-48.

_____ and Gambera, Michele. "Banking Market Structure, Financial Dependence and Growth: International Evidence from Industry Data." *Journal of Finance*, April 2001, *56*(2), pp. 617-48.

Collender, Robert N. and Shaffer, Sherrill. "Local Bank Office Ownership, Deposit Control, Market Structure, and Economic Growth." *Journal of Banking and Finance*, January 2003, *27*(1), pp. 27-57.

Cyrnak, Anthony W. "Bank Merger Policy and the New CRA Data." *Federal Reserve Bulletin*, September 1998, *84*(9), pp. 703-15.

_____ and Hannan, Timothy H. "Is the Cluster Still Valid in Defining Banking Markets? Evidence from a New Data Source." *Antitrust Bulletin*, Summer 1999, *44*(2), pp. 313-31.

DeYoung, Robert; Hunter, William C. and Udell, Gregory F. "The Past, Present and Probable Future for Community Banks." Presented at the conference *Whither the Community Bank?* Federal Reserve Bank of Chicago, 13-14 March 2003.

Edwards, Franklin R. and Heggestad, Arnold A. "Uncertainty, Market Structure, and Performance in Banking: the Galbraith-Caves Hypothesis and Managerial Motives in Banking."*Quarterly Journal of Economics*, August 1973, *87*(3), pp. 455-73.

Emmons, William R. and Schmid, Frank A. "Bank Competition and Concentration: Do Credit Unions Matter?" Federal Reserve Bank of St. Louis *Review*, May/June 2000, *82*(3), pp. 29-42.

Evanoff, Douglas D. and Fortier, Diana L. "Reevaluation of the Structure-Conduct-Performance Paradigm in Banking." *Journal of Financial Services Research*, June 1988, *1*(3), pp. 277-94.

Feinberg, Robert M. "The Competitive Role of Credit Unions in Small Financial Services Markets." *Review of Economics and Statistics*, August 2001, *83*(3), pp. 560-63.

Frame, W. Scott and Kamerschen, David R. "The Profit-Structure Relationship in Legally Protected Banking Markets Using Efficiency Measures." *Review of Industrial Organization*, February 1997, *12*(1), pp. 9-22.

Gilbert, R. Alton. "Bank Market Structure and Competition: A Survey." *Journal of Money, Credit, and Banking*, November 1984, *16*(4, part 2), pp. 617-45.

Hannan, Timothy H. "Bank Commercial Loan Markets and the Role of Market Structure: Evidence from Surveys of Commercial Lending." *Journal of Banking and Finance*, February 1991a, *15*(1), pp. 133-49.

_____. "Foundations of the Structure-Conduct-Performance Paradigm in Banking." *Journal of Money, Credit, and Banking*, February 1991b, *23*(1), pp. 68-84.

_____. "Market Share Inequality, the Number of Competitors, and the HHI: An Examination of Bank Pricing." *Review of Industrial Organization*, February 1997, *12*(1), pp. 23-35.

_____. "The Impact of Credit Unions on the Rates Offered for Retail Deposits by Banks and Thrift Institutions." Finance and Economics Discussion Series 2003-6, Board of Governors of the Federal Reserve System, 10 September 2002.

_____. "Changes in Non-Local Lending to Small Businesses." Unpublished manuscript, Board of Governors of the Federal Reserve System, 10 January 2003.

_____ and Berger, Allen N. "The Rigidity of Prices: Evidence from the Banking Industry." *American Economic Review*, September 1991, *81*(4) pp. 938-45.

_____ and Liang, J. Nellie. "Inferring Market Power from Time-Series Data: The Case of the Banking Firm." *International Journal of Industrial Organization*, June 1993, *11*(2), pp. 205-18.

_____ and _____. "The Influence of Thrift Competition on Bank Business Loan Rates." *Journal of Financial Services Research*, June 1995, *9*(2), pp. 107-22.

_____ and Prager, Robin A. "The Competitive Implications of Multimarket Bank Branching." Unpublished manuscript, Board of Governors of the Federal Reserve System, 27 January 2003.

Heitfield, Erik A. "What Do Interest Rate Data Say about the Geography of Retail Banking Markets?" *Antitrust Bulletin*, Summer 1999, *44*(2), pp. 333-47.

_____ and Prager, Robin A. "The Geographic Scope of Retail Deposit Markets." Finance and Economics Discussion Series 2002-49, Board of Governors of the Federal Reserve System, 13 August 2002.

Hicks, John R. "Annual Survey of Economic Theory: The Theory of Monopoly." *Econometrica*, January 1935, *3*(1), pp. 1-20.

Holder, Christopher L. "The Use of Mitigating Factors in Bank Mergers and Acquisitions: A Decade of Antitrust at the Fed." Federal Reserve Bank of Atlanta *Economic Review*, March/April 1993, *78*(2), pp. 32-44.

Jackson, William E. III. "Is the Market Well Defined in Bank Merger and Acquisition Analysis?" *Review of Economics and Statistics*, November 1992, *74*(4), pp. 655-61.

_____. "Market Structure and the Speed of Price Adjustments: Evidence of Non-Monotonicity." *Review of Industrial Organization*, February 1997, *12*(1), pp. 37-57.

_____ and Eisenbeis, Robert A. "Geographic Integration of Bank Deposit Markets and Restrictions on Interstate Banking: A Cointegration Approach." *Journal of Economics and Business*, July/August 1997, *49*(4), pp. 335-46.

Kahn, Charles M.; Pennacchi, George G. and Sopranzetti, Ben J. "Bank Deposit Rate Clustering: Theory and Empirical Evidence." *Journal of Finance*, December 1999, *54*(6), pp. 2185-214.

_____; _____ and _____. "Bank Consolidation and the Dynamics of Consumer Loan Interest Rates." *Journal of Business* (forthcoming).

Kwast, Myron L.; Starr-McCluer, Martha and Wolken, John D. "Market Definition and the Analysis of Antitrust in Banking." *Antitrust Bulletin*, Winter 1997, *42*(4), pp. 973-95.

Moore, Robert R. "Concentration, Technology, and Market Power in Banking: Is Distance Dead?" Federal Reserve Bank of Dallas *Financial Industry Studies*, December 1998, pp. 1-10.

Neumark, David and Sharpe, Steven A. "Market Structure and the Nature of Price Rigidity: Evidence from the Market for Consumer Deposits." *Quarterly Journal of Economics*, May 1992, *107*(2), pp. 657-80.

Petersen, Mitchell A. and Rajan, Raghuram G. "The Effect of Credit Market Competition on Lending Relationships." *Quarterly Journal of Economics*, May 1995, *110*(2), pp. 407-43.

_____ and _____. "Does Distance Still Matter? The Information Revolution in Small Business Lending." *Journal of Finance*, December 2002, *57*(6), pp. 2533-70.

Pilloff, Steven J. "Multimarket Contact in Banking." *Review of Industrial Organization*, March 1999a, *14*(2), pp. 163-82.

_____. "Does the Presence of Big Banks Influence Competition in Local Markets?" *Journal of Financial Services Research*, May 1999b, *15*(3), pp. 159-77.

_____. "Money Market Mutual Funds: Are They a Close Substitute for Accounts in Insured Depository Institutions?" *Antitrust Bulletin*, Summer 1999c, *44*(2), pp. 365-85.

_____. "What's Happened at Divested Bank Offices? An Empirical Analysis of Divestitures in Bank Mergers?" Finance and Economics Discussion Series 2002-60, Board of Governors of the Federal Reserve System, December 2002.

_____ and Rhoades, Stephen A. "Structure and Profitability in Banking Markets." *Review of Industrial Organization*, February 2002, *20*(1), pp. 81-98.

Prager, Robin A. and Hannan, Timothy H. "Do Substantial Horizontal Mergers Generate Significant Price Effects?

Evidence from the Banking Industry." *Journal of Industrial Economics*, December 1998, *46*(4), pp. 433-52.

Radecki, Lawrence J. "The Expanding Geographic Reach of Retail Banking Markets." Federal Reserve Bank of New York *Economic Policy Review*, June 1998, *4*(2), pp. 15-34.

_____. "Competition in Shifting Product and Geographic Markets." *Antitrust Bulletin*, Fall 2000, *45*(3), pp. 571-613.

Rhoades, Stephen A. "Structure-Performance Studies in Banking: An Updated Summary and Evaluation." *Federal Reserve Bulletin*, August 1982, *68*(8), pp. 477-78.

_____. "Market Share Inequality, the HHI, and Other Measures of the Firm-Composition of a Market." *Review of Industrial Organization*, December 1995, *10*(6), pp. 657-74.

_____. "Competition and Bank Mergers: Directions for Analysis from Available Evidence." *Antitrust Bulletin*, Summer 1996, *41*(2), pp. 339-64.

_____ and Rutz, Roger D. "Market Power and Firm Risk: A Test of the 'Quiet Life' Hypothesis." *Journal of Monetary Economics*, January 1982, *9*(1), pp. 73-85.

Santomero, Anthony M. "Bank Mergers: What's a Policymaker To Do?" *Journal of Banking and Finance*, February 1999, *23*(2-4), pp. 637-43.

Shaffer, Sherrill. "Competitive Bank Pricing and Adverse Selection, with Implications for Testing the SCP Hypothesis." *Quarterly Review of Economics and Finance*, Summer 2002, *42*(3), pp. 633-47.

Sharpe, Steven A. "The Effect of Consumer Switching Costs on Prices: A Theory and Its Application to the Bank Deposit Market." *Review of Industrial Organization*, February 1997, *12*(1), pp. 79-94.

Shull, Bernard. "The Origins of Antitrust in Banking: An Historical Perspective." *Antitrust Bulletin*, Summer 1996, *41*(2), pp. 255-88.

_____ and Hanweck, Gerald A. *Bank Mergers in a Deregulated Environment: Promise and Peril*. Westport, CT: Quorum Books, 2001.

Simons, Katerina and Stavins, Joanna. "Has Antitrust Policy in Banking Become Obsolete?" Federal Reserve Bank of Boston *New England Economic Review*, March/April 1998, pp. 13-26.

Tokle, Robert J. and Tokle, Joanne G. "The Influence of Credit Union and Savings and Loan Competition on Bank Deposit Rates in Idaho and Montana." *Review of Industrial Organization*, December 2000, *17*(4), pp. 427-39.

Webb, Robert L. "Divestiture: A Prescription for Healthy Competition." Federal Reserve Bank of St. Louis *Regional Economist*, January 2001, pp. 10-11.

Weiss, Leonard W. "A Review of Concentration-Price Studies in Banking," in Leonard W. Weiss, ed., *Concentration and Price*. Cambridge, MA: MIT Press, 1989, pp. 219-54.

Wolken, John D. and Rohde, Douglas. "Changes in the Location of Small Businesses' Financial Service Suppliers between 1993 and 1998." Unpublished manuscript, Board of Governors of the Federal Reserve System, 28 January 2002.

Woosley, Lynn W.; King, B. Frank and Padhi, Michael S. "Is Commercial Banking a Distinct Line of Commerce?" Federal Reserve Bank of Atlanta *Economic Review*, Fourth Quarter 2000, *85*(4), pp. 39-58.

Zarutskie, Rebecca. "Does Bank Competition Affect How Much Firms Can Borrow? New Evidence from the U.S." Presented at the 39th Annual Conference on Bank Structure and Competition: *Corporate Governance: Implications for Financial Services Firms*, Federal Reserve Bank of Chicago, May 2003.

The Use of Long-Run Restrictions for the Identification of Technology Shocks

Neville R. Francis, Michael T. Owyang, and Athena T. Theodorou

In many economic models, business cycles are driven by some combination of monetary, fiscal, and technological innovations, where "technology" is often thought of as the unexplainable component of the business cycle that is manifested as a change in the overall productive capacity of the economy. Recently, a growing empirical literature has undertaken the challenge of defining technology shocks and their effects on the economy in structural statistical models.

In this paper, we survey the recent literature on long-run identified technology shocks. We present the results of a bivariate vector autoregression (VAR) with labor productivity and labor hours as a benchmark for the recent results found for technology shocks. We then propose an alternative approach for identifying and studying the effects of technology shocks.

We propose a reverse approach to that used in the structural VAR literature, the motivation of which is to provide a robustness check of the recent results from the existing literature. Our new methodology entails four basic steps. We first estimate the reduced-form VAR, saving the coefficient and the error variance-covariance matrices. Given the estimated reduced-form coefficient and covariance matrices, the second step is to constrain the impulse response for labor productivity. Specifically, we restrict the sign of the impulse response for productivity such that technology shocks have long-lasting positive effects on productivity. The third step is to collect all the shocks that can generate this long-horizon response of productivity—we call these disturbances potential technology shocks. The final step is to examine the response of labor hours to these shocks. Contrary to standard real business cycle (RBC) theory, recent studies in this literature have found that labor hours respond negatively to a positive technology shock. We test the robustness of this result.

Neville R. Francis is an assistant professor of economics at Lehigh University; Michael T. Owyang is an economist and Athena T. Theodorou is a research associate at the Federal Reserve Bank of St. Louis. The authors thank Valerie Ramey and Tara Sinclair for valuable comments. Kristie Engemann and Mark L. Opitz provided research assistance.

The remainder of the paper is organized as follows: We define the properties of the VAR-based technology shock and review the current empirical findings in the second section. In the third section, we examine a standard application of long-run restrictions used to identify technology shocks and present our (bivariate) benchmark results from this exercise. In the fourth section, we employ an alternative form of a long-run restriction that is adapted from the agnostic algorithm originally proposed by Uhlig (1999).

EMPIRICAL TECHNOLOGY SHOCKS: A SURVEY

The traditional view in macroeconomics was that economic fluctuations arose from transitory shocks, e.g., temporary shocks to monetary and fiscal policy. Secular trends were believed not to contribute to quarter-to-quarter or even year-to-year fluctuations in macroeconomic data. In a very influential paper, King et al. (1991) empirically examined the effects of shifts in stochastic trends common to several macroeconomic series. They presented an economic model with a single common stochastic trend, interpreted as a permanent shock to productivity, that altered the steady state of the model economy. This stochastic trend, the unit root in productivity, is now widely referred to as a "technology shock"; currently, the challenge for macroeconomists is how to more accurately identify this measure of technology shocks.

The growth accounting approach proposed by Solow (1957) has been widely used to identify technology shocks. Under the assumption of competitive markets and constant returns to scale in production, total factor productivity (or the Solow residual) is that part of output that is left unexplained after accounting for the contributions of capital and labor. A typical growth accounting equation would be of the form:

$$\log(Y_t) = \gamma\log(L_t) + (1-\gamma)\log(K_t) + \log(A_t),$$

where Y_t is period-t output; K_t and L_t are period-t capital and labor, respectively; γ is the labor share of output; and A_t is the so-called Solow residual.

Innovations to the Solow residual were thought of as shocks to technology.[1] However, there are three potential shortcomings with the use of the Solow residual as a proxy for technology shocks. First, growth accounting does not incorporate either workers' effort or capital utilization. Thus, embedded in the residual A_t are these confounding measures that have nothing to do with technology shocks. Second, the probability of technological regress using the Solow residual is of the order of 40 percent, which is implausible to some economists. It is not apparent that the structural VAR (SVAR) method overcomes this criticism, implying that it is nearly equally likely to have technological regress as progress. Third, the measure failed what are now referred to as the Hall (1988) and Evans (1992) tests. These studies found that the Solow residual is correlated with other exogenous shocks—such as shocks to money, interest rates, and government spending—that are not related to technology.[2]

These shortcomings led economists either to seek to improve upon the Solow residual or search for an alternative measure of technology shocks. Basu, Fernald, and Kimball (1998) sought to improve upon the Solow residual by incorporating unobserved factor inputs into their estimations. They followed Hall (1990) and regressed the growth rate of output on the growth rate of inputs at a disaggregated level with proxies for capacity utilization. Technological change is then defined as an appropriately weighted sum of the resulting residuals. They found that technological improvements contradict RBC theory predictions about the (technology-driven) co-movement of labor hours and productivity across the business cycle; specifically, hours fall, at least in the short run, when hit with a productivity-improving technology shock.

The search for an alternative measure of technology shocks has proceeded along two lines. The first line of research concerns the assumption(s) used to identify technology shocks. The second line involves the choice of data used to identify technology shocks and asks: Are technology shocks either (i) a manifestation of the unexplained component of labor productivity or output or (ii) the culmination of research and development?

Proceeding along the first line of research, Gali (1999) attempted to disentangle technology and non-technology shocks by analyzing labor productivity and hours of employment. He estimated a SVAR with the key identifying assumption that technology shocks alone can produce long-run effects on labor productivity.[3] Gali estimated a bivariate model of productivity and hours.[4] He found that hours fell in response to a shock that permanently raised labor productivity (the technology shock). Gali thus concluded that technology shocks were not the driving force behind cyclical fluctuations and that his "non-technology" shocks better explained the short-run movements in aggregate economic data. Kiley (1998) followed Gali and applied a similar methodology to 17 two-digit manufacturing industries. He found that, for a majority of these industries, technology shocks identified by these SVARs produced the same negative hours response as found for the aggregate data.

Francis and Ramey (2002) used Gali as a starting point in their recent analysis of technology shocks. Using the SVAR approach, they reexamined Gali's work by first testing whether the shocks identified in this framework can be plausibly interpreted as technology shocks. They first derived additional long-run restrictions and used them as overidentifying tests. For example, they estimated a model of real wages and hours with the assumption that only technology shocks can have permanent effects on real wages. If this assumption is true, then real wages and productivity should share a common trend, an assumption not rejected by the data.[5] Next, they augmented Gali's basic model with data on real wages, investment, and consumption and determined whether the impulse responses for these variables accorded with theory. Finally, they tested whether their technology shocks were Granger-caused by exogenous events unrelated to technology as per Hall (1988) and Evans (1992). Their measure of technology survived the scrutiny of all three tests.

[1] This view is not the consensus of the growth accounting literature. For example, Denison (1979) views productivity as a measure of society's ability to increase standards of living.

[2] King and Rebelo (1999) provide a comprehensive survey of the RBC literature. In particular they highlight the features of the RBC model, e.g., indivisible labor and capital utilization, that generate business-cycle-like second moments while correcting for the failures of the Solow residual.

[3] In a bivariate framework, the employed identification is equivalent to a Wold causal chain structure in the long run.

[4] Gali (1999) also estimates a five-variable model that includes money, inflation, and interest rates. Results from this model are consistent with the bivariate framework.

[5] The first-order condition states that workers are each paid their marginal product. Therefore, it stands to reason that the same assumption for the effect of technology shocks on labor productivity must also hold for technology shocks on real wages.

However, they still found that labor hours responded negatively on impact to a technology shock.[6]

Shea (1999) proceeded along the second line of research. He used data on both patents and research and development to identify technology shocks and found that hours fell in response to a technology shock. However, unlike the above studies, the decline in hours is a long-run response—that is, hours rise in the short run but then eventually fall.

In sum, using different methodologies to identify technology shocks, these recent lines of research have produced similar results. Further, the identified technology shock is unable to explain a substantial proportion of the variation in hours across the business cycle. Our contribution will be to add a fourth methodology that provides a robustness check of the SVAR results.

IMPLEMENTING LONG-RUN RESTRICTIONS

In this section, we present a bivariate long-run restricted SVAR model of productivity and hours as a benchmark to the technology literature. Essentially, this section reproduces the bivariate results described in Gali (1999) and Francis and Ramey (2002).

Data

The data are quarterly and cover the period 1948:Q1 to 2000:Q4. The labor productivity series is from the Bureau of Labor Statistics (BLS) "Index of output per hour, business," while the labor hours series is from the BLS "Index of hours in business." We tested and failed to reject unit roots for both labor productivity and hours; therefore, in our benchmark VAR specification, we enter these series in first differences. Productivity and labor are also not cointegrated. We use four lags of the dependent variables in each equation of the VAR. The lag length was chosen by means of the Schwarz or Bayesian information criterion (BIC).

Econometric Framework

The recent methodology of choice in the technology shock literature is the SVAR, a standard reduced-form VAR with additional restrictions that are drawn from theory to separate and identify the components of the residuals. These restrictions can be short run (often comprising short-run restrictions or the impact effects of shocks) or long run. A discussion of long-run restrictions follows.

Consider the following k-lag VAR:

$$\Phi(L)Y_t = \varepsilon_t,$$

where

$$Y_t = \begin{bmatrix} \Delta x_t \\ \Delta n_t \end{bmatrix},$$

$$\varepsilon_t = \begin{bmatrix} \varepsilon_t^x \\ \varepsilon_t^n \end{bmatrix},$$

and $\Phi(L)$ is a kth-order matrix polynomial in the lag operator. The VAR can be rewritten in its moving average (MA) representation:

$$Y_t = C(L)\varepsilon_t, \tag{1}$$

where $C(L)$ is a (infinite) polynomial matrix in the lag operator $\Phi(L) = C(L)^{-1}$. The series x_t denotes the log of labor productivity, and n_t denotes the log of labor hours. We label ε_t^x the technology shock and ε_t^n the non-technology shock, and we make the usual assumption that these shocks are orthogonal and serially uncorrelated.

For ease of exposition, it is useful to rewrite (1) as

$$Y_t = \begin{bmatrix} C_{11}(L) & C_{12}(L) \\ C_{21}(L) & C_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_t^x \\ \varepsilon_t^n \end{bmatrix}. \tag{2}$$

We impose long-run restrictions to identify the technology shock, ε_t^x. Each of the matrices in (2) is a polynomial in the lag operator. To achieve exact identification, we restrict the non-technology shock's long-run impact on productivity to be zero. This assumption identifying the technology shock implies that $C_{12}(1) = 0$, which restricts the unit root in productivity to originate solely from the technology shock.[7] The identifying restrictions do not restrict the effect the technology shock can have on hours at either the long or short horizon.[8]

We estimate the model using the method pro-

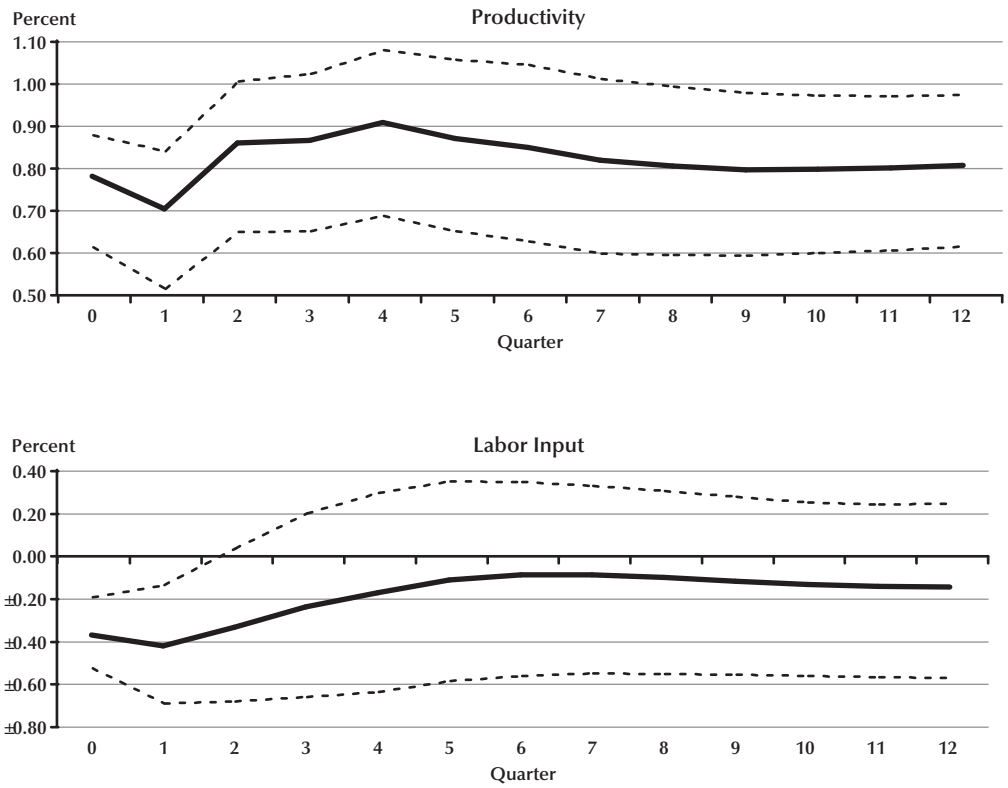
[6] Christiano, Eichenbaum, and Vigfusson (2003) and Uhlig (2002) challenge the results of the aforementioned literature. They claim that hours entered in levels would overturn the negative short-run hours response when a technology shock hits the economy. However, Francis and Ramey (2003), in another unpublished manuscript, show that hours, properly detrended, experiences a decline on impact of a technology shock.

[7] In principle, the model presented above could be augmented to measure the effects of shocks on other variables (see Gali, 1999, and Francis and Ramey, 2002). The identification scheme here assumes that any other shock, regardless of the size of the system, has no long-run effect on labor productivity.

[8] It can be shown that the identification scheme explained in this section is equivalent to a Wold causal chain on the steady-state structure of the model (see Rasche, 2001).

Figure 1

Impulse Responses to a Technology Shock
(95% Bootstrapped Standard Error Bands)



posed by Shapiro and Watson (1988). By using this method we can estimate the equations in the VAR one at a time. The productivity equation is as follows:

$$(3) \qquad \Delta x_t = \sum_{j=1}^{p} \alpha_{xx,j} \Delta x_{t-j} + \sum_{j=0}^{p-1} \beta_{xn,j} \Delta^2 n_{t-j} + \varepsilon_t^x ,$$

where Δ^2 is the square of the difference operator. Imposing the long-run restriction is equivalent to restricting the hours variable to enter the productivity equation (3) in double differences.[9] Because the current value of $\Delta^2 n_t$ will be correlated with ε_t^x, we estimate this equation using instrumental variables. We use lags 1 through p of Δx_t and Δn_t as instruments. The hours equation is then estimated as follows:

$$(4) \quad \Delta n_t = \sum_{j=1}^{p} \alpha_{nx,j} \Delta x_{t-j} + \sum_{j=1}^{p} \alpha_{nn,j} \Delta n_{t-j} + \rho_{n,x} \varepsilon_t^x + \varepsilon_t^n .$$

Technology, ε_t^x, enters into the hours equation (4) in order to achieve orthogonality between the technology and non-technology shocks. We estimate the hours equation using ordinary least squares, since there is no contemporaneous independent variable that would be correlated with the residual ε_t^n. The Shapiro-Watson methodology, applied to the same data, produces results identical to the matrix method used by Gali.[10] We present results from an illustrative two-variable system in the next subsection.

Benchmark Results

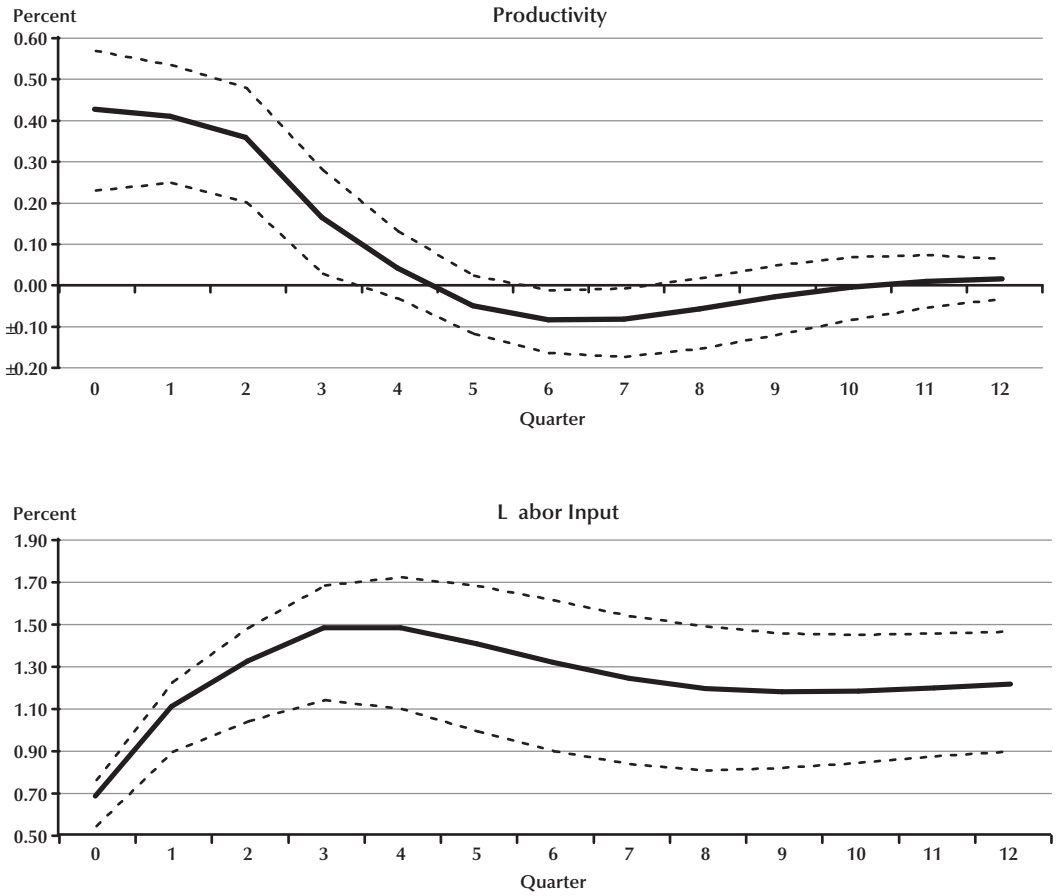
Figure 1 presents the impulse responses from a shock to technology in the bivariate model of labor

[9] Labor hours enters in double differences because we assume that labor hours has a unit root. If the labor hours series were stationary, then, to impose long-run restrictions, we would enter hours into the productivity equation in first differences.

[10] The interested reader is directed to Appendix A for a detailed derivation of the long-run restriction methodology. There, we demonstrate the equivalence between the matrix method and the Shapiro-Watson method of long-run identification.

Figure 2

Impulse Responses to a Non-Technology Shock
(95% Bootstrapped Standard Error Bands)



productivity and hours.[11] Labor productivity immediately rises by 0.8 percent, displays a hump-shaped pattern, and eventually settles to a new steady state approximately 0.8 percentage points above its pre-shock level. This persistent rise in productivity is at the heart of the identification, as only the technology shock can have this permanent positive effect.

The hours response is somewhat curious. On impact, labor hours experience a statistically significant decline in response to the technology shock; moreover, the point estimate for the response remains negative for the entire response period. However, according to the 95 percent bootstrapped confidence bands, the decline in labor hours is statistically significant for only two quarters; thereafter, it is insignificantly different from zero.

The responses of labor productivity and hours to a non-technology shock—the shock that, according to Gali (1999), coincides with cyclical fluctuations—are shown in Figure 2.[12] Labor productivity gradually rises for about one year, but eventually the effect of the non-technology shock on productivity disappears over time. On the other hand, the non-technology shock has a permanent impact on hours worked. Following the shock, hours worked increases for about one year, displaying a hump-shaped pattern, and eventually reaches a new steady state higher than its pre-shock level.

[11] Note that this is identical to Figure 1a in Francis and Ramey (2002).

[12] We refrain from attributing any structural interpretation to the non-technology shock. This shock can be thought of as a combination of a number of shocks that remain unidentified within our system.

IMPULSE RESPONSE RESTRICTIONS

In this section, we demonstrate how long-run restrictions can be implemented in a framework that leaves the structural parameters of the VAR unrestricted but, instead, imposes sign restrictions on the resulting impulse responses (see Uhlig, 1999).[13] We can, therefore, estimate the model without imposing the exact restrictions on the estimated parameters, as in the long-run identification schemes of Blanchard and Quah (1989) and Shapiro and Watson (1988). We search for shocks that produce impulse responses consistent with what we believe technology should produce, i.e., a long-run positive response to labor productivity. Our goal is to determine the robustness of the results found in the preceding section by determining the percentage of long-run effective shocks that produce an hours/productivity negative co-movement.

An additional advantage to this approach, which we leave to be exploited by further research, is that hypothetical responses can be posed. The resulting shocks required to induce those responses can be computed and used to perform counterfactual experiments. In this sense, we can work backward to test the validity of our assumptions about the effects of the shocks by performing, say, exogeneity tests.[14]

Framework

Here, we outline the methodology that incorporates restrictions on the signs of the impulse responses to identify the model. What we are doing, in essence, is defining how a type of shock should effect the economy and determining which shocks might generate those results. While, to the casual reader, this identification might seem to be constructed backward, it has theoretical foundations that are detailed in Appendix B.

Formally, the reaction to the reduced-form shock (e_t from Appendix B) cannot be interpreted in a structural context. However, it can be shown that the structural shock ε_t is related to the reduced-form shock by means of the contemporaneous impact matrix, A_0:

$$e_t = A_0^{-1}\varepsilon_t,$$

where $A_0^{-1}A_0^{-1'} = \Sigma$. Thus, the jth column of the matrix A_0^{-1} can be interpreted as the contemporaneous effect of the jth fundamental shock (which we will call an *impulse vector*). However, this decomposition is not unique; for any orthonormal matrix Q, $A_0^{-1}QQ'A_0^{-1'} = \Sigma$ is also a permissible decomposition. In the previous section, we distinguished between acceptable rotations by imposing restrictions on the form of the rotation matrix Q.

The identification technique we employ in this section involves sampling from the distributions for both the coefficient and covariance matrices that are estimated from the model's reduced form. We draw a candidate impulse vector and compute the impulse response; each impulse vector that generates an impulse response consistent with a predetermined set of sign restrictions is saved.[15] Iteration of this process generates a distribution for the impulse vectors we will call technology shocks.

While the methodology utilized in the previous section uniquely identified a (estimated) reduced-form shock, the technique in this section estimates a distribution for this shock. Exact identification using this technique requires a large number of restrictions, since the constraints on the impulse responses may not bind at all horizons. Thus, instead of imposing, for example, an explicit causal ordering, we are able to define the technology shock based on its ex post impulse response for certain variables. We concentrate on identification of the technology shock. In principle, other shocks that are effect-orthogonal, i.e., have sets of mutually exclusive restrictions, could also be identified.

A number of recent papers have employed this algorithm to impose sign restrictions on impulse responses. Uhlig (1999, 2001) and Owyang (2002) restrict the responses of both inflation and interest rates to identify a monetary shock. Mountford and Uhlig (2002) impose restrictions on revenues, expenditures, and deficits to identify fiscal shocks. However, these applications of the algorithm have centered primarily on the short-run responses to shocks. Here, we can adapt the algorithm to test for restrictions at long horizons. In this application, we constrain the long-run response of labor productivity to a technology shock to be positive.[16]

[13] Other ex post restrictions could also be employed. Examples of these include restricting the forecast error variances (Faust, 1998) or the cross-correlation (Canova and De Nicolo, 2002).

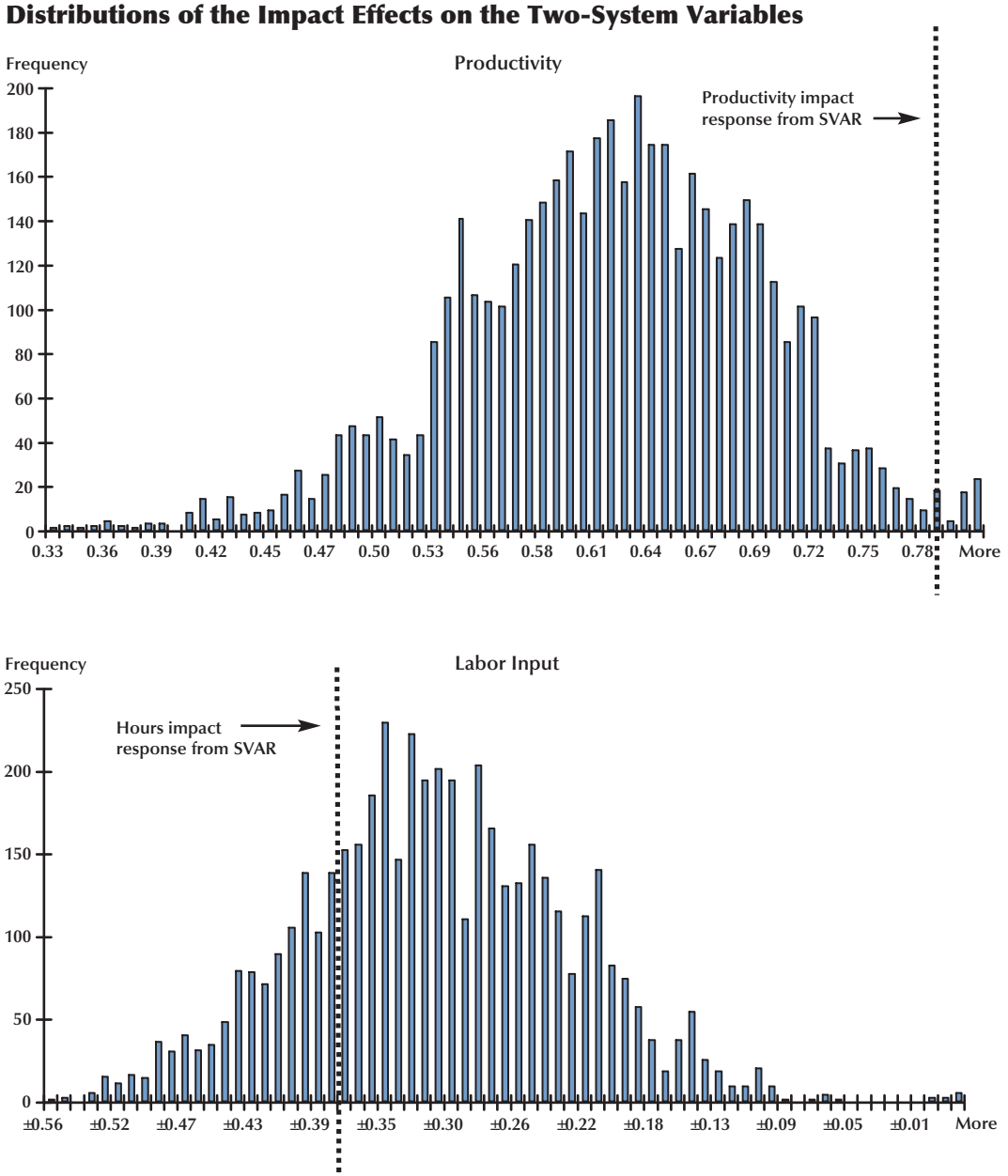
[14] An example of this line of research can be found in Francis and Owyang (2003).

[15] Mathematical details for the estimation and identification can be found in Appendix C. For an explicit discussion of the relationship between the impulse vector and the identified structural shock, see Uhlig (1999).

[16] In addition to long-horizon restrictions on the productivity response, we also impose impact restrictions. We assume that a positive technology shock raises productivity on impact.

Figure 3

Distributions of the Impact Effects on the Two-System Variables



Empirical Results

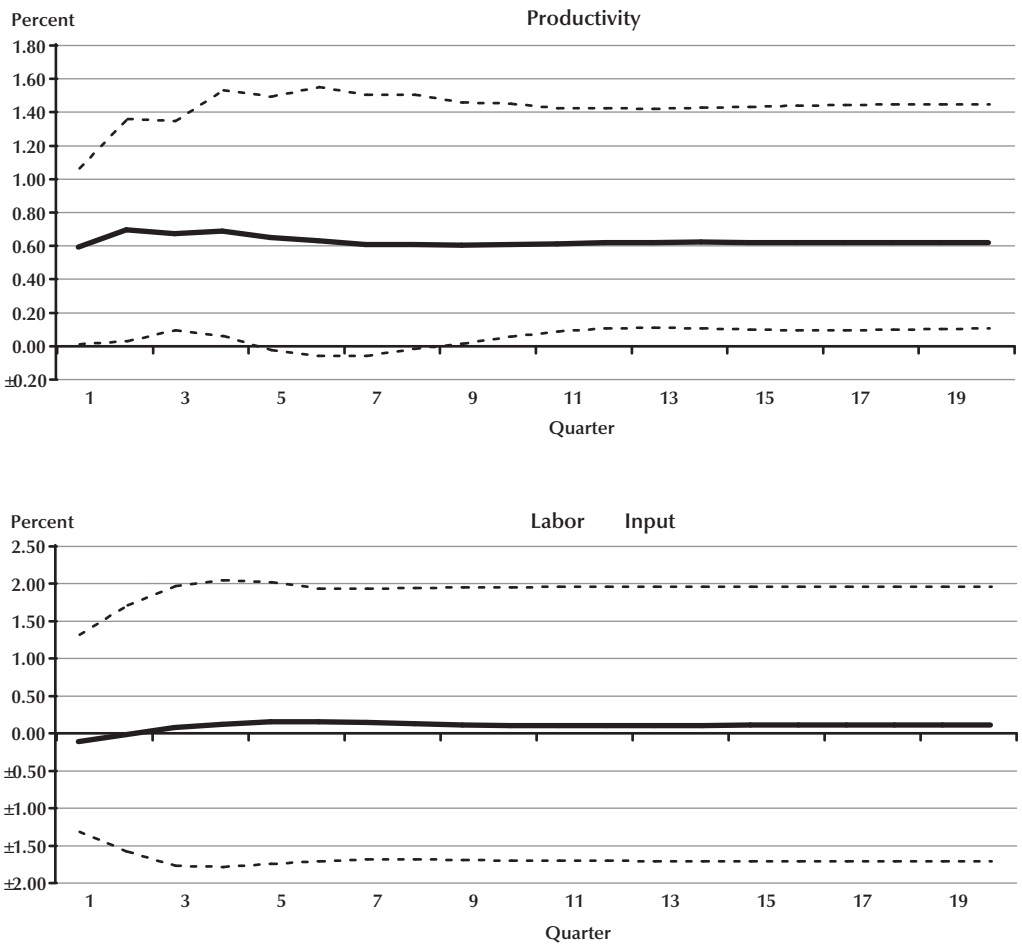
The system that we estimate is a VAR with prior distributions on the parameters that we describe in Appendix C. We make 1000 draws from the posterior distributions generated by estimating the VAR. For each draw from the parameter space, we draw 1000 candidate shocks.[17]

The distributions of the impact effects on the two-system variables are shown in Figure 3. We include the point estimates of the impact effects for the exactly identified shock from the previous section. Labor productivity's impact response from the SVAR lies to the right of the mean of the impact

[17] We forgo identification of the hours shock in this section. Identification of this shock can be achieved either through independent draws or by utilizing an orthogonality assumption to decompose the system residuals.

Figure 4

Impulse Responses for Sign-Restriction Algorithm for Labor Input in Differences
(60% Coverage Interval Shown)



distribution from the sign-restriction algorithm. That is, the initial productivity response from the SVAR is greater than the mean impact response obtained from the sign-restriction algorithm. However, the opposite is true for the hours response. That is, the hours response from the SVAR lies to the left of the mean of the impact distribution from the sign-restriction approach. Therefore, the sign-restriction algorithm produces initial hours responses that are invariably less negative (i.e., closer to zero) than the impact response obtained from the SVAR with long-run restrictions. In this sense the sign-restriction approach is less restrictive than the SVAR approach but nevertheless produces an initial hours response that is negative on average.[18]

The resulting mean impact effects of the identified technology shock are

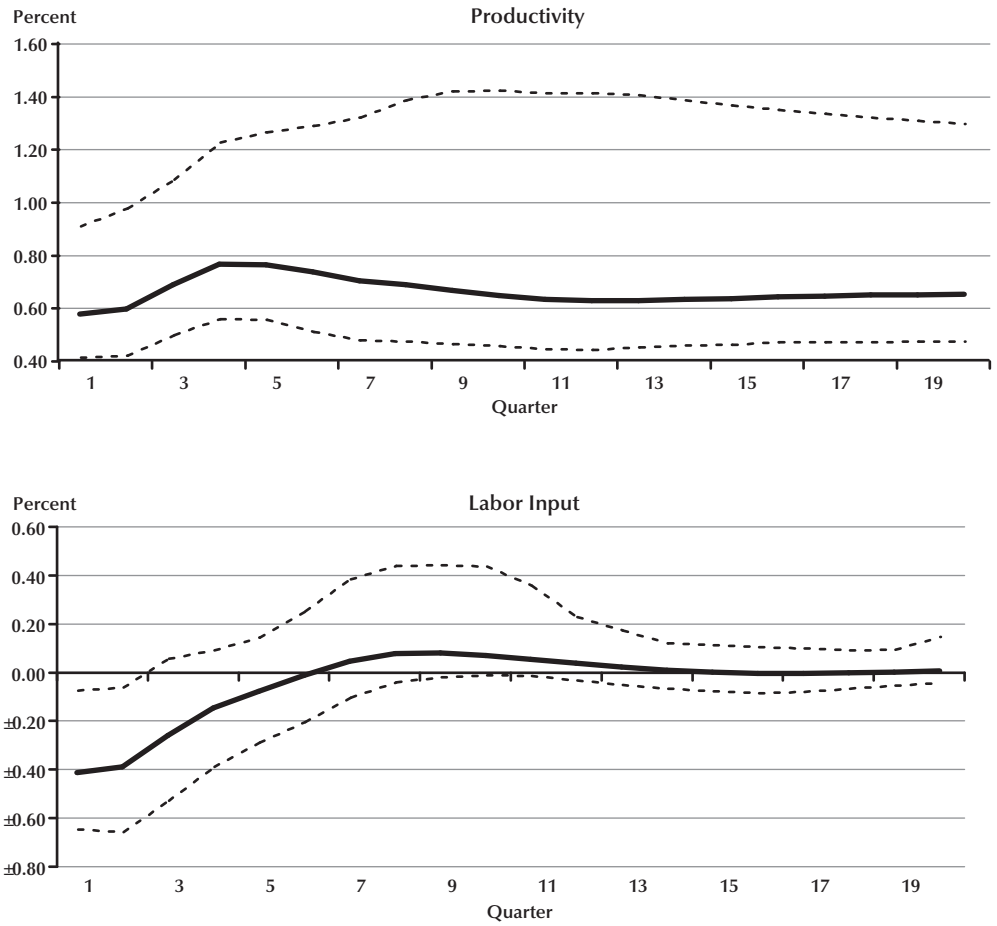
$$a = \begin{bmatrix} 0.62 \\ -0.31 \end{bmatrix},$$

(0.62 for labor productivity and –0.31 for labor hours), and the associated impulse responses are

[18] The same is true when the sign-restriction algorithm has hours entering the VAR in levels. This means that the SVAR with hours in levels does not impose enough restrictions to identify technology shocks. In these SVARs, non-technology shocks have long-lasting effects on productivity, contrary to the initial identifying assumption. Our algorithm with hours in levels imposes enough ex post restrictions to circumvent such problems and thus produces negative labor hours results just like its first-differenced counterpart. See Francis and Ramey (2003) for further exposition.

Figure 5

Impulse Responses for Sign-Restriction Algorithm for Labor Input in Differences with Long-Run Neutrality of Technology on Hours (60% Coverage Interval Shown)



illustrated in Figure 4.[19] For the long-horizon sign-restriction algorithm, we compute the responses out to 40 quarters. Consistent with the findings above, this estimation presupposes that labor hours possesses a unit root and is entered in differences. The productivity response to a technology shock is positive on impact and converges to a steady-state value of 0.6 percent approximately eight periods after the initial shock. The algorithm imposes a rise in labor productivity in the tenth year.[20] However, we note that the response to a technology shock for the majority of prior periods turns out to also be positive.

Next, note that the average labor hours response is negative on impact. In fact, in approximately 95 percent of the accepted draws, the candidate technology shock produces a negative response of hours on impact. However, on average, the decrease in hours is not permanent. Based on our findings using this impulse response–restricted algorithm, we cannot reject the hypothesis that a technology shock causes labor hours to fall on impact. This conclusion stems from our ability to draw a variety of candidate

[19] Figure 4 shows the mean response of the technology shock over the saved draws. In addition, we provide a coverage interval that shows the interior 60 percent of the distribution of effects. We do not provide standard error bands since the distributions for the impulse responses may be non-normal.

[20] In other words, we calculate the impulse responses for 40 periods and impose that the productivity response from the 37th to the 40th periods be positive.

shocks, which produce both long-run productivity responses and negative hours responses.[21]

Finally, note that the coverage intervals in Figure 4 are relatively large compared with the error bands associated with the SVAR in the preceding section. Recall that the technology shock produced by the impulse response–restricted algorithm is not exactly identified—that is, the algorithm identifies only a distribution for the candidate shocks. Exact identification requires further restrictions, and each additional (binding) restriction contributes to a narrowing in the coverage intervals. As an example of this, consider Figure 5. Here, we have identified the technology shock with the additional restriction that imposes long-run neutrality of technology on hours, i.e., the impulse response of hours to a technology shock is negligible at long horizons. In particular, notice that the coverage interval for the hours response is much narrower and that, in this case, a positive hours response on impact is even less likely to occur.

CONCLUSION

Economists have long assumed that one of the primary components of the business cycle is shocks to technology that produce long-run changes in labor productivity. In this article, we surveyed some recent papers that attempted to identify such shocks. We especially focused on papers using the SVAR approach, with its accompanying long-run restrictions, to identify technology shocks.

Recent results using the SVAR approach to identify technology shocks have shown that they induce a negative impact response of labor hours. Further, using a long-horizon impulse response–restricted system, we generated "technology" by assuming that it is the only shock with a long-horizon impact (say, out to ten years) on labor productivity. Technology shocks generated with this methodology invariably produce the (non-standard) negative labor hours impact result. That is, the probability of having a fall in hours is found to be greater than the probability of having a rise in hours for technology generated in this manner, regardless of whether the VAR is estimated with labor hours in levels or in first differences.

Future research could apply the impulse response–restricted technique in larger macroeconomic models instead of the bivariate model employed here. From this we could examine which technology shock, from labor hours in levels or in first differences, produces the more plausible impulses for variables such as consumption, investment, and real wages. Future research should also examine which measure of technology stands up to the scrutiny of the Hall-Evans tests as per Francis and Ramey (2002).

[21] We performed a similar analysis using labor hours in levels. We found that the hours response to a positive technology shock is still, on average, negative on impact.

REFERENCES

Basu, Susantu; Fernald, John and Kimball, Miles. "Are Technology Improvements Contractionary?" International Finance Discussion Papers 1998-625, Board of Governors of the Federal Reserve System, September 1998.

Blanchard, Olivier Jean and Quah, Danny. "The Dynamic Effects of Aggregate Demand and Supply Disturbances." *American Economic Review*, September 1989, *79*(4), pp. 655-73.

Canova, Fabio and De Nicolo, Gianni. "Monetary Disturbances Matter for Business Fluctuations in the G-7." *Journal of Monetary Economics*, September 2002, *49*(6), pp. 1131-59.

Christiano, Lawrence J.; Eichenbaum, Martin and Vigfusson, Robert. "What Happens After a Technology Shock?" NBER Working Paper No. 9819, National Bureau of Economic Research, July 2003.

Denison, Edward F. *Accounting for Slower Growth: The United States in the 1970s*. Washington, DC: The Brookings Institution, 1979.

Evans, Charles L. "Productivity Shocks and Real Business Cycles." *Journal of Monetary Economics*, April 1992, *29*(2), pp. 191-208.

Faust, Jon. "The Robustness of Identified VAR Conclusions About Money." *Carnegie-Rochester Conference Series on Public Policy*, December 1998, *49*(0), pp. 207-44.

Francis, Neville R. and Owyang, Michael T. "What Is a Technology Shock? A Bayesian Perspective." Unpublished manuscript, 2003.

_____ and Ramey, Valerie A. "Is the Technology-Driven Real Business Cycle Hypothesis Dead? Shocks and Aggregate Fluctuations Revisited." NBER Working Paper No. 8726, National Bureau of Economic Research, January 2002.

_____ and _____. "The Source of Historical

Economic Fluctuations: An Analysis Using Long-Run Restrictions." Unpublished manuscript, May 2003.

Gali, Jordi. "Technology, Employment, and the Business Cycle: Do Technology Shocks Explain Aggregate Fluctuations?" *American Economic Review*, March 1999, *89*(1), pp. 249-71.

Hall, Robert E. "The Relation Between Price and Marginal Cost in U.S. Industry." *Journal of Political Economy*, October 1988, *96*(5), pp. 921-47.

_____. "Invariance Properties of Solow's Residual," in Peter Diamond, ed., *Growth, Productivity, Unemployment*. Cambridge, MA: MIT Press, 1990.

Kiley, Michael T. "Labor Productivity in U.S. Manufacturing: Does Sectoral Comovement Reflect Technology Shocks?" Unpublished manuscript, 1998.

King, Robert G.; Plosser, Charles I.; Stock, James H. and Watson, Mark W. "Stochastic Trends and Economic Fluctuations." *American Economic Review*, September 1991, *81*(4), pp. 819-40.

_____ and Rebelo, Sergio T. "Resuscitating Real Business Cycles," in *Handbook of Macroeconomics*. Volume 1B. New York: Elsevier Science, North-Holland, 1999, pp. 927-1007.

Mountford, Andrew and Uhlig, Harald. "What Are the Effects of Fiscal Policy Shocks?" Discussion Paper 3338, Centre for Economic Policy Research, April 2002.

Owyang, Michael T. "Modeling Volcker as a Non-Absorbing State: Agnostic Identification of a Markov-Switching VAR." Working Paper 2002-018A, Federal Reserve Bank of St. Louis, 2002.

Rasche, Robert H. "Identification of Dynamic Economic Models from Reduced Form VECM Structures: An Application of Covariance Restrictions." Working Paper 2000-011B, Federal Reserve Bank of St. Louis, 2001.

Shapiro, Matthew D. and Watson, Mark W. "Sources of Business Cycle Fluctuations," in Stanley Fischer, ed., *NBER Macroeconomics Annual 1988*, Volume 3. Cambridge, MA: MIT Press, 1988, pp. 111-48.

Shea, John. "What Do Technology Shocks Do?" in Ben Bernanke and Julio Rotemberg, eds., *NBER Macroeconomics Annual 1998*. Volume 13. Cambridge, MA: MIT Press, 1999, pp. 275-310.

Solow, Robert M. "Technical Change and the Aggregate Production Function." *Review of Economics and Statistics*, August 1957, *39*, pp. 312-20.

Uhlig, Harald. "What Are the Effects of Monetary Policy on Output? Results from an Agnostic Identification Procedure." Research Discussion Paper 28, Tilburg University, Center for Economic Research, 1999.

_____. "Did the FED Surprise the Market in 2001? A Case Study for VARs with Sign Restrictions." Discussion Paper 88, Tilburg University, Center for Economic Research, 2001.

_____. "Do Productivity Shocks Lead to a Decline in Labor?" Unpublished manuscript, 2002.

Appendix A

Recall from (1) the MA representation of the VAR, reproduced here for convenience:

$$Y_t = C(L)\varepsilon_t,$$

where we have implicitly assumed that $C(L)$ is invertible, $C(L)^{-1} = \Phi(L)$, $\Phi(L)$ is the matrix polynomial in the lag operator, and the roots of $|\Phi(z)|$ are outside the unit circle. From the assumption that only technology can have long-run effects on productivity, $C(1)$ is lower triangular, which implies that $\Phi(1)$ is also lower triangular.[22]

The first equation of $\Phi(L)Y_t = \varepsilon_t$ then becomes

$$\text{(A.1.1)}\quad \Delta x_t = \sum_{j=1}^{p} \alpha_{xx,j}\Delta x_{t-j} + \sum_{j=0}^{p} \alpha_{xn,j}\Delta n_{t-j} + \varepsilon_t^x .$$

Since $\Phi(1)$ is lower triangular, the long-run multiplier on Δn_t is identically zero, so the coefficients of its lags sum to zero. (Note, we do not impose any short-run dynamics so the contemporaneous value of Δn_t appears in the productivity (Δx_t) equation.)

Imposing this constraint yields

$$\Delta x_t = \sum_{j=1}^{p} \alpha_{xx,j}\Delta x_{t-j} + \sum_{j=0}^{p-1} \beta_{xn,j}\Delta^2 n_{t-j} + \varepsilon_t^x .$$

The preceding equation is only a matter of algebra. The equivalence of the two methods is shown in the example below for a particular lag length.

Set $p = 4$.[23] Then, rewrite (A.1.1) as

(A.1.2)

$$\begin{aligned}\Delta x_t &= \alpha_{xx,1}\Delta x_{t-1} + \alpha_{xx,2}\Delta x_{t-2} + \alpha_{xx,3}\Delta x_{t-3} \\ &\quad + \alpha_{xx,4}\Delta x_{t-4} + \alpha_{xn,0}\Delta n_t + \alpha_{xn,1}\Delta n_{t-1} \\ &\quad + \alpha_{xn,2}\Delta n_{t-2} + \alpha_{xn,3}\Delta n_{t-3} + \alpha_{xn,4}\Delta n_{t-4} + \varepsilon_t^x .\end{aligned}$$

In this case, the long-run restriction $C_{12}^{(1)} = 0$ of lower triangularity implies

$$\text{(A.1.3)}\quad \alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2} + \alpha_{xn,3} + \alpha_{xn,4} = 0.$$

Thus, we have

$$\begin{aligned}\Delta x_t &= \sum_{j=1}^{4} \alpha_{xx,j}\,\Delta x_{t-j} + \alpha_{xn,0}\,\Delta n_t + \alpha_{xn,1}\,\Delta n_{t-1} \\ &\quad + \alpha_{xn,2}\,\Delta n_{t-2} + \alpha_{xn,3}\,\Delta n_{t-3} + \alpha_{xn,4}\,\Delta n_{t-4} \\ &= \sum_{j=1}^{4} \alpha_{xx,j}\,\Delta x_{t-j} + \alpha_{xn,0}\,[\Delta n_t - \Delta n_{t-1}] \\ &\quad + [\alpha_{xn,0} + \alpha_{xn,1}](\Delta n_{t-1} - \Delta n_{t-2}) \\ &\quad + [\alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2}](\Delta n_{t-2} - \Delta n_{t-3}) \\ &\quad + [\alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2} + \alpha_{xn,3}](\Delta n_{t-3} - \Delta n_{t-4}) \\ &\quad + [\alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2} + \alpha_{xn,3} + \alpha_{xn,4}]\,\Delta n_{t-4} .\end{aligned}$$

Restriction (A.1.3) implies that the coefficient on Δn_{t-4} is identically zero. Thus, we have

(A.1.4)

$$\begin{aligned}\Delta x_t &= \sum_{j=1}^{4} \alpha_{xx,j}\,\Delta x_{t-j} + \alpha_{xn,0}\,\Delta^2 n_t + \left(\alpha_{xn,0} + \alpha_{xn,1}\right)\Delta^2 n_{t-1} \\ &\quad + \left(\alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2}\right)\Delta^2 n_{t-2} \\ &\quad + \left(\alpha_{xn,0} + \alpha_{xn,1} + \alpha_{xn,2} + \alpha_{xn,3}\right)\Delta^2 n_{t-3} + \varepsilon_t^x .\end{aligned}$$

We rewrite this as

$$\text{(A.1.4}'\text{)}\quad \Delta x_t = \sum_{j=1}^{4} \alpha_{xx,j}\Delta x_{t-j} + \sum_{j=0}^{3} \beta_{xn,j}\Delta^2 n_{t-j} + \varepsilon_t^x ,$$

where the βs are functions of the αs. Note that equation (A.1.4′) here is identical to (3).

The hours equation (4) is straightforward. Note that we do not require the contemporaneous value of Δx_t in the hours equation since ε_t^x enters into equation (4) directly.

[22] We are essentially imposing that the system is a Wold causal chain structure in the steady state.

[23] We arbitrarily choose four lags, but the results will hold true for any general lag length.

Appendix B

Consider the reduced-form VAR

$$A(L)Y_t = e_t,$$

where $A(L)$ is an $(n \times n)$ matrix of lag polynomials and $e_t \sim N(0, \Sigma)$. We can rewrite this VAR in its $MA(\infty)$ representation:

$$Y_t = B(L)e_t,$$

where $B(L) = A(L)^{-1}$. The model residuals e_t have no structural interpretation; the objective of this exercise is to identify the structural shocks ε_t defined in the third section, on implementing long-run restrictions. This can be accomplished by imposing restrictions on either the contemporary impact matrix or by imposing effect restrictions on the long-run multipliers $C_{ij}(1)$ defined in (2). Once the structural shocks ε_t are identified, the s-period-ahead response to shock ε_t^i can be computed by

$$\text{(A.2.1)} \qquad \frac{\partial E(Y_{t+s})}{\partial Y_t^i} = C_s \varepsilon_t^i,$$

where C_s is the lag-s matrix derived from the MA representation, $C_s = B_s * R$ and $\varepsilon_t = R^{-1}e_t$. R is a (rotation) matrix that maps the reduced form into the structural form and, thus, depends on the nature of the restrictions imposed.

Since $B(L)$ is generated from the reduced-form estimation, one can easily see that sufficient restrictions on the left-hand side of (A.2.1) can be used to uniquely identify $C(L)$ and ε_t^i. The alternative identification that we impose in the fourth section of the paper takes a decidedly different tack. Instead of imposing restrictions on either the contemporary impact matrix or the long-run multipliers, we restrict the impulse responses (A.2.1) directly. Since our algorithm imposes only sign restrictions, which may not be binding, we do not exactly identify the structural shock. Instead, we must draw candidate shocks and test whether the sign restrictions are violated. This allows us to identify a distribution of structural shocks, which we use to test the robustness of the conclusions drawn from the estimation in the third section of the paper.

Appendix C

We begin with the reduced-form, four-lag VAR:

$$\text{(A.3.1)} \qquad Y_t = \sum_{i=1}^{4} D_i Y_{t-i} + e_t,$$

where the D_i are the lag-i coefficient matrices, $I - D(L) = A(L)$, and the e_i are the i.i.d. reduced-form residuals with covariance matrix Σ. It is convenient to stack the system (A.3.1) in the following manner:

$$\text{(A.3.2)} \qquad \mathbf{Y} = \mathbf{XD} + \mathbf{e},$$

where $\mathbf{D} = [D_1, D_2, \ldots D_k]'$, $\mathbf{Y} = [y_1, y_2, \ldots y_T]'$, $X_t = [y'_{t-1}, y'_{t-2}, \ldots y'_{t-k}]'$, $\mathbf{X} = [X_1, X_2, \ldots X_T]'$, and $\mathbf{e} = [e_1, e_2, \ldots e_T]'$. Here, T is the sample length and k is the lag order ($k = 4$ in our case).

The system (A.3.2) can be estimated as a VAR with a normal-inverted Wishart prior conjugate distribution with parameters v_0, N_0, δ_0, and S_0. Then, the VAR parameters can be drawn from the joint posterior distribution, also a normal-inverted Wishart distribution centered on δ and S with v degrees of freedom and precision matrix N. The parameters for the posterior distribution are given by

$$v = T + v_0,$$

$$N = N_0 + \mathbf{X}'\mathbf{X},$$

$$\delta = N^{-1}(N_0\delta_0 + \mathbf{X}'\mathbf{X}\hat{D}),$$

$$S = \frac{v_0}{v} S_0 + \frac{T}{v}\Sigma + \frac{1}{v}(\hat{D} - \delta_0)' N_0 N^{-1} \mathbf{X}'\mathbf{X}(\hat{D} - \delta_0),$$

where $\hat{D} = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{Y}$ and $\hat{\Sigma} = (\mathbf{Y} - \mathbf{X}\hat{D})'(\mathbf{Y} - \mathbf{X}\hat{D})$.[24]

We can characterize the impulse vector $\hat{\theta}$ by

$$\hat{\theta} = Q\vartheta,$$

where $QQ' = \Sigma$ is the Cholesky decomposition of the state-dependent covariance matrix and ϑ is a vector drawn from the unit circle. The Cholesky factorization does not impose a causal ordering

[24] In estimating the Bayesian VAR (A.3.2), we utilize uninformative priors. That is, we assume $v_0 = 0$ and $N_0 = \bar{0}_n$, with S_0 and δ_0 arbitrary. This makes (A.3.2) a simple reduced-form VAR.

in this case but provides a means of orthogonalizing the shocks.[25] We then apply (A.3.3) and (A.3.4) to generate impulse responses and test them against the restriction matrix R. Any $\hat{\theta}$ that satisfies the restrictions on y_{t+j} is retained. Multiple iterations over a single set of sampled model parameters yield a distribution for the shocks, $\Theta(\mathbf{D},\Sigma,R)$.[26]

Suppose the impulse response to any vector innovation $\hat{\theta}$ can be defined as

$$\Delta y_{t+j} = \Gamma^{j}\bar{\theta}, \tag{A.3.3}$$

where $\bar{\theta} = [\hat{\theta}', 0_{1\times 2(k-1)}]'$ and the $(2k \times 2k)$ impulse-generating matrix Γ is defined by

$$\Gamma = \begin{bmatrix} \mathbf{D}' \\ I_{2(k-1)} \quad \tilde{0}_{2(k-1)\times 2} \end{bmatrix}. \tag{A.3.4}$$

Here, $\mathbf{D}$ is the stacked coefficient matrix, $I_{2(k-1)}$ is the $2(k-1)\times 2(k-1)$ identity matrix and $\tilde{0}_{2(k-1)\times 2}$ is a $2(k-1)\times 2$ matrix of zeros.

The algorithm for identifying the technology shock is as follows: The impulse response to any shock $\hat{\theta}$ can be calculated using (A.3.3) and (A.3.4). The shock $\hat{\theta}$ is associated with a restriction matrix R that is invariant to the state of the economy. R is an $(n \times l)$ matrix that represents the priors that we impose on the response of model variables to the incidence of a shock $\hat{\theta}$ out to a horizon l. Our identification centers on the selection of the shock $\hat{\theta}$ that produces an impulse response satisfying the restriction matrix R.

[25] See Mountford and Uhlig (2002) for a discussion of the use of the Cholesky factorization.

[26] Our characterization of the impulse vector space is slightly different from Uhlig (1999). He implicitly assumes that the sign restrictions on the impulse response functions hold out to horizon l, and he characterizes the space as $\Theta(\mathbf{D},\Sigma,l)$. Since we will impose long-run restrictions, it is beneficial to denote the impulse vector space as dependent on a restriction matrix R.

Federal Reserve Bank of St. Louis Working Paper Series, 2003

Working papers from the Federal Reserve Bank of St. Louis contain preliminary results of staff research and are made available to encourage comment and discussion, as well as to invite suggestions from other researchers for revision.

The views expressed in the working papers are those of the authors and do not necessarily reflect official positions of the Federal Reserve Bank of St. Louis, the Federal Reserve System, or the Board of Governors.

Visit our web site (research.stlouisfed.org/wp/) for a listing of working papers by year, author, or subject. For published papers, contact the author (research.stlouisfed.org/econ/) or the publication listed. To order single copies of working papers, please send your request to the Working Paper Coordinator at the following address:

Federal Reserve Bank of St. Louis
Research Department
P.O. Box 442
St. Louis, MO 63166-0442

2003 WORKING PAPERS

2003-001B: Neville Francis and Michael T. Owyang, "Asymmetric Common Trends: An Application of Monetary Policy in a Markov-Switching VECM."

2003-002A: William T. Gavin, "FOMC Forecasts: Is All the Information in the Central Tendency?"

2003-003B: Thomas A. Garrett, "Does Consumer Sentiment Predict Regional Consumption?"

2003-004B: Patricia S. Pollard and Cletus C. Coughlin, "Pass-Through Estimates and the Choice of an Exchange Rate Index."

2003-005A: Thomas A. Garrett, Thomas L. Marsh, and Maria I. Marshall, "Political Allocation of Agriculture Disaster Payments in the 1990s."

2003-006A: Richard G. Anderson, "Some Tables of Historical U.S. Currency and Monetary Aggregates Data."

2003-007A: Hui Guo, "Does the Consumption-Wealth Ratio Forecast Stock Market Returns in Real Time?"

2003-008A: Michael T. Owyang and Howard Wall, "Regional Disparities in the Transmission of Monetary Policy."

2003-009B: Abbigail J. Chiodo, Massimo Guidolin, Michael T. Owyang, and Makoto Shimoji, "Subjective Probabilities: Psychological Evidence and Economic Applications."

2003-010E: Neville R. Francis, Michael T. Owyang, and Athena T. Theodorou, "The Use of Long-Run Restrictions for the Identification of Technology Shocks." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, November/December 2003, *85*(6), pp. 53-66.

2003-011C: Michael T. Owyang, Jeremy Piger, and Howard J. Wall, "Business Cycle Phases in U.S. States."

2003-012A: Hui Guo, "On the Out-of-Sample Stock Return: The International Evidence."

2003-013A: James Bullard and Stefano Eusepi, "Did the Great Inflation Occur Despite Policymaker Commitment to a Taylor Rule?"

2003-014A: Michael D. Bordo, Robert Dittmar, and William T. Gavin, "Gold, Fiat Money, and Price Stability."

2003-015A: Chang-Jin Kim, Jeremy Piger, and Richard Startz, "Estimation of Markov Regime-Switching Regression Models with Endogenous Switching."

2003-016A: Michael R. Pakko, "On the Information Content of Asymmetric FOMC Policy Statements: Evidence from a Taylor-Rule Perspective."

2003-017B: James Bullard and James Feigenbaum, "A Leisurely Reading of the Life-Cycle Consumption Data."

2003-018A: Christopher Neely, "Implied Volatility from Options on Gold Futures: Do Statistical Forecasts Add Value or Simply Paint the Lilly?"

2003-019A: Edward Nelson, "Money and the Transmission Mechanism in the Optimizing IS-LM Specification."

2003-020A: Amit Kara and Edward Nelson, "International Evidence on the Stability of the Optimizing IS Equation."

2003-021A: Robert D. Dittmar and Daniel L. Thornton, "Testing the Expectations Hypothesis: Some New Evidence."

2003-022A: Daniel L. Thornton, "Tests of the Expectations Hypothesis: Resolving the Campbell-Shiller Paradox."

2003-023A: Michael R. Pakko, "A Spectral Analysis of the Cross-Country Consumption Correlation Puzzle."

2003-024A: Michael Dueker, Martin Sola, and Fabio Spagnolo, "Contemporaneous Threshold Autoregressive Models: Estimation, Forecasting, and Rational Expectations Applications."

2003-025A: Hui Guo and Robert Savickas, "Does Idiosyncratic Risk Matter: Another Look."

2003-026A: Richard G. Anderson, "Retail Deposit Sweep Programs: Issues for Measurement, Modeling, and Analysis."

2003-027A: William T. Gavin, "Inflation Targeting: Why It Works and How To Make It Work Better."

2003-028A: Hui Guo and Robert Savickas, "Idiosyncratic Volatility, Stock Market Volatility, and Expected Stock Returns."

2003-029A: Patricia S. Pollard and Cletus C. Coughlin, "Size Matters: Asymmetric Exchange Rate Pass-Through at the Industry Level."

2002 WORKING PAPERS

2002-001A: Hui Guo, "Understanding the Risk-Return Tradeoff in the Stock Market."

2002-002A: James Bullard and In-Koo Cho, "Escapist Policy Rules."

2002-003A: Michael J. Dueker, Andreas M. Fischer, and Robert D. Dittmar, "Stochastic Capital Depreciation and the Comovement of Hours and Productivity."

2002-004A: Hui Guo, "Stock Prices, Firm Size, and Changes in the Federal Funds Rate Target."

2002-005B: Lucio Sarno, Daniel L. Thornton, and Giorgio Valente, "Federal Funds Rate Prediction."

2002-006A: James Bullard and Bruce D. Smith, "Intermediaries and Payments Instruments." PUBLISHED: *Journal of Economic Theory*, April 2003, *109*(2), pp. 172-97.

2002-007A: Christopher J. Neely and Lucio Sarno, "How Well Do Monetary Fundamentals Forecast Exchange Rates." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, September/October 2002, *84*(5), pp. 51-74..

2002-008B: Hui Guo, "On the Out-of-Sample Predictability of Stock Market Returns?"

2002-009A: Cletus C. Coughlin, Jeffrey P. Cohen, and Sarosh R. Khan, "Aviation Security and Terrorism: A Review of the Economic Issues."

2002-010C: Thomas A. Garrett and Marvin E. Dodson III, "Inefficient Education Spending in Public School Districts: A Case for Consolidation." FORTHCOMING: *Contemporary Economic Policy*.

2002-011A: Thomas A. Garrett and Russell S. Sobel, "State Lottery Revenue: The Importance of Game Characteristics."

2002-012B: Thomas A. Garrett and Russell S. Sobel, "The Political Economy of FEMA Disaster Payments." PUBLISHED: *Economic Inquiry*, July 2003, *46*(3), pp. 496-509.

2002-013B: Hui Guo, "Time-Varying Risk Premia and the Cross Section of Stock Returns."

2002-014D: Chang-Jin Kim, James Morley, and Jeremy Piger, "Nonlinearity and the Permanent Effects of Recessions."

2002-015A: Néstor Gándelman and Rubén Hernández-Murillo, "Tax Competition and Tax Harmonization with Evasion."

2002-016A: Michael Dueker and Thomas W. Miller, Jr., "Directly Measuring Early Exercise Premiums Using American and European S&P 500 Index Options." PUBLISHED: *Journal of Futures Markets*, March 2003, *23*, pp. 287-313.

2002-017B: Christopher J. Neely, "Forecasting Foreign Exchange Volatility: Is Implied Volatility the Best We Can Do?"

2002-018A: Michael T. Owyang, "Modeling Volcker as a Non-Absorbing State: Agnostic Identification of a Markov-Switching VAR."

2002-019A: Yannis Georgellis and Howard J. Wall, "Entrepreneurship and the Policy Environment."

2002-020A: R. Alton Gilbert, David C. Wheelock, and Paul W. Wilson, "New Evidence on the Fed's Productivity in Providing Payments Services."

2002-021A: Michael T. Owyang and Abbigail J. Chiodo, "Duration Dependence in Monetary Policy: International Evidence."

2002-022A: Leora Friedberg and Michael T. Owyang, "Explaining the Evolution of Pension Structure and Job Tenure."

2002-023C: Andrew T. Levin and Jeremy M. Piger, "Is Inflation Persistence Intrinsic in Industrial Economies?"

2002-024B: Thomas A. Garrett, "Aggregated vs. Disaggregated Data in Regression Analysis: Implications for Inference." PUBLISHED: *Economic Letters*, October 2003, *81*(1), pp. 61-65.

2002-025B: Michael J. Dueker and Charles R. Nelson, "Business Cycle Detrending of Macroeconomic Data Via a Latent Business Cycle Index."

2002-026A: William R. Emmons and Frank A. Schmid, "Cracks in the Façade: American Economic and Financial Structures After the Boom." FORTHCOMING: *Structural Foundations of International Finance*, Pier Carlo Padoan, Paul Brenton, and Gavin Boyd, eds., Cheltenham, UK: Edward Elgar, 2003.

2002-027A: Frank A. Schmid and Mark Wahrenburg, "Mergers and Acquisitions in Germany."

2002-028B: Daniel L. Thornton, "Monetary Policy Transparency: Transparent About What?" FORTHCOMING: *The Manchester School*.

2002-029A: Lucio Sarno, Daniel L. Thornton, and Yi Wen, "What's Unique About the Federal Funds Rate? Evidence from a Spectral Perspective."

2002-030A: Michael R. Pakko, "Substitution Elasticities and Investment Dynamics in International Business Cycle Models."

2002-031A: Ruben Hernandez-Murillo and Gerard Llobet, "Patent Licensing Revisited: Heterogeneous Firms in International Business Cycle Models."

2002-032C: Howard J. Wall, "Entrepreneurship and the Deregulation of Banking." FORTHCOMING: *Economic Letters*.

2001 WORKING PAPERS

2001-001A: Hui Guo and Robert Whitelaw, "Risk and Return: Some New Evidence."

2001-002A: Michael Owyang and Garey Ramey, "Regime Switching and Monetary Policy Measurement."

2001-003C: David C. Wheelock and Paul W. Wilson, "Consolidation in U.S. Banking: Which Banks Engage in Mergers?"

2001-004D: Daniel L. Thornton, "Forecasting the Treasury's Balance at the Fed." FORTHCOMING: *Journal of Forecasting*.

2001-005C: William T. Gavin and Rachel J. Mandal, "Evaluating FOMC Forecasts." FORTHCOMING: *International Journal of Forecasting*.

2001-006A: Cletus C. Coughlin, "Trade Opinions at the State Level."

2001-007B: Howard J. Wall and Gylfi Zoega, "The British Beveridge Curve: A Tale of Ten Regions." PUBLISHED: *Oxford Bulletin of Economics and Statistics*, July 2002, *64*(3), pp. 257-76.

2001-008A: Richard G. Anderson and Robert H. Rasche, "The Remarkable Stability of Monetary Base Velocity in the United States, 1919-1999."

2001-009B: Christopher J. Neely and Paul A. Weller, "Predicting Exchange Rate Volatility: Genetic Program vs. GARCH." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, May/June 2002, *84*(3), pp. 43-54.

2001-010C: Robert Dittmar, William T. Gavin, and Finn E. Kydland, "Inflation Persistence and Flexible Prices."

2001-011A: James Bullard and Bruce D. Smith, "The Value of Inside and Outside Money: Expanded Version."

2001-012B: Michael Dueker, "Dynamic Forecasts of Qualitative Variables: A Qual VAR Model of U.S. Recessions."

2001-013A: Charles Nelson, Eric Zivot, and Jeremy M. Piger, "Markov Regime Switching and Unit Root Tests." PUBLISHED: *Journal of Business and Economic Statistics*, October 2001, *19*(4), pp. 404-15.

2001-014A: Chang-Jin Kim and Jeremy M. Piger, "Common Stochastic Trends, Common Cycles, and Asymmetry in Economic Fluctuations." PUBLISHED: *Journal of Monetary Economics*, September 2002, *49*(6), pp. 1189-1211.

2001-015B: Evan F. Koenig, Sheila Dolmas, and Jeremy M. Piger, "The Use and Abuse of 'Real-Time' Data in Economic Forecasting." PUBLISHED: *Review of Economics and Statistics*, August 2003, *85*(3), pp. 618-28.

2001-016C: Chang-Jin Kim, Charles Nelson, and Jeremy M. Piger, "The Less Volatile U.S. Economy: A Bayesian Investigation of Timing, Breadth, and Potential Explanations." FORTHCOMING: *Journal of Business and Economic Statistics*.

2001-017B: Chang-Jin Kim, Richard Startz, and Jeremy M. Piger, "Permanent and Transitory Components of Business Cycles: Their Relative Importance and Dynamic Relationship."

2001-018A: Michael D. Bordo, Michael J. Dueker, and David C. Wheelock, "Aggregate Price Shocks and Financial Stability: The United Kingdom 1796-1999." PUBLISHED: *Explorations in Economic History*, April 2003, *40*, pp. 143-69.

2001-019A: Michael J. Dueker and Katrin Wesche, "Forecasting Output with Information from Business Cycle Turning Points: A Qualitative Variable VAR."

2001-020A: Michael R. Pakko, "What Happens When the Technology Growth Trend Changes?: Transition Dynamics, Capital Growth, and the 'New Economy.'" PUBLISHED: *Review of Economic Dynamics*, April 2002, *5*(2), pp. 376-407.

2001-021C: Michael Dueker and Christopher J. Neely, "Can Markov Switching Models Predict Excess Foreign Exchange Returns?"

2001-022D: Ming Chien Lo and Jeremy Piger, "Is the Response of Output to Monetary Policy Asymmetric? Evidence From a Regime-Switching Coefficients Model." FORTHCOMING: *Journal of Money, Credit, and Banking*.

2001-023A: William R. Emmons and Frank A. Schmid, "Corporate Governance Entrenched Labor, and Economic Growth."

2001-024A: William R. Emmons, R. Alton Gilbert, and Timothy J. Yeager, "The Importance of Scale Economies and Geographic Diversification in Community Bank Mergers?"

2001-025B: Michael J. Dueker and Andreas M. Fischer, "Fixing Swiss Potholes: The Importance of Improvements." PUBLISHED: *Economic Letters*, June 2003, *79*, pp. 409-15.

2000 WORKING PAPERS

2000-001E: James Bullard and Kaushik Mitra, "Learning About Monetary Policy Rules." PUBLISHED: *Journal of Monetary Economics*, September 2002, *49*(6), pp. 1105-29.

2000-002A: Richard G. Anderson and Robert H. Rasche, "The Domestic Adjusted Monetary Base."

2000-003C: Daniel L. Thornton, "The Conventional of the Expectations Hypothesis: Resolving the Anomalies When the Short-Term Rate is the Federal Funds Rate."

2000-004B: Daniel L. Thornton and Clemens J.M. Kool, "The Expectations Theory and the Founding of the Fed: Another Look at the Evidence."

2000-005B: Michael D. Bordo, Michael J. Dueker, and David C. Wheelock, "Aggregate Price Shocks and Financial Instability: A Historical Analysis." PUBLISHED: *Economic Inquiry*, October 2002, *40*(4), pp. 521-38.

2000-006A: William R. Emmons and Frank A. Schmid, "Banks vs. Credit Unions: Dynamic Competition in Local Markets."

2000-007A: William T. Gavin, "Controlling Inflation After Bretton Woods: An Analysis Based on Policy Objectives." PUBLISHED as Chapter 3 in Warren Coats, ed., Inflation Targeting in Transition Economics: The Case of the Czech Republic. Prague: Czech National Bank, and Washington: *International Monetary Fund*, 2000, pp. 39-59.

2000-008A: William R. Emmons and Frank A. Schmid, "Pricing and Dividend Policies in Open Credit Cooperatives." PUBLISHED: *Journal of Theoretical and Institutional Economics*, June 2002, *158*(2), pp. 234-55.

2000-009C: Rowena A. Pecchenino and Patricia S. Pollard, "A Simple Model of International Capital Flows, Exchange Rate Risk, and Portfolio Choice."

2000-010A: William Poole and Robert H. Rasche, "Perfecting the Market's Knowledge of Monetary Policy." PUBLISHED: *Journal of Financial Services Research*, December 2000, *18*, pp. 255-98.

2000-011B: Robert H. Rasche, "Identification of Dynamic Economic Models from Reduced Form VECM Structures: An Application of Covariance Restrictions."

2000-012A: Costas Azariadis, James Bullard, and Bruce Smith, "Private and Public Circulating Liabilities." PUBLISHED: *Journal of Economic Theory*, July/August 2001, *99*(1/2), pp. 59-116.

2000-013A: William T. Gavin and Finn E. Kydland, "The Nominal Facts and the October 1979 Policy Change." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, November/December 2000, *82*(6), pp. 39-61.

2000-014D: Michael R. Pakko, "Changing Technology Trends, Transition Dynamics, and Growth Accounting."

2000-015B: Rowena A. Pecchenino and Patricia S. Pollard, "Aging, Myopia, and the Pay-As-You-Go Public Pension Systems of the G7: A Bright Future?"

2000-016A: Michael Dueker and Apostolos Serletis, "Do Real Exchange Rates Have Autoregressive Unit Roots? A Test Under the Alternative of Long Memory and Breaks."

2000-017C: Howard J. Wall, "NAFTA and the Geography of North American Trade." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, March 2003, *85*(2), pp. 13-26.

2000-018C: Christopher J. Neely, "The Temporal Pattern of Trading Rule Returns and Central Bank Intervention: Intervention Does Not Generate Technical Trading Rule Profits." PUBLISHED: *Journal of International Economics*, *58*(1), pp. 211-32.

2000-019A: James Bullard and Eric Schaling, "New Economy—New Policy Rules?" PUBLISHED: Federal Reserve Bank of St. Louis *Review*, September/October 2001, *83*(5), pp. 57-66.

2000-020A: R. Alton Gilbert and Mark D. Vaughan, "Do Depositors Care About Enforcement Actions?" PUBLISHED: *Journal of Economics and Business*, March/June 2001, *53*(2/3), pp. 283-311.

2000-021A: R. Alton Gilbert, Andrew P. Meyer, and Mark D. Vaughan, "The Role of a CAMEL Downgrade Model in Bank Surveillance?" PUBLISHED: as "Can Feedback from the Jumbo CD Market Improve Off-Site Surveillance of Community Banks?" in Kaufman, ed., *Prompt Corrective Action Ten Years Later*, New York, JAI/Elsevier Press, 2002, *14*(Part 1).

2000-022A: Cletus C. Coughlin and Patricia S. Pollard, "Exchange Rate Pass-Through in U.S. Manufacturing: Exchange Rate Index Choice and Asymmetry Issues."

2000-023A: Richard G. Anderson and Robert H. Rasche, "Retail Sweep Programs and Bank Reserves, 1994-1999." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, January/February 2001, *83*(1), pp. 51-72.

2000-024A: Howard J. Wall, "Gravity Model Specification and the Effects of the Canada-U.S. Border."

2000-025B: Gary Gorton and Frank Schmid, "Class Struggle Inside the Firm: A Study of German Codetermination."

2000-026A: William T. Gavin and Rachel J. Mandal, "Forecasting Inflation and Growth: Do Private Forecasts Match Those of Policymakers?" PUBLISHED: *Business Economics*, January 2001, *36*(1), pp. 13-20. REPRINTED: Federal Reserve Bank of St. Louis *Review*, May/June 2001, *83*(3), pp. 11-19.

2000-027C: James Bullard and Bruce D. Smith, "The Value of Inside and Outside Money." FORTHCOMING: *Journal of Monetary Economics*.

2000-028A: Christopher J. Neely, "The Practice of Central Bank Intervention: Looking Under the Hood." PUBLISHED: *Central Banking*, November 2002. Reprinted Federal Reserve Bank of St. Louis *Review*, *83*(3), May/June 2001, pp. 1-10.

2000-029B: Cletus C. Coughlin and Howard J. Wall, "NAFTA and the Changing Pattern of State Exports." FORTHCOMING: *Papers in Regional Science*.

2000-030B: James Bullard and Kaushik Mitra, "Determinacy, Learnability, and Money Policy Inertia."

2000-031C: Hui Guo, "Limited Stock Market Participation and Asset Prices in a Dynamic Economy." FORTHCOMING: *Journal of Financial and Quantitative Analysis*.

2000-032C: Lucio Sarno and Daniel L. Thornton, "The Dynamic Relationship Between the Federal Funds Rate and the Treasury Bill Rate: An Empirical Investigation." PUBLISHED: *Journal of Banking and Finance*, June 2003, *27*(6), pp. 1079-110.

1999 WORKING PAPERS

99-001B: Cletus C. Coughlin and Eran Segev, "Foreign Direct Investment in China: A Spatial Econometric Study." PUBLISHED: *The World Economy*, January 2000, *23*(1), pp. 1-23.

99-002A: Michael R. Pakko, "Do High Interest Rates Stem Capital Outflows?" PUBLISHED: *Economic Letters*, May 2000, *67*(2), pp. 187-92.

99-003A: Ali M. Kutan and Josef C. Brada, "The End of Moderate Inflation in Three Transition Economies."

99-004A: Donald S. Allen, "Seasonal Production Smoothing." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, September/October 1999, *81*(5), pp. 21-40.

99-005A: Joseph A. Ritter and Lowell J. Taylor, "Low-Powered Incentives."

99-006A: Howard J. Wall, "Voting with Your Feet in the United Kingdom: Using Cross-Migration Rates to Estimate Relative Living Standards." PUBLISHED: *Papers in Regional Science*, January 2001, *80*(1), pp. 1-23.

99-007A: Howard J. Wall and Stratford Douglas, "Measuring Relative Quality of Life From a Cross-Migration Regression with an Application to Canadian Provinces." PUBLISHED: *Research in Labor Economics*, 2000, *19*, pp. 191-214.

99-008B: Howard J. Wall and Yannis Georgellis, "Gender Differences in Self-Employment: Panel Evidence from the Former West Germany."

99-009A: Howard J. Wall and Yannis Georgellis, "What Makes a Region Entrepreneurial? Evidence from Britain." PUBLISHED: *Annals of Regional Science*, August 2000, *34*(3), pp. 385-403.

99-010C: Howard J. Wall and I-Hui Cheng, "Controlling for Heterogeneity in Gravity Models of Trade."

99-011A: Joseph A. Ritter, "Feeding the National Accounts." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, March/April 2000, *82*(2), pp. 11-20.

99-012B: Rowena A. Pecchenino and Patricia S. Pollard, "Government Mandated Private Pensions: A Dependable and Equitable Foundation for Retirement Security?"

99-013A: Donald S. Allen and Leonce Ndikumana, "Income Inequality and Minimum Consumption: Implications for Growth."

99-014A: R. Alton Gilbert, "Effects of Federal Reserve Services on the Efficiency of the System for Collecting Checks in the United States: 1915-30." PUBLISHED: as "The Advent of the Federal Reserve and the Efficiency of the System for Collecting Checks in the U.S., 1915-30," *Explorations in Economic History*, April 2000, *37*(2), pp. 121-48.

99-015D: Christopher Neely, "Risk-Adjusted, Ex Ante, Optimal, Technical Trading Rules in Equity Markets." PUBLISHED: *International Review of Economics and Finance*, 2003, *12*(1), pp. 69-87.

99-016B: Christopher J. Neely and Paul Weller, "Intraday Technical Trading in the Foreign Exchange Market." PUBLISHED: *Journal of International Money and Finance*, 2003, *22*(2), pp. 223-37.

99-017A: Howard Wall, Subhayu Bandyopadhyay, and Eun-Soo Park, "Endogenous Export Subsidies and Welfare Under Domestic Cost Heterogeneity."

99-018A: William R. Emmons and Frank A. Schmid, "Corporate Governance and Corporate Performance." PUBLISHED *Corporate Governance and Globalization*, Gavin Boyd and Stephen Cohen, eds., Cheltenham, U.K.: Edward Elgar, 2000, pp. 59-94.

99-019B: Michael Dueker and Katrin Wesche, "European Business Cycles: New Indices and Analysis of Their Synchronicity." PUBLISHED: *Economic Inquiry*, January 2003, *41*, pp. 116-31.

99-020A: Joseph G. Haubrich and Joseph A. Ritter, "Committing and Reneging: A Dynamic Model of Policy Regimes."

99-021A: Robert Dittmar and William T. Gavin, "What Do New Keynesian Phillips Curves Imply for

Price Level Targeting?" PUBLISHED: Federal Reserve Bank of St. Louis *Review*, March/April 2000, *82*(2), pp. 21-30.

99-022B: Daniel L. Thornton, "The Relationship Between the Federal Funds Rate and the Fed's Funds Rate Target: Is It Open Market or Open Mouth Operations?" FORTHCOMING: *Journal of Financial and Quantitative Analysis*.

99-023A: David C. Wheelock and Paul W. Wilson, "The Contribution of On-Site Examination Ratings to an Empirical Model of Bank Failures."

1998 WORKING PAPERS

98-001A: William R. Emmons and Frank A. Schmid, "Universal Banking, Allocation of Control Rights, and Corporate Finance in Germany." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, July/August 1998, *80*(4), pp. 19-42.

98-002D: James Bullard and Christopher J. Waller, "Central Bank Design in General Equilibrium." FORTHCOMING: *Journal of Money, Credit, and Banking*.

98-003A: Daniel L. Thornton, "Lifting the Veil of Secrecy From Monetary Policy: Evidence From the Fed's Early Discount Rate Policy." PUBLISHED: *Journal of Money, Credit, and Banking*, May 2000, *32*(2), pp. 155-67.

98-004B: Donald S. Allen and Leonce Ndikumana, "Financial Intermediation and Economic Growth in Southern Africa."

98-005A: William G. Dewald, "Inflation, Real Interest Tax Wedges, and Capital Formation." PUBLISHED: Federal Reserve Bank of St. Louis *Review*, January/February 1998, *80*(1), pp. 29-36.

98-006A: Joseph A. Ritter and Lowell Taylor, "Seniority-Based Layoffs as an Incentive Device."

98-007A: Michael R. Pakko, "Dynamic Shoe-Leather Costs in a Shopping-Time Model of Money."

98-008C: Richard G. Anderson, Dennis L. Hoffman, and Robert H. Rasche, "A Vector Error-Correction Forecasting Model of the U.S. Economy." PUBLISHED: *Journal of Macroeconomics*, December 2002, *24*(4), pp. 569-98.

98-009A: Daniel L. Thornton, "The Federal Reserve's Operating Procedure, Nonborrowed Reserves, Borrowed Reserves and the Liquidity Effect." PUBLISHED: *Journal of Banking and Finance*, September 2001, *25*(9), pp. 1717-39.

98-010B: David C. Wheelock, "National Monetary Policy by Regional Design: The Evolving Role of the Federal Reserve Banks in Federal Reserve System Policy." PUBLISHED: *Regional Aspects of Monetary Policy in Europe*, J. Von Hagen and C. Waller, eds., Boston: Kluwer Academic Publishers, 2000, pp. 241-74.

98-011A: Michael Dueker, "Conditional Heteroscedasticity in Qualitative Response Models of Time Series: A Gibbs Sampling Approach to the Bank Prime Rate." PUBLISHED: *Journal of Business and Economic Statistics*, October 1999, *17*(4), pp. 466-72.

98-012A: Cletus C. Coughlin and Patricia S. Pollard, "Constructing and Using National and Regional TWEXS: The Case for Chaining." PUBLISHED: *Journal of Economic and Social Measurement*, 1999, *24*(3/4), pp. 279-94.

98-013A: Scott Freeman and Finn Kydland, "Monetary Aggregates and Output."

98-014A: Michael Dueker and Gyuhan Kim, "A Monetary Policy Feedback Rule in Korea's Fast-Growing Economy." PUBLISHED: *Journal of International Financial Markets, Institutions and Money*, January 1999, *9*(1), pp. 19-31.

98-015B: Costas Azariadis, James Bullard, and Lee Ohanian, "Complex Eigenvalues and Trend-Reverting Fluctuations." FORTHCOMING: *Journal of Economic Theory*.

98-016A: James Bullard and John Duffy, "Learning and Excess Volatility." PUBLISHED: *Macroeconomic Dynamics*, April 2001, *5*(2), pp. 272-302.

98-017A: Victor E. Li and Chia-Ying Chang, "Money, Credit, and the Cyclical Behavior of Household Investment."

98-018A: Derek Laing, Victor E. Li, and Ping Wang, "Inflation and Economic Activity in a Multiple Matching Model of Money."

98-019A: Victor E. Li, "Household Credit and the Monetary Transmission Mechanism."

98-020A: Alison Butler and Michael R. Pakko, "R&D Spending and Cyclical Fluctuations: Putting the 'Technology' in Technology Shocks."

98-021A: Ali M. Kutan and Josef C. Brada, "The Persistence of Moderate Inflation in the Czech Republic and the Koruna Crisis of May 1997." PUBLISHED: *Prague Economic Papers*, December 1999.

98-022A: Selahattin Dibooglu and Ali M. Kutan, "Sources of Real and Nominal Exchange Rate Fluctuations in Transition Economies." PUBLISHED: *Journal of Comparative Economics*, as "Sources of Real Exchange Rate Fluctuations in Transition Economies: The Case of Hungary and Poland," June 2001, *29*(2), pp. 257-75.

98-023B: Rowena A. Pecchenino and Patricia S. Pollard, "The Effects of Aging and Myopia on the Pay-As-You-Go Social Security Systems of the G7."

Federal Reserve Bank of St. Louis *Review*, Annual Index, 2003

JANUARY/FEBRUARY

MARCH/APRIL

MAY/JUNE

JULY/AUGUST

Finance and Real Economic Activity

SEPTEMBER/OCTOBER

Richard G. Anderson and Robert H. Rasche, with Jeffrey Loesel, "A Reconstruction of the Federal Reserve Bank of St. Louis Adjusted Monetary Base and Reserves."

NOVEMBER/DECEMBER

William Poole, "Fed Transparency: How, Not Whether."

Michael R. Pakko and Patricia S. Pollard, "Burgernomics: A Big Mac™ Guide to Purchasing Power Parity."

R. Alton Gilbert and Adam M. Zaretsky, "Banking Antitrust: Are the Assumptions Still Valid?"

Neville R. Francis, Michael T. Owyang, and Athena T. Theodorou, "The Use of Long-Run Restrictions for the Identification of Technology Shocks."

All nonproprietary and nonconfidential data and programs for the articles written by Federal Reserve Bank of St. Louis staff and published in *Review* are available to our readers on our web site: < **research.stlouisfed.org/publications/review** > . Also, you may request data and programs on either disk or hard copy: **Research Department**, Federal Reserve Bank of St. Louis, P.O. Box 442, St. Louis, MO 63166-0442. Please include the author, title, issue date, and page numbers with your request.

These data and programs are also available through **Inter-university Consortium for Political and Social Research (ICPSR)**. Member institutions may request data through the CDNet Order facility. Nonmembers may write to ICPSR, Institute for Social Research, P.O. Box 1248, Ann Arbor, MI 48106-1248; call 734-998-9900; or e-mail < **netmail@icpsr.umich.edu** > .

General data can be obtained through **FRED (Federal Reserve Economic Data)**, a database providing U.S. economic and financial data and regional data for the Eighth Federal Reserve District. You may access FRED through our web site: < **research.stlouisfed.org/fred** > .

ON THE INTERNET

research.stlouisfed.org

THE FEDERAL RESERVE BANK of ST. LOUIS

Federal Reserve Bank of St. Louis
P.O. Box 442
St. Louis, MO 63166-0442