Borrowing by U.S. Households

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Wherever one turns these days, one seems to run into comments about the financial condition of the American household. Most of these comments refer to sources of increasing stress on the American consumer, from the historically low household savings rate to the historically high rates of bankruptcy and debt delinquency. On top of all this, demographic trends are raising the prospect of having to finance the coming retirement of the baby boom generation. These conditions have led some to question the ability of consumer spending to hold up under such growing financial stress. Credit markets and consumers' use of credit products take a central place in this picture. Stories in the popular business press have taken the view that consumer debt will represent a drag on consumption growth in 2006, as the burden of making payments on debt limits households' abilities to make other purchases.[1]

Debt and credit are value-laden terms that evoke distinct images in people's minds. Indeed, cultural historian Lendol Calder has noted the seemingly contradictory value judgments that run through American cultural attitudes about borrowing.[2] "Credit" is seen as a good thing, in that it allows the household financial flexibility in meeting its consumption needs. On the other hand, "debt" is typically viewed as bad, because it represents a lack of self-discipline and holds the household hostage to its past choices. And so we have what appears to be a paradox. The ability to borrow is both liberating and constraining—a path to both rising wealth and the poorhouse.

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[1] An example is "Night of the Living Debt" in the January 4, 2006, *Wall Street Journal*.
[2] See Calder (1999).

Another way to view this seeming paradox is to think of "credit" and "debt" from two different vantage points. "Credit" typically refers to the moment when a borrower has access to funds made available by a lender. From this vantage point, it is a tool to help households achieve their desired levels of consumption. "Debt," on the other hand, is an after-the-fact concept, referring to the amount owed. We see this dichotomy in contemporary discussions of credit markets. The expansion of access to credit for households previously thought to be sharply constrained in their ability to borrow is a stated goal of public policy. On the other hand, the financial stress facing some heavily indebted households is seen by many as a problem requiring a public policy solution.

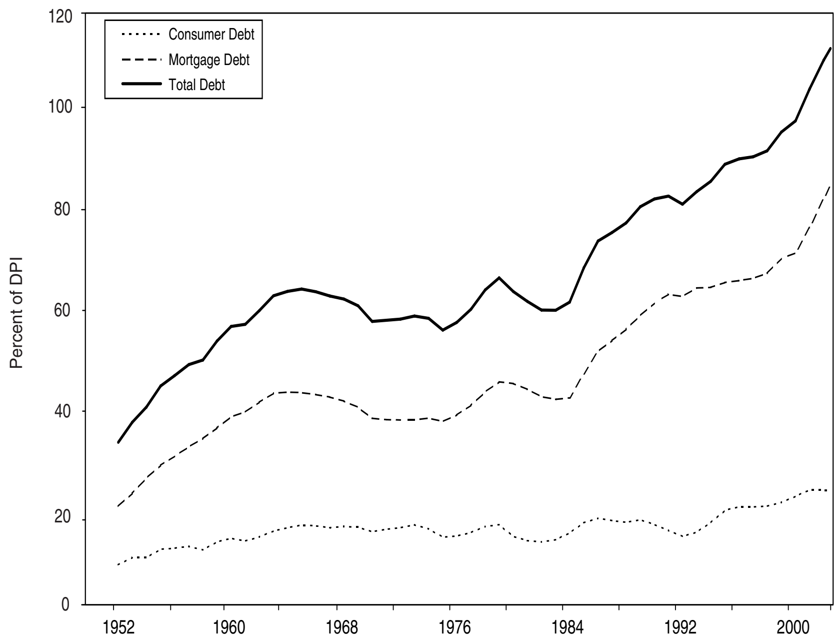
This essay explores the use of credit by U.S. households. The first section describes some facts concerning consumer borrowing and its growth in recent decades. The following sections present some of the economics of household borrowing, beginning with an explanation of the role of borrowing in helping a household to meet its consumption goals over time, and then using that perspective to interpret the facts. This perspective generally does not support the view that consumer debt causes future weakness in consumption growth at the macroeconomic level.

This essay's initial focus is on averages and aggregates, examining trends in total borrowing by U.S. households and assessing those trends from the point of view of the typical or average household. While this perspective is appropriate for thinking about broad trends in credit markets, it can mask the fact that market changes can have different impacts on different people. Indeed, these differences are often important to the way people think about public policy toward credit markets. A look at more disaggregated data, in fact, reveals that much of the expansion of credit that has occurred in recent decades has come in the lower brackets of the income distribution. Accordingly, the essay will address the question of whether the economics of borrowing by lower-income individuals is significantly different from the general economics of credit.

1. TRENDS IN CONSUMER CREDIT

How indebted are U.S. consumers? In 2004, the ratio of all consumer debt to disposable personal income was about 108 percent. The bulk of this debt, 84 percent of income, was in the form of mortgage debt, with the remaining 24 percent in revolving and nonrevolving consumer credit. Historically, the debt-to-income ratio has shown steady growth over much of the last half-century as is shown in Figure 1. Total debt to income stood at about 35 percent in 1952 and rose to around 50 percent by 1960. It then fluctuated between 55 and 60 percent for much of the 1960s and 1970s, before beginning a sustained increase in the mid-1980s. But by far the largest share of this growth has been

Figure 1 Household Debt Relative to Disposable Personal Income



Source: Federal Reserve Board of Governors

in the mortgage portion of household credit, which was 23 percent of income in 1952. By contrast, nonmortgage consumer credit roughly doubled in this 50-year period, going from 12 to 24 percent.

As is apparent, a very large part of the increase in household debt since the 1950s has been the rise of mortgage debt. To some extent, this rise in mortgage debt does not represent the typical homeowner borrowing more against the house that he or she owns. Rather, part of this increase is due to a steadily rising rate of homeownership, which went from 55 percent of U.S. households in 1950 to 69 percent in 2005. Another source of this increase is growth in the value of housing assets owned by consumers. Especially in the 1990s, the median value of privately owned homes grew faster than median income. Still, households have generally increased the share of their homeownership financed by mortgage debt.

Growth in the use of credit has been widespread among U.S. households. While borrowing by households in all income ranges has grown, this growth has been the most pronounced among households with medium and low levels of income. Also, while disparities in borrowing behavior continue to exist between minority and nonminority households, those disparities have tended to decline. This type of disaggregated information comes primarily from the Federal Reserve Board's Survey of Consumer Finances (SCF), which is conducted every three years. An analysis of trends for households in different ethnic and income groups was conducted by Raphael Bostic.[3] Trends for people at different income levels are discussed later in this essay.

Does rising debt to income mean that the typical household's debt burden has risen? The debt burden of a household is usually measured by the payments on its debts relative to its income. Given the wide variety of terms on retail credit—from fixed term, fixed interest rate mortgages to open-ended lines of credit with variable rates—specification of the "payments" used to determine the burden of servicing one's debts is not straightforward. But the two main determinants of a household's repayment obligation are the amount of debt and the interest rates charged. So, while a precise measurement of the payment burden would require detailed data on loan characteristics at a very disaggregated level, it is possible to construct a rough estimate from aggregate data. Dean Maki provides one such estimated time series of the aggregate debt burden of U.S. households.[4] For the time period covered in that series, from 1980 to 2000, the payment burden fluctuates around an average level of about 13 percent. The debt-service burden tends to rise during expansions and fall during recessions. This pattern reflects two other facts. First, interest rates tend to rise in expansions and fall in recessions. But, perhaps more importantly, the growth rate of consumer credit is also procyclical, with credit growing more rapidly in expansions, on average.

The burden households face in servicing their debts, together with the pattern of growth in those debts, focuses attention on the "credit is good, but debt is bad" dichotomy. Does the data on household debt suggest more that "credit" acts a tool for managing consumption growth or that the burden of "debt" constrains consumption growth, as is suggested in the popular media. Making this distinction empirically is difficult, since both these forces may be at work for any given household and the mix may vary considerably across households. Maki finds that his debt burden measure does not have strong predictive power for consumption growth, suggesting that, on average, debt is not a strong constraining force. In addition, growth in consumer credit tends to be positively correlated with future consumption growth. This relationship suggests that credit is an important tool for households in making their consumption choices. How household make those choices is the subject of the next section.

[3] Bostic (2002).

[4] Maki (2002).

2. HOW HOUSEHOLDS USE FINANCIAL INSTRUMENTS

It is important to view use of credit in the broader context of how a household chooses to consume and save or borrow over its lifetime. A household's financial decisions are driven by the fact that its income varies over time. Broadly speaking, there are two types of variation in income. First, there is a typical, largely predictable, pattern by which an individual's income first rises, say from young adulthood into middle age, then falls as the person or household moves into retirement. But there are also variations in income that are less predictable. Households face an array of shocks that affect their ability to participate and earn income in the labor market. Some of these shocks have only temporary effects, like an illness that keeps a worker out of the workforce but from which the worker fully recovers. Others can be more long lasting, like a permanent decline in demand facing an industry in which a worker has accumulated a great deal of experience and skill.

Against these variations in income, a household uses financial services related to saving and borrowing to achieve the best lifetime pattern of consumption possible. What makes one pattern of consumption better than another? Well, for one thing, more is better than less, so a pattern that gives a household more consumption of goods and services at every point in time is clearly better than one that gives less. But most comparisons of consumption patterns over one's lifetime are not so straightforward. In particular, saving and borrowing decisions have to do with trading off consumption today for consumption in the future. So the important point to bear in mind is that household financial decisions are driven not so much by how people feel about having a bigger savings account or being more in debt as they are by how people feel about having more consumption today versus more consumption in the future.

One principle for thinking about people's preferences for consumption over time and how those preferences affect financial decisions is that people typically have a preference for smooth consumption—consumption that doesn't vary too much over time. In other words, a household that gets a one-time windfall, like from winning a lottery, for example, will probably not want to spend it all immediately on consumption of goods and services. Rather, the lucky household will want to save some of its temporarily higher income so that it can spread the consumption benefits over a longer period of time. An important distinction here is between spending on durable versus nondurable goods. A lottery winner may in fact pour a large bulk of his or her winnings into the purchase of durable goods. But such expenditures bear a similarity to savings, because durable goods provide benefits to their owner over an extended period of time, and the key thing about consumption smoothing is that the individual will want to use a temporary rise in income to generate consumption benefits that last over a long time period. This logic works on the other side as well, when a household faces a temporary income shortfall but expects to have higher income in the future. Such a household will want to keep its consumption up by drawing down savings or borrowing against those future increases in income.

The desire for smooth consumption over time can be explained by economists' usual assumption of diminishing marginal utility. This simply means that the less someone has consumed of a good or of goods and services in general, the more eager he or she is to increase consumption. So, if a household has a low income today but expects a higher income in the future, it faces the prospect of having less consumption today than in the future. According to diminishing marginal utility, the household would be eager to give up some of its consumption in the relatively abundant future for a little more in the present.

The same characteristic of people's preferences for consumption that makes them prefer smooth consumption over time also makes them dislike facing risk to their consumption opportunities. That is, diminishing marginal utility of consumption implies that people are risk averse and will be willing to take costly actions or purchase costly insurance to avoid risk.

So the usual assumptions about consumer preferences imply that households will typically desire a smooth consumption path even as their incomes vary over time. The two main sources of income variation are life-cycle effects and the effects of shocks to an individual's ability to earn income. To a large extent, the life-cycle pattern of income is predictable. Labor income rises from young adulthood to middle age, reaches a peak in the 45-54 age range, and then falls. Smoothing consumption over this pattern of income would usually imply borrowing (or drawing down savings) when young, paying off debt and accumulating savings in the peak earning years, and using those savings for consumption in the later years.

Shocks to a household's income come in two forms. Some shocks are specific to an individual household. Prolonged illness of a wage earner, for instance, can limit a household's earning ability. This sort of specific uncertainty in income is referred to as idiosyncratic. Other shocks affect larger groups of people. Swings in employment caused by decline of an industry or by the ups and downs of the business cycle affect the incomes of many households. That is, some income fluctuations are associated with aggregate risk. Financial markets are more effective at helping people smooth consumption against idiosyncratic shocks than against systematic or aggregate shocks. In fact, if financial markets worked perfectly, then people would be able to completely protect themselves against idiosyncratic shocks. Similarly, complete and well-functioning financial markets would allow people to smooth out their lifetime variation in income, since this is largely predictable. In this case, the only fluctuations in consumption would be those arising from aggregate income risk.

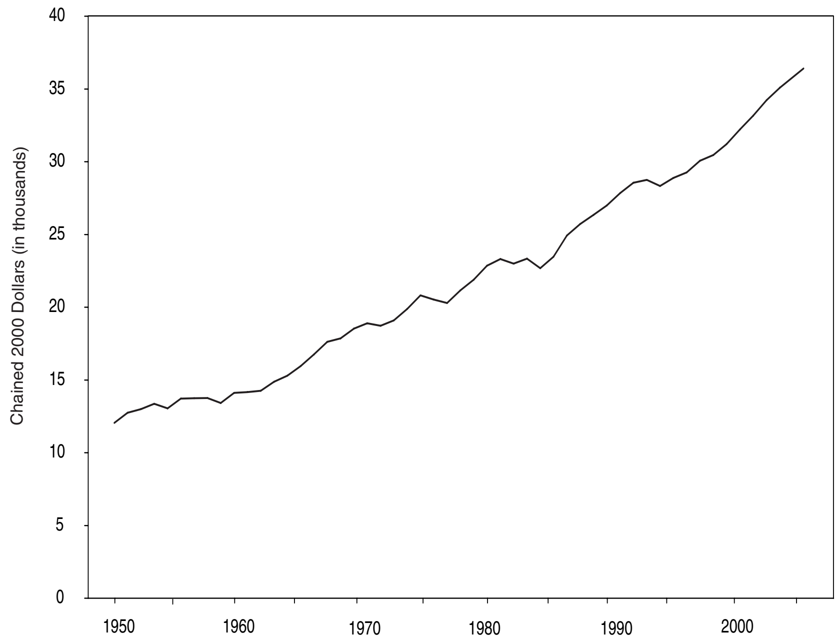
In perfect financial markets, in addition to cases where standard saving and borrowing instruments are used, households would have access to a wide array of contracts that would allow them to insure against any specific event that might cause a disruption to their incomes. But financial markets are not perfect, and there are limitations to households' abilities to smooth their consumption, even against idiosyncratic or life-cycle income fluctuations. Households and other market participants face an array of constraints on the types of financial contracts available for managing income risk. Some of these constraints have to do with information. Lenders typically cannot perfectly screen borrowers according to their likelihood or propensity to default. It is also difficult to monitor the behavior of borrowers once they have taken a loan. Other constraints have to do with the costs of enforcing contracts. Bankruptcy laws, for instance, limit the options available to a lender if a borrower defaults. These constraints have two kinds of effects. First, they limit the extent of specific insurance against income fluctuations that households can receive, making saving and borrowing the main means of consumption smoothing for many households. Second, the constraints tend to raise the costs of borrowing and place upper limits on the amount of debt any given household can accumulate. So while the bankruptcy option actually facilitates consumption smoothing for households that have fallen on hard enough times—by releasing them from some debt payment obligations—the more general effect of bankruptcy laws and other credit market constraints is to increase the cost of borrowing and to therefore limit opportunities to smooth consumption.

As Figure 1 clearly shows, the largest part of household debt is that used to finance housing. This specific use of credit is quite similar to the general use of credit for consumption smoothing purposes, since the purchase of a home—a very lumpy transaction—allows the household to consume a smooth stream of housing services. And while constraints associated with limited information and enforcement costs place limits on a household's unsecured borrowing capacity, such limitations are less stringent when borrowing is collateralized, as in the case of mortgage credit. Collateral reduces the risk of loss for the lender should a borrower become unable to repay a loan. Similarly, a portion of nonmortgage consumer credit is used to purchase cars and other durable goods. Much of this credit is tied directly to—that is, secured by—the items purchased. Still, the fastest growing part of nonmortgage credit, especially since the 1990s, has been unsecured borrowing.

3. THINKING ABOUT CHANGES IN CREDIT MARKETS—CAUSES

Figure 1 showed how consumers' use of credit has grown over time. This growth could be the result of a number of factors. One possibility is changes in the rate of income growth. Remember that in the most basic description of consumption behavior, a household will seek to perfectly smooth its consumption over time. This means that a household expecting a growing income will

Figure 2 Real GDP Per Capita



Source: Bureau of Economic Analysis

borrow against future income to even out its consumption expenditures. The amount that a household will want to borrow will depend on how rapidly it expects its income to grow. So the total amount of borrowing done by households in an economy might be expected to depend on the anticipated growth in income. This logic—faster anticipated income growth makes people willing to take on more debt—carries over to the case where financial markets (and therefore consumption smoothing) are not perfect.

There have, in fact, been several swings in average income growth in the United States in the last 50 years. Figure 2, for instance, shows real GDP per capita. Of particular note is an extended period of slow growth around 1980, with a pickup in growth beginning around 1984 and continuing to the present, with two brief interruptions for the recessions of the early 1990s and the early 2000s. This latter period of faster income growth roughly coincides with the period of greatest growth in household debt-to-income ratios. And debt growth was basically flat during the extended period of stagnating income growth.

People's beliefs about their future income prospects are one determinant of the demand for credit. Demand could also be affected by variability of income. Given the limitations to financial arrangements that result from information and enforcement constraints, saving and borrowing constitute the main tool used by households to smooth consumption in the face of income risk. A household will feel well-prepared to deal with shocks to its income if it has a pool of savings to draw on or if it is confident that it will have ample access to credit. So, if a household faces an upper limit on how much credit it will receive from financial institutions, it will want to make sure it stays far enough away from that upper limit so that hitting the limit in the event of a reduction in income would be unlikely. If income risk increases—if income becomes more variable—the household will want to increase this cushion between its borrowings and its debt limit.

Evidence examined by Dirk Krueger and Fabrizio Perri suggests that income risk faced by households has increased since 1980, implying a rising possibility of running up against limits on debt capacity.[5] This change could have been a force for lessening household demand for borrowing, perhaps partially offsetting the increase in demand that is likely to have come from faster income growth. On the other hand, Krueger and Perri argue that rising income risk could actually increase a household's borrowing capacity. Their argument follows from the assumption that, following default on a loan, a household's access to credit would be sharply reduced. Rising income risk makes losing access to credit more costly and therefore could make a borrower less likely to default. Knowing that a borrower is less likely to default makes a lender more willing to lend. So the effects of rising income risk on overall household borrowing are uncertain. But there are other factors affecting both demand and supply that could be at work in U.S. credit markets.

The make-up of household consumption among housing services, durable goods, and nondurable goods is one additional demand-side factor that could affect household borrowing. Since homes and durable goods are quite typically purchased with credit, an increase in consumers' relative demand for these goods could well be associated with an increase in borrowing. Some evidence in favor of this factor appeared earlier in this essay. As previously mentioned, rising homeownership and rising home values relative to income are at least suggestive of an increase in the relative demand for housing.

Also on the demand side, a household's willingness to borrow could be affected by its perceptions about the consequences of default. In the United States, defaulting borrowers can seek the protection of the bankruptcy law, which allows them to either reschedule their payments to their creditors (under Chapter 13 of the bankruptcy code) or dismiss their debts in exchange for

[5] See Krueger and Perri (2005).

surrendering their assets, above a personal exemption (under Chapter 7, with exemptions determined at the state level). Some observers have argued that a greater propensity to file for bankruptcy is evidence of consumers seeing default as less costly than in the past and is one cause of rising consumer indebtedness. This is often discussed in terms of a sense of stigma that households may feel when filing for bankruptcy. The argument is that stigma, a psychic cost of default, has declined over time, perhaps for cultural reasons not directly related to credit market conditions. Such a decline of the perceived costs of default would make a household more willing to borrow at a given interest rate.

But the effect that a decline in stigma or in other costs of default has on borrowing amounts is at least muted because of the effect this change would have on lenders and the price of credit. Borrowers who increase their debt because they do not mind defaulting increase the risk faced by lenders, and lenders, in turn, will have to raise their interest rates in order to compensate for this increase in risk. This rise in interest rates will tend to reduce borrowing, especially by those who consider themselves unlikely to default. In fact, Kartik Athreya has shown that the overall effect of declining stigma would likely be a decline in total borrowing.[6]

There could also be factors on the supply side of credit markets that contributed to a period of rising debt among U.S. households. In particular, technological improvements have reduced the costs to lenders of evaluating borrowers and managing exposures to default risks. This type of change would amount to a reduction of the overall cost of lending and would thereby lead to an increase in the supply of credit. This increase in supply would show up in a reduction in the financial intermediary's "spread" between the interest paid to retail savers and the rate charged on loans.

Of course, the financial intermediary that makes the loan is not the ultimate supply of funds to a borrower. Rather funds originate with the savings of other households or businesses. And the funds could come from within the same country or from abroad. In recent years, funds from other countries have indeed been a major source of supply for U.S. credit markets. Even though the bulk of this foreign investment is the purchase of government securities, these transactions do constitute an increase in the total amount of funds flowing into U.S. financial markets, which could translate into an easing of credit conditions for borrowing households.

Interpreting evidence on interest rates or spreads over time is made difficult by another trend in the pricing of loans. There is an increasing tendency of lenders to differentiate their lending terms based on borrower characteristics that are associated with default risk. In the 1980s, consumer lenders, especially

[6] See Athreya (2004).

for unsecured debt like credit card borrowings, usually set a single interest rate at which they lent to all acceptable borrowers. Lenders then used relatively rough evaluations of borrower-default risk to determine who got credit.

Advances in credit scoring and other techniques allow lenders to estimate borrowers' default risk in a more precise way than was possible in the past, making it easier to offer different prices to borrowers, depending on their risk characteristics. This change has differing effects on the various types of borrowers. Very low-risk borrowers probably benefit, as they pay an interest rate that more closely reflects their risk level. On the other end of the spectrum, high-risk borrowers, who previously were screened out of access to credit, also benefit by finding their ability to borrow enhanced. Borrowers in the middle, on the other hand, could be hurt by a move from uniform to differential pricing of credit. These in-between borrowers may have benefited in the past from interest rates that averaged them in with lower-risk borrowers. The effects on different types of borrowers of increased use of differential pricing are detailed by Wendy Edelberg.[7] Still, the technological change that makes differential pricing more practical is the same change that lowers the overall costs of lending, making it likely that many, if not most types of borrowers, have seen either a reduction in the cost of borrowing or an increase in access to credit.

Another change on the supply side of credit markets that would have effects similar to declining costs of lending is an increase in the degree of competition among lenders. If competition is weak, then lenders are able to set interest rate margins at levels that more than compensate for risk and the costs of lending. Many descriptions of the credit card lending market describe it as having relatively weak competition in the 1980s.[8] The structure of the credit card market has changed considerably since then, with many observers concluding that increased competition has put downward pressure on interest rate spreads. Competition appears to have increased in the mortgage lending market as well, where consumers are increasingly able to search over a nationwide pool of potential lenders, rather than being restricted to a smaller set of local firms. Falling average costs of borrowing, from a combination of improved technology and increased competition, appears to be a major contributing factor to the expansion of consumer credit.[9]

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[7] Edelberg (2003).

[8] A notable example is Ausubel (1991).

[9] Athreya (2004) examines alternative sources of rising credit and finds a strong case for technology and/or competition as a primary factor.

4. THINKING ABOUT CHANGES IN CREDIT MARKETS—CONSEQUENCES

Changes in credit market conditions shift the demand or supply of credit, resulting in changes in the amount of borrowing done by households. The data show clearly that the net effect of these changes in recent decades has been to increase borrowing relative to income. But to evaluate these changes, we would like to have a sense of how they affected the overall economic well-being of the typical household. Some of the changes discussed in the previous section were supply changes that have the effect of reducing the cost of borrowing. These changes enhance households' ability to smooth their consumption and are therefore likely to make the average household better off.

When an increase in borrowing is driven by increases in demand for credit, the effect on a household's well-being depends on the reasons for the increase in demand. For instance, a temporary increase in borrowing could result from a disruption to a household's income. While the use of credit allows the household to respond efficiently to the disruption, the rise in borrowing in such an instance is occurring as the household is becoming worse off. So, a short-lived surge in borrowing could be an indicator of households experiencing some financial stress. But the evidence reviewed in this essay deals more with a sustained rise in borrowing. As discussed previously, the demand-side factor most likely to be associated with such a sustained increase is rising expectations of income growth. In this case, increased debt would be associated with improving economic well-being.

Given that a main motivation in households' use of credit is smoothing of consumption, one way to assess the impact of credit expansion is to ask whether this expansion has facilitated consumption smoothing. The previous section noted evidence studied by Krueger and Perri that points to rising income risk for U.S. households since the 1980s. These authors also examine the variability of consumption and find that, while consumption risk has risen over time as well, it has not risen nearly as much as income risk. They conclude that households' ability to smooth consumption has improved over time, consistent with a view that the expansion of credit has, on average, benefited households.

The fact that the typical household's welfare improves with a sustained expansion of credit does not mean that such a trend creates no problems or difficulties. Most importantly, the forgoing discussion assumes that household decisionmaking is well-informed by the relevant facts and based on sound analysis of the costs and benefits of credit. While this may be a reasonable assumption for enough households to make our conclusion about the "average" household valid, there may well be households whose decisions are imprudent, naïve, or based on faulty analysis. This may be particularly true in a period when credit use is growing relatively rapidly. First, a period of credit expansion may be a period when the number of new and inexperienced borrowers is particularly high, and such borrowers may be more likely to make mistakes in their financial decisions. Second, if the growth of credit is associated with the introduction of new credit instruments or new ways of pricing credit, even some more experienced borrowers may not fully appreciate the implications of their decisions under the new arrangements.

If credit market changes leave some consumers relatively uninformed about the choices they face, then these changes could also create opportunities for some providers of credit services to exploit consumers' lack of knowledge. It should, therefore, not be surprising to see periods of rapid credit growth coincide with increased instances and allegations of abusive practices. One particular area of change and growth in credit markets in the last 15 years has been in subprime lending. Products and practices in the subprime market have expanded the set of consumers with access to credit, meaning the average subprime borrower is even more likely to be an inexperienced borrower than the average borrower overall. So, in recent years we have seen rising public concern regarding potentially predatory lending, or abusive practices in the subprime lending market.

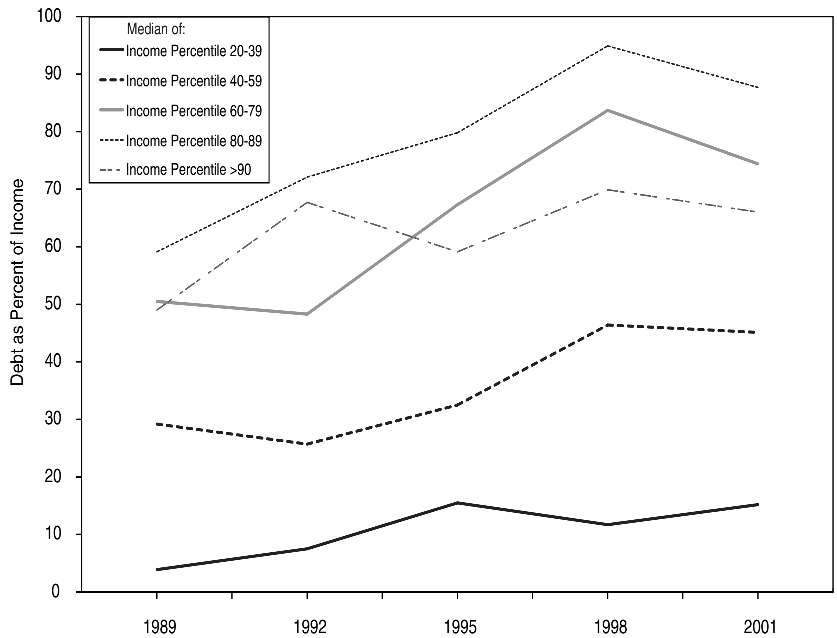
Of course, even for borrowers who are capable of evaluating their credit market opportunities and making well-informed decisions, outcomes are not always positive. A consumer may face unanticipated expenses or changes in income that limit the ability to service debt, leading to default, bankruptcy, or foreclosure on a mortgaged home. And it is often hard to know, after the fact, whether a distressed borrower made a sound financial decision at the time a loan was originally taken out. So distinguishing those who were victimized from those who were careless and from those who were just unlucky is not always possible.

The growth in bad outcomes from borrowing, a trend that follows from the general growth in the use of credit, can be a driving force for proponents of a public policy response to credit market phenomena. As more borrowers find themselves experiencing difficulties, sentiment emerges for policies that could keep consumers out of credit-induced financial trouble. With such policies tending to be aimed at protecting borrowers of low and moderate means, a look at the relevant facts regarding credit use by households of different income levels may prove useful.

5. BORROWING TRENDS ACROSS THE INCOME DISTRIBUTION

The data presented in Figure 1 provide a picture of the borrowing behavior of the entire household sector. That is, these data might be thought of as reflective of the average household in the United States. These trends appear to be explained by the supply and demand factors discussed in the previous section. But as was mentioned before, changes in credit market conditions

Figure 3 Total Debt to Income for Select Income Percentiles



Source: Federal Reserve Board of Governors

do not affect all households in the same way. In particular, the uses and consequences of debt may differ among households at different income levels. Figure 3 presents information on household borrowing trends across the income distribution. These data are drawn from the Federal Reserve Board's SCF, which is conducted every three years, with the most recent data coming from the 2001 survey.[10] The data from this source do not stretch back as far as the aggregate data, but they do include the period of rapid credit growth in the 1990s.

The five graphs in the figure show the growth in median debt-to-income ratios for the second, third, and fourth income quintiles and for the top two income deciles. In broad terms, the trends for different income quintiles look similar to the aggregate, with debt-to-income ratios rising steadily through the 1990s. In percentage terms, this growth was the most pronounced for the group between the 20th and 39th percentiles, which registered a 290 percent

[10] At the time this Report was in production, the 2004 SCF results had not yet been released.

increase, albeit from a very low base. By contrast, the median debt-to-income ratio among the wealthiest households—the top quintile—rose by 48 percent.

The poorest consumers—those in the lowest income quintile—are missing in Figure 3. This is because the figure shows median debt to income for each quintile, and throughout this period, fewer than half of all households in the lowest quintile had any debt. If we were to plot, instead, the median ratio in each quintile only for those households with debt, the lowest quintile would look more similar to the others. Doing this leaves out growth in debt that comes from increased participation in credit markets and measures only the extent to which borrowing increased by people who were already borrowing. Among households having at least some debt, debt-to-income ratios grew fastest—78 percent growth from 1989 to 2001—for households in the lowest quintile. At the same time, the fraction of low- and moderate-income households with debt increased during this period. This rate of "participation" in taking on debt increased in all income groups below the median, with the fastest growth coming in the second lowest quintile.

The predominance of debt-to-income growth among households in the lower part of the income distribution raises questions about whether the causes or consequences of growing credit use among these households are different than for households at or above the median income level. As described in Section 3, there are both demand and supply factors that have contributed to the growing use of credit among U.S. households. On the demand side, a major determinant of borrowing is a household's expectations of income growth. The growth of the aggregate use of credit in the 1990s lines up well with a pickup in income growth during that period. But income growth was uneven, with income inequality expanding. That is, the acceleration of income growth occurred more for higher-income households. So this demand-side factor might not have been as important for the growth of borrowing by low-income households.

On the supply side, the main factors increasing debt have been improvements in technology that allow improved underwriting practices and a move to greater sensitivity of prices depending on borrowers' risk characteristics. Both of these factors are likely to have improved financial markets' and institutions' ability to bear the risks associated with lending to lower-income households. The greater variability of pricing, in particular, is likely to have helped expand credit to households that previously would have been rationed out of the credit market. This effect may be reflected in the growth in the fraction of low-income households that hold credit.

To the extent that growing credit use among low-income households is being driven by growth in the number of borrowers, it is likely that this expansion has brought new, inexperienced borrowers into the market. This is consistent with the direction of much of the recent discussion about consumer credit policy.

6. POLICY RESPONSES TO CHANGES IN CREDIT MARKETS

There are three broad types of policy approaches to limiting financial difficulties for borrowers. First, one can imagine policies aimed at the problem of borrowers being uninformed about financial choices. Second, policies that seek to identify and punish instances of abuse by lenders could provide some protection to borrowers. Finally, regulators could try to place limits on the terms and prices that lenders can offer in the marketplace.

Efforts to raise consumers' understanding of financial choices have gained considerable attention recently. There are two broad sets of tools that serve this goal. One can require disclosures by lenders with the aim of ensuring that consumers can easily compare alternative credit options. This is the approach taken under the truth in lending laws. It is not always easy to summarize all of the relevant conditions in a credit contract with a few simple numbers, however. As the variety of terms and conditions available in the market continues to expand, there may be a limit to how much disclosures alone can enhance consumer knowledge.

The other avenue to creating better informed consumers is through the provision of financial literacy services. Credit counseling is one form of such services, and the 2005 bankruptcy legislation included counseling from an approved nonprofit provider as a precondition for bankruptcy filing. The act also provides for the development of postfiling educational materials. There has also been movement in some states to require financial literacy curricula in public primary and secondary schools. Some financial institutions and trade associations have become directly involved in the development of financial literacy programs, perhaps as an investment in their public image, but also perhaps because many banks see better informed customers as a legitimate business goal.

What exactly is it that consumers should learn from financial education? The goal, presumably, is for a household to be able to make informed, forward-looking choices with regard to the use of credit instruments. But being able to fully calculate the expected present value of different options may be beyond the reach of many consumers. Retail credit products are not simple financial contracts. They often involve provisions that amount to options for either the borrower or the lender. Such options might be explicit in the contract, like the option to prepay a mortgage, or implicit, like the option to file for bankruptcy. Accurately evaluating options is difficult, even for the financially sophisticated. Perhaps one realistic goal of financial education is for borrowers to appreciate that if one credit alternative has a lower initial monthly payment than another, then it is probably more costly on another dimension. Borrowers who can understand such trade-offs are less likely to make choices that have a high chance of negative outcomes.

A by-product of raising the level of financial savvy among borrowers is that the potential gain to deceptive and abusive practices would be reduced.

Still, there will always be instances of such behavior, and effective law enforcement is an important supplement to a well-informed population of borrowers. Prosecution of specific acts, however, is difficult and costly, leading some to advocate credit market regulations that prohibit certain practices that are believed to be particularly susceptible to abuse. The prospect of prohibiting specific contractual terms presents a difficult trade-off. Such a prohibition may effectively prevent some instances of bad outcomes such as defaults, foreclosures, or bankruptcies. And some of those instances would undoubtedly represent cases where it was probably not in the borrower's best interest to take out a loan with the particular terms. Some would be the result of borrowers simply making mistakes, and some would arise from lenders being deceptive or manipulative. But some cases of bad outcomes would result even for borrowers making sound, well-informed choices. For those, the particular credit contract was the best option at the time they borrowed.

A prohibition of a particular practice limits some households' ability to manage their finances and consumption. So such a regulatory approach to credit market behavior necessarily protects some borrowers at the expense of others. Still, one could argue that such a policy is warranted if it were the case that the group that would be helped is much larger than the group that would be hurt, or if the amount by which some are helped significantly exceeds the amount by which others are hurt. But the type of data necessary to make this kind of determination is very hard to come by. To fully understand the overall impact on borrowers of a particular lending practice and to assess the likely effect of prohibiting it, one would want to take a look at a sample of households, some who used the product in question and some who did not. By tracking that sample for a considerable period, both before and after taking on the loan, one would reveal the average determinants of using the product together with its impact.

Without such detailed data, the regulatory prohibition of lending practices should be viewed very cautiously. The general description provided in this essay of the economics of and trends in household credit suggests that, on the whole, the growth of credit we have observed in recent decades has been beneficial for consumers, providing them with an expanded set of options for managing their lifetime consumption. And this observation points to an important principle for evaluating changes in credit markets, whether those changes are in the form of new products or new regulations. The decision to borrow is inherently a forward-looking decision. Households borrow to align their consumption today, as well as their holdings of housing and durable goods, with their beliefs about their consumption possibilities in the future. Accordingly, the appropriate perspective in evaluating the addition or elimination of a credit product is from the point in time at which a household is making a borrowing choice. Is a household made better off or worse off by having access to this product? Adopting this perspective does not mean that one should ignore the bad outcomes that result from use of the product. It means, instead, that one should think of those bad outcomes as part of a distribution of possible outcomes and ask whether this distribution presents the household, on average, with better consumption opportunities than would be available without the product. Without the data necessary to evaluate the distribution of outcomes, we are left simply knowing that the elimination of a particular credit product may help some but hurt others. Simply knowing that there is a trade-off is a first step, but a small step on the way to policy analysis.

REFERENCES

Athreya, Kartik. 2004. "Shame as It Ever Was: Stigma and Personal Bankruptcy." Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Spring): 1–19.

Ausubel, Lawrence. 1991. "The Failure of Competition in the Credit Card Market." *American Economic Review* 81 (March): 50–81.

Bostic, Raphael W. 2002. "Trends in Equal Access to Credit Products." In *The Impact of Public Policy on Consumer Credit*, eds. Thomas Durkin and Michael Staten. Boston: Kluwer Academic Publishers, 171–203.

Calder, Lendol. 1999. *Financing the American Dream: A Cultural History of Consumer Credit*. Princeton: Princeton University Press.

Edelberg, Wendy. 2003. "Risk-based Pricing of Interest Rates in Household Loan Markets." Board of Governors of the Federal Reserve System, Divisions of Research & Statistics and Monetary Affairs, Finance and Economics Discussion Series 2003-62.

Eisinger, Jesse. 2006. "Night of the Living Debt." *Wall Street Journal* (January 4): C1.

Krueger, Dirk, and Fabrizio Perri. 2005. "Does Income Inequality Lead to Consumption Equality? Evidence and Theory." Federal Reserve Bank of Minneapolis, Research Department Staff Report 363 (June).

Maki, Dean. 2002. "The Growth of Consumer Credit and the Household Debt Service Burden." In *The Impact of Public Policy on Consumer Credit*, eds. Thomas Durkin and Michael Staten. Boston: Kluwer Academic Publishers, 43–63.

The Productivity of Nations

Margarida Duarte and Diego Restuccia

In this article, we document observations on labor productivity across countries over time. Using data from Heston, Summers, and Aten (2002) on gross domestic product (GDP) per worker—our measure of labor productivity—we emphasize three main facts about the distribution of labor productivity across countries between 1960 and 1996.[1] First, there is substantial dispersion in labor productivity across countries. For instance, in 1960 an average worker in the richest 5 percent of countries in the world produces about 35 times more output than an average worker in the poorest 5 percent of countries in the world.

Second, disparity in labor productivity has increased over time. By 1996, the labor productivity ratio between the richest and poorest countries increased to approximately 46. This increase in disparity is explained by a substantial deterioration in labor productivity in the poorest countries of the world relative to that of the United States. We report several statistics of dispersion indicating that labor productivity differences between the richest and poorest countries have increased since the mid-1980s. This characterization of increased dispersion in labor productivity contrasts with a relative stability documented in previous studies, in which the coverage period ended in 1985.

Third, there is substantial mobility of individual countries in the distribution of labor productivity over time. For instance, labor productivity in Hong Kong relative to that in the United States rose from 19 percent in 1960 to 94 percent in 1996—an increase of a factor of almost 5 during the period—while relative labor productivity in Venezuela declined from 94 percent in 1964 to 36 percent in 1996—a more than twofold drop in relative productivity. We also document a number of individual episodes of growth and decline. Ac-

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[1] Throughout the article, we refer to GDP per worker, output per worker, and labor productivity interchangeably.

counting for these specific labor productivity paths may prove useful not only from a policy perspective, but also in testing and improving existing theories of productivity levels or in the development of alternative theories.

This article relates to a large literature on the world distribution of income that includes Kaldor (1961), Kuznets (1966), Maddison (1995, 2001), Parente and Prescott (1993), Chari, Kehoe, and McGrattan (1996), Jones (1997), among many others. We contribute to this literature by adding the period between 1985 and 1996 to the analysis. In addition, we focus on output per worker as opposed to output per capita since output per worker relates more directly to theories of labor productivity. The difference between the two measures is given by the employment-to-population ratio. While there are substantial differences in these ratios across countries, the differences are not systematically related to development. Therefore, our summary statistics characterizing output per worker over time are similar to statistics calculated using output per capita. However, there are substantial changes in employment-to-population ratios for individual countries over time, and these changes are not systematically related to development or growth in relative productivity. Therefore, for an individual country, changes in output per capita can severely overstate or understate changes in labor productivity.

There are two additional differences between this article and the previous literature. First, we characterize disparity and mobility using trended data. That is, we use the Hodrick-Prescott filter to abstract from business-cycle fluctuations in the data. Second, we seek to systematically identify remarkable episodes of growth (positive or negative) in the data at some point during the 1960–1996 period. In the literature, countries facing these episodes are typically referred to as miracles and disasters. We document 13 miracle and 17 disaster episodes in our data set. Among the miracle episodes, we report the movement of labor productivity in Botswana relative to that in the United States from 7 percent to 30 percent in 26 years; in Hong Kong, from 19 percent to 94 percent in 36 years; and in China, from 4 percent to 8 percent in 18 years. We also document the recent, but not yet as long, growth episodes of Chile, Ireland, and India, which may become miracle episodes within the next two decades.

Furthermore, we also systematically document depression episodes in our panel data. Ever since the study of the Great Depression in the United States by Cole and Ohanian (1999), there has been substantial interest in studying depression episodes (defined broadly as periods of lower-than-usual relative productivity).[2] We follow this literature in characterizing depression episodes by using the raw data on output per worker relative to a trend growth of

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[2] This marked interest is reflected, for instance, in the work of Prescott (2002) and in several articles published in a special volume of the *Review of Economic Dynamics* edited by T. Kehoe and E.C. Prescott (see Kehoe and Prescott 2002).

2 percent per year. Even in our relatively small sample period, we find that depressions are quite common, both among rich and poor countries. We report 29 depression episodes in Section 4.

Our study also relates to a broad literature on models that seek to explain development facts such as those of disparity and mobility discussed above. For excellent surveys of this literature see, for instance, Klenow and Rodríguez-Clare (1997) and Caselli (2005). Our study complements this literature by expanding and updating the set of facts that theories of development should be able to explain.

This article is organized as follows. In the next section, we describe in detail the data we use for the analysis. Section 2 documents the main facts about dispersion and mobility in the distribution of labor productivity. In Section 3, we discuss the remarkable episodes of growth during the period, namely miracle and disaster episodes, and in Section 4, we document the episodes of depressions. Section 5 discusses our main findings relative to those using instead output per hour, an alternative sample of countries, and output per capita. We conclude in Section 6.

1. DATA

We focus on output per worker as our measure of labor productivity. We use annual data on PPP-adjusted GDP per worker in chained 1996 prices obtained from Heston et al. (2002), also known as the Penn World Table V6.1 (PWT6.1). We choose the PWT6.1 for our analysis because it is the most comprehensive source of comparable measures of output per worker across countries.

We focus on output per worker in order to emphasize the connection of the data with research on productivity differences across countries. Although output per hour is a more complete measure of labor productivity, we abstract from differences in hours per worker across countries due to the lack of systematic data for a large number of countries over the entire period of our study. However, in Section 5, we use the available data on hours per worker to calculate output per hour and discuss our findings relative to this more complete measure of labor productivity. Measures of output per capita are appropriate when the focus is on wealth differences across countries.[3] We also discuss our findings relative to the use of output per capita in Section 5.

[3] Maddison (1995, 2001) documents comparable measures of output per capita for a wide range of countries and time periods. However, we note that, as in the PWT6.1, Maddison uses the detailed price data from the International Comparisons Project (ICP) of the United Nations to calculate purchasing power parity (PPP) conversion factors at a point in time, and national accounts data to extrapolate over time. In this sense, Maddison's output data is comparable to PWT6.1, especially for the Benchmark countries (see Section 5 for a definition of Benchmark countries).

Our data set consists of annual observations for 99 countries from 1960 to 1996.[4] The countries in our data set satisfy two restrictions. First, the total population of each country was at or above 1 million people in 1996. Second, data was available at each date from 1960 to 1996. We make this second restriction in order for the sample of countries to be constant throughout the period of analysis. Data is available for 48 countries from 1950 to 2000. However, countries without observations between 1950 and 1960 and between 1996 and 2000 tend to be poorer countries. Thus, the smaller sample from 1950 to 2000 is less representative of the world distribution of output per worker than our sample with 99 countries from 1960 to 1996.

In documenting observations about dispersion, mobility, and miracles and disasters, we abstract from business-cycle fluctuations and trend the data using the Hodrick-Prescott filter.[5] Abstracting from business-cycle fluctuations when reporting development facts is not innocuous. As we document in Section 4, countries undergo episodes of substantial growth and decline that are not entirely related to their development process. To illustrate the cycles in the annual data, we report in Figure 1 the raw data on output per worker and the trended data for four countries: the United States, Argentina, Romania, and Switzerland. As is true with many other countries in our panel data, these countries have undergone relatively short-lived variations in their output per worker at different points in time. Our documentation of the development facts abstracts from these fluctuations.

For the most part, we report statistics on output per worker relative to that of the United States. Our view is that the United States is a rich, stable, and diverse country. For most of the period of analysis, the United States had the highest labor productivity. Moreover, in the post-war period, (trended) labor productivity grew at roughly 2 percent per year. Therefore, the United States represents a good benchmark against which to measure potential gains in labor productivity in all countries.

2. LABOR PRODUCTIVITY ACROSS COUNTRIES

We emphasize three facts about the distribution of labor productivity across countries. First, there is a large disparity in output per worker across countries. Second, there is a substantial increase in disparity over time. Third, there are substantial movements of individual countries in the world distribution of productivity. In the remainder of this section we characterize these facts in detail.

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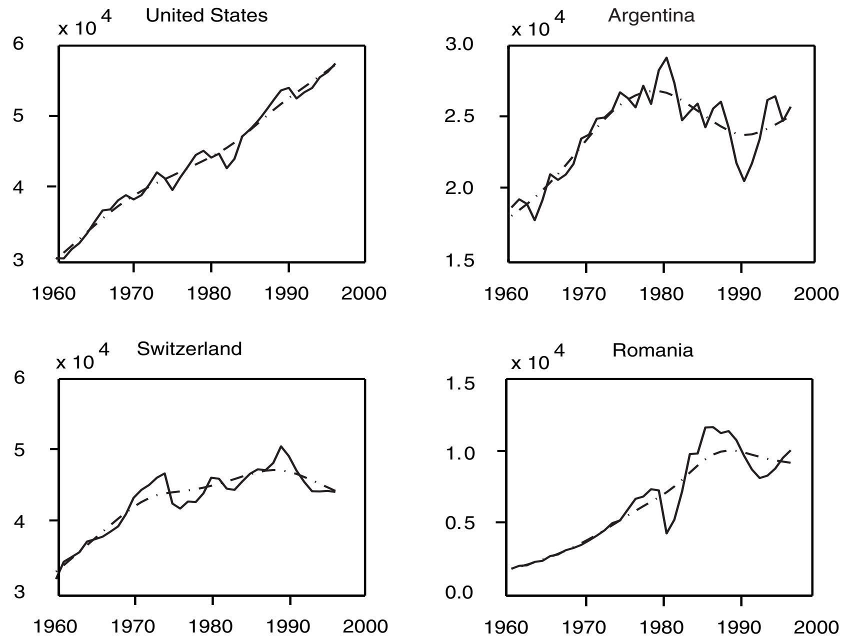
[4] See the Appendix for a list of countries in our data set.

[5] We set the smoothing parameter λ equal to 100.

Figure 1 Output per Worker in Four Countries



Notes: For each country, the solid line represents the raw data on output per worker and the dotted-dashed line the HP-trended data.

Disparity

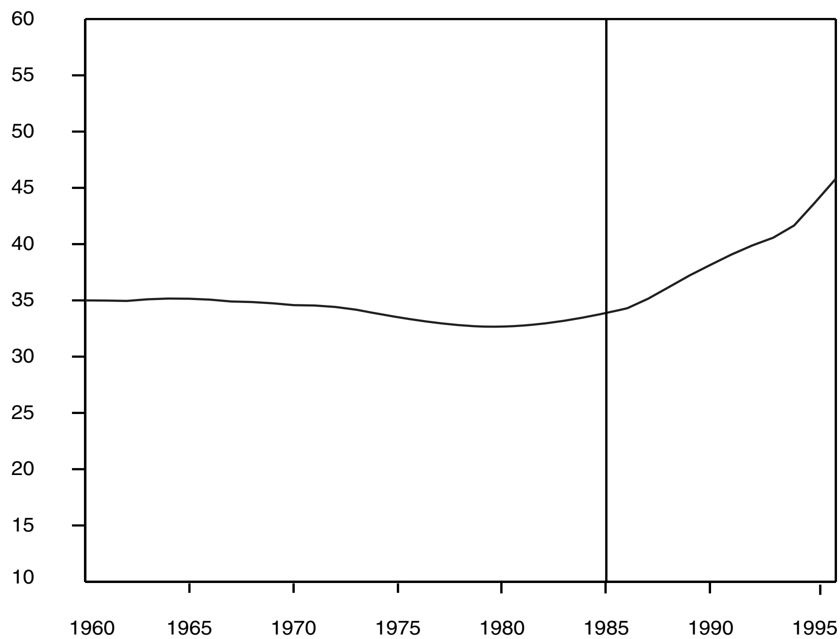
A remarkable fact of modern development data is the large disparity in productivity among countries. Here we focus on different measures of disparity and their evolution between 1960 and 1996.

We start by focusing on the five richest and five poorest countries in our sample. We compute the ratio of average output per worker for the five richest and five poorest countries for each year from 1960 to 1996, illustrated in Figure 2. This ratio varies between 35 and 46 over the period of analysis. That is, the average worker in the richest countries produces between 35 and 46 times more output than the average worker in the poorest countries. These are remarkable differences in labor productivity.

This measure of disparity in productivity across countries has been roughly constant from 1960, at 35, until the mid-1980s. The ratio declined slightly around 1980 but has increased steadily since then to a factor of 46 in 1996.[6]

[6] The ratio of average output per worker for the 5 richest and 5 poorest countries computed using the data set of 48 countries with data from 1950 to 2000 shows the same pattern as in

Figure 2 Output per Worker—Ratio of Five Richest to Five Poorest Countries



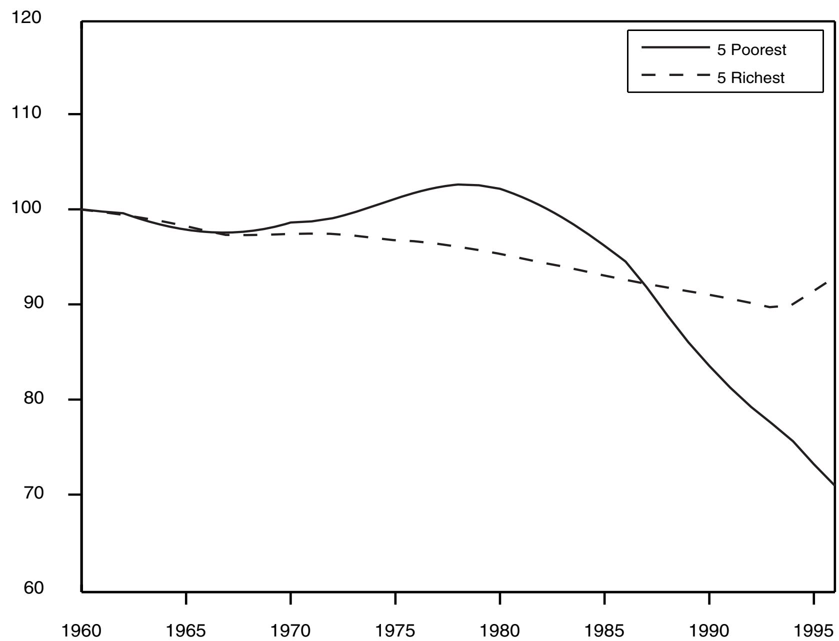
Notes: Between 1960 and 1996, the following countries comprised the five richest at some point in time: the United States, Switzerland, Canada, New Zealand, the Netherlands, Belgium, Italy, Norway, and Hong Kong. During the same period, the following countries comprised the five poorest countries at some point in time: Tanzania, Guinea Bissau, Burundi, Ethiopia, Burkina Faso, Uganda, and the Democratic Republic of Congo.

This increase in dispersion runs contrary to the established view in the development literature that dispersion in the world distribution of productivity has been rather constant over time (see, for instance, Parente and Prescott 1993; Chari, Kehoe, and McGrattan 1996). The reason for this view is that until about 1985 (the end date in most previous studies), the productivity ratio of the richest to the poorest countries was roughly constant. See Figure 2 where the line drawn at 1985 emphasizes the connection with the earlier literature.

In Figure 3 we report the relative productivity of the five poorest and five richest countries between 1960 and 1996, each normalized to 100 in

Figure 2. For this data set, the ratio of rich to poor increases steadily from the early 1980s to 2000.

Figure 3 Relative Output per Worker—Five Richest and Five Poorest (1960=100)



Notes: Average output per worker relative to the United States for the five richest and five poorest countries. Both series are normalized to 100 in 1960. In 1960, the average relative output per worker of the five poorest countries is 2.8 percent, while for the five richest countries, it is 99 percent.

1960.[7] This figure shows that the increase in dispersion in relative productivity between the richest and poorest countries reported in Figure 2 is mostly due to the decline in relative productivity of the five poorest countries. Between 1960 and 1996, relative productivity in the richest countries fell by about 10 percent, while relative productivity in the poorest countries fell by about 30 percent. It is of interest to note that even the five richest countries declined in productivity relative to that in the United States. Duarte and Restuccia (2006) show that the decline in productivity in the richest countries relative to that in the United States is accounted for by the movement of employment to the

[7] In 1960, the average output per worker of the five poorest countries relative to that of the United States is 2.8 percent, while the average of the five richest countries is 99 percent. By 1996, average relative labor productivity is 2 percent in the five poorest countries and 92 percent in the five richest countries.

Table 1 Relative Output per Worker by Decile

	1960	1970	1980	1990	1996
Deciles:			(percent)		
D1	3.4	3.3	3.4	2.8	2.4
D2	6.0	5.8	5.5	4.6	3.7
D3	7.8	7.9	7.7	6.4	5.4
D4	11.0	10.6	12.2	11.4	10.6
D5	16.7	18.1	20.1	17.8	17.4
D6	21.2	22.8	27.8	25.1	23.9
D7	27.2	32.8	34.5	31.7	32.5
D8	38.6	44.1	50.2	48.0	51.0
D9	56.6	65.3	70.2	69.5	72.7
D10	89.6	89.7	88.3	85.2	86.0
Ratios:					
D10/D1	26.3	27.1	25.9	30.9	35.6
D9/D2	9.5	11.3	12.7	15.2	19.6

Notes: Decile i (Di) includes countries within the $10 \times (i-1)$ and $10 \times i$ percent of the distribution.

service sector (associated with the process of structural transformation) and the low labor productivity in this sector relative to that in the United States.

We now focus on the entire distribution of labor productivity across countries. Table 1 reports the average relative output per worker of countries at each decile of the distribution of countries and for a selected number of years. The first decile includes the 10 percent of countries at the bottom of the distribution of output per worker, while the tenth decile includes the 10 percent of countries at the top of the distribution of output per worker. The last two rows report the ratio of the tenth decile to the first and the ratio of the ninth decile to the second.

In 1960, the poorest 10 percent of countries had an average labor productivity of around 3 percent of that of the United States, while the richest 10 percent of countries had an average productivity of 90 percent of that of the United States, yielding a ratio of 26 between the richest 10 percent to the poorest 10 percent of countries. In turn, for the same year, the ratio of productivity for countries in the ninth decile to the second decile is a factor of almost 10. Note that these ratios increase substantially during our period of analysis, but especially do so after 1980. Note also that, over time, countries in the sixth, seventh, eighth, and ninth deciles improved their average relative productivity (particularly those in the eighth and ninth deciles) while countries in the bottom five deciles and in the top decile had either fallen further behind or stagnated relative to that of the United States. These patterns indicate that increasing dispersion in relative labor productivity is occurring not only at the extremes of the distribution but also in the middle.

Table 2 Relative Output per Worker by Quintile

	1960	**1970**	**1980**	**1990**	**1996**
Quintiles:			(percent)		
Q1	4.7	4.5	4.5	3.7	3.1
Q2	9.4	9.3	10.0	8.9	8.0
Q3	19.1	20.7	24.1	21.6	20.8
Q4	34.1	39.9	43.8	41.8	43.8
Q5	74.5	78.7	80.4	78.0	80.0
Ratios:					
Q5/Q1	15.8	14.5	18.0	21.3	26.1
Q4/Q2	3.6	4.3	4.4	4.7	5.5

Notes: Quintile i (Qi) includes countries within the $20 \times (i-1)$ and $20 \times i$ percent of the distribution.

Disparity in relative productivity between rich and poor countries is apparent even for broader groups of countries. Table 2 reports the average relative output per worker by quintile. Even when the 20 richest and 20 poorest countries are averaged, dispersion in labor productivity is large (a ratio of 15.8 between these two sets of countries in 1960 and 26.1 in 1996), and the poorest countries have lost ground in productivity relative to the richest countries over time (from 4.7 percent of the United States in 1960 to 3.1 percent in 1996).

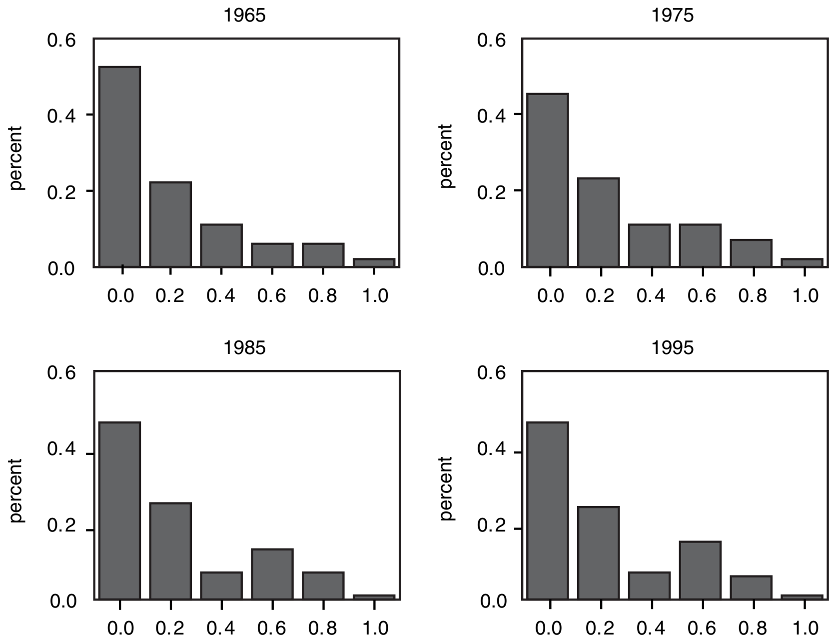
The disparity facts we have documented are supported by other summary statistics of dispersion. The Gini coefficient, for instance, is a commonly used measure of inequality. We compute the Gini coefficient for each year in our sample and we find that this statistic confirms our earlier findings.[8] The Gini coefficient was roughly constant (at about 0.49) until the early 1980s and it has increased since then (to about 0.52 in 1996).

Changes in the dispersion of relative labor productivity over time across countries suggest movements of individual countries in the distribution of productivity across countries over time. To document these changes, we report the histogram of the distribution of relative output per worker across countries at different points in time in Figure 4. The most noticeable change in the distribution from 1965 to 1995 is the movement of mass from the middle of the distribution to the right and to the left, creating what the literature calls "twin peaks" in the world distribution of relative output per worker.[9]

[8] We compute the Gini coefficient as $G = \frac{N}{N-1}\frac{\sum_{i=1}^{N}(2i-N-1)x_i}{N^2\mu}$, where x is an $N \times 1$ vector with the observations sorted in ascending order and μ is its mean. This coefficient varies between 0, reflecting complete equality and 1, which indicates complete inequality (all income is concentrated in only one country).

[9] See, for instance, Jones (1997).

Figure 4 Distribution of Relative Output per Worker



Notes: The bins in these histograms are defined as follows: 0 = [0, 0.2], 0.2 = [0.2, 0.4], 0.4 = [0.4, 0.6], 0.6 = [0.6, 0.8], 0.8 = [0.8, 1.0], and 1 = [1.0, 1.2].

Therefore, this statistic also captures an increase in the dispersion of relative productivity across countries.

We have presented statistics that capture an increase in the dispersion of labor productivity across countries, especially after the mid-1980s. This increase is relevant for theories of development because, in these theories, relative productivity levels are related to policies and institutional factors at the country level. We emphasize, however, that the observed increase in disparity in productivity does not necessarily imply an increase in income inequality in the world. There are at least three reasons. First, our disparity statistics do not adjust for changes in the employment-to-population ratios over time and in the size of population across countries. In particular, improvements in the standard of living in China and India alone (as we document later in this article) imply improvements in the standard of living for a sizeable portion of the population in the world (about 35 percent).[10] Second, our disparity statistics

[10] See, for instance, Bourguignon and Morrison (2002).

Table 3 Relative Output per Worker by Region

	1960	1970	1980	1990	1996
Asia	0.14	0.18	0.23	0.28	0.34
Latin America	0.34	0.35	0.35	0.28	0.25
Africa	0.12	0.13	0.14	0.12	0.12
Western Europe	0.62	0.71	0.77	0.75	0.75
Canada	0.92	0.90	0.88	0.83	0.79
Oceania	0.68	0.65	0.60	0.54	0.52

do not adjust for inequality within countries. Sala-i-Martin (2006) documents a reduction in global inequality in income per capita when including within-country inequality in the analysis. Third, our dispersion statistics do not capture improvements in broader notions of quantity and quality of life, such as improvements in life expectancy.[11]

In this section, we have documented that disparity in relative productivity across countries is large and that it has increased over the period of analysis. Below, we relate disparity in relative productivity with the geographical location of countries. We report substantial differences in labor productivity across regions in the world as well as substantial movements in these regional differences over time.

Table 3 reports averages of labor productivity by region for selected years. For instance, in 1960 the average labor productivity of the Asian countries in our data set was only 14 percent of that in the United States (about the same level of relative labor productivity in Africa) and 41 percent of that in Latin America. By 1996, Asia improved its position relative to that of the United States to 34 percent, surpassing both Latin America and Africa. On average, labor productivity in Africa did not improve relative to that in the United States (at roughly 12 percent). However, as we document below, this is a result of disparate experiences within Africa, with some countries declining in labor productivity both in absolute levels and relative to that of the United States, as well as with countries growing faster than the United States. In contrast, Latin America declined relative to the United States, from about 34 percent in 1960 to 25 percent in 1996. In the case of Latin America, the common path of relative labor productivity was one of decline, perhaps with the only exception being Chile, which started rapidly catching up to the United States in 1990. Countries in Western Europe had a relative productivity of 62 percent in 1960, experienced a period of relative fast gain to 77 percent in 1980, but have since stagnated relative to the United States to average levels of 75 percent. Canada,

[11] See, for instance, Becker et al. (2005).

Table 4 Mobility Matrix—Relative Output per Worker

		$t+20$				
		0-0.075	0.075-0.15	0.15-0.3	0.3-0.6	0.6-1.2
	0-0.075	0.86	0.11	0.03	0	0
	0.075-0.15	0.38	0.46	0.11	0.05	0
t	0.15-0.30	0.01	0.15	0.57	0.26	0.01
	0.3-0.6	0	0.02	0.22	0.48	0.28
	0.6-1.2	0	0	0	0.10	0.90

as well as countries in Oceania, had high relative labor productivity in 1960 but slowly declined relative to the United States.

Mobility

Associated with changes in the dispersion of relative labor productivity over time across countries is a substantial mobility of individual countries in the distribution of relative productivity over time. In the remainder of this section, we provide different characterizations of mobility in our data set. In the next two sections, we focus on individual country experiences.

To start, we characterize mobility in our data through two mobility matrices. The matrix in Table 4 reports the frequency of movements, defined over a period of 20 years, for relative productivity in our sample. We consider 5 bins for relative productivity, which imply a distribution of countries in 1960 that is roughly uniform. For each year since 1960, we ask how the position in relative productivity for a particular country changed in 20 years. Then we average all the experiences across countries and over time (all the 20-year windows from 1960 to 1996) in Table 4. For instance, the first element of this matrix, 0.86, is the average frequency with which countries with relative productivity between zero and 0.075 in a given year also have relative productivity between zero and 0.075 20 years later.

Mobility in Table 4 (as measured by the off-diagonal elements of the matrix) is higher in the middle of the relative productivity distribution than in its extremes. The diagonal elements of this matrix are substantially higher for the poorest countries (with relative productivity between zero and 0.075) and the richest countries (with relative productivity between 0.6 and 1.2), compared to diagonal elements for the other groups of countries. In addition, note that among middle-productivity countries (those with relative productivity between 0.075 and 0.6), most improvements in relative productivity in a span of 20 years have occurred for the richer countries in this subset, while most declines have occurred for the poorer countries. For instance, out of all countries with relative productivity between 0.075 and 0.15 at some year in our sample

Table 5 Mobility Matrix by Quintile

		$t+20$ Q1	Q2	Q3	Q4	Q5
	Q1	0.78	0.21	0.01	0	0
	Q2	0.22	0.64	0.11	0.03	0
t	Q3	0	0.14	0.62	0.24	0
	Q4	0	0.02	0.24	0.58	0.16
	Q5	0	0	0	0.16	0.84

Notes: Quintile i (Qi) includes countries within the $20 \times (i-1)$ and $20 \times i$ percent of the distribution of relative output per worker.

period, 20 years later, 46 percent of these countries remained in the same relative productivity bracket and 38 percent declined to a relative productivity between zero and 0.075. In contrast, for countries with relative productivity between 0.15 and 0.3, 20 years later, 57 percent remained in the same relative productivity bracket and 26 percent improved to a relative productivity between 0.3 and 0.6. This finding is consistent with the characterization of deciles in the previous subsection.

The matrix in Table 4 focuses on the mobility for relative productivity in our sample. In Table 5 we report an alternative mobility matrix constructed by quintile. In this matrix, the first element (0.78) represents the average frequency with which countries in the bottom quintile of the relative income distribution in a given year are also in the bottom quintile 20 years later. Note that this second mobility matrix focuses on mobility for the relative position of a country within the distribution. Therefore, unlike Table 4, this matrix does not provide direct information on changes in the level of average relative productivity of countries in a given bin.

The same basic patterns described for Table 4 also emerge in this second mobility matrix. In particular, mobility is lower for countries in the bottom and top quintiles than in the middle quintiles.

We can also characterize mobility by comparing the level of relative productivity of countries in 1960 and 1996. Figure 5 summarizes this information. In this figure, countries in the 45-degree line represent those in which productivity relative to that of the United States has not changed from 1960 to 1996. Recall that for countries on the 45-degree line, labor productivity grew at roughly 2 percent per year during the sample period. Countries above (below) the 45-degree line are those that have improved (deteriorated) their relative productivity.

Figure 5 Relative Output per Worker, 1960 vs. 1996 (log scale)

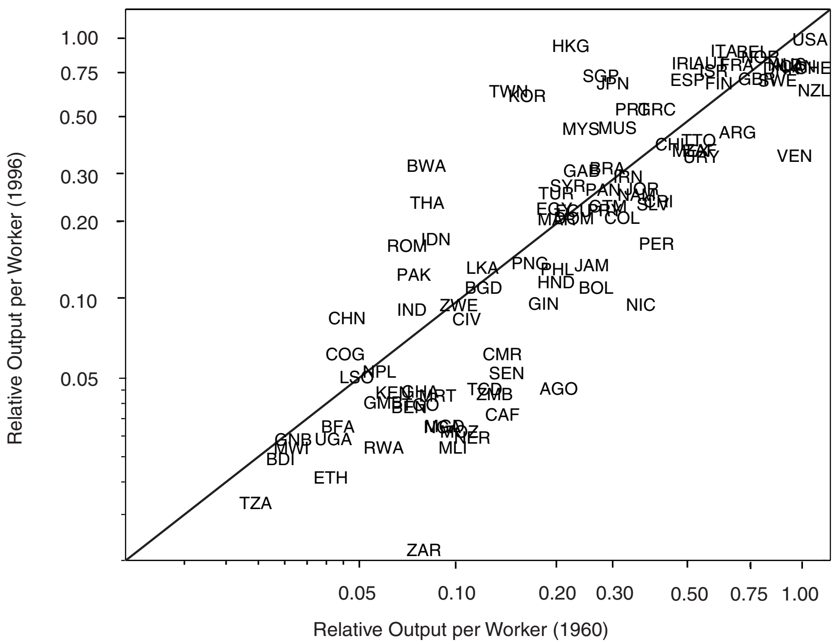


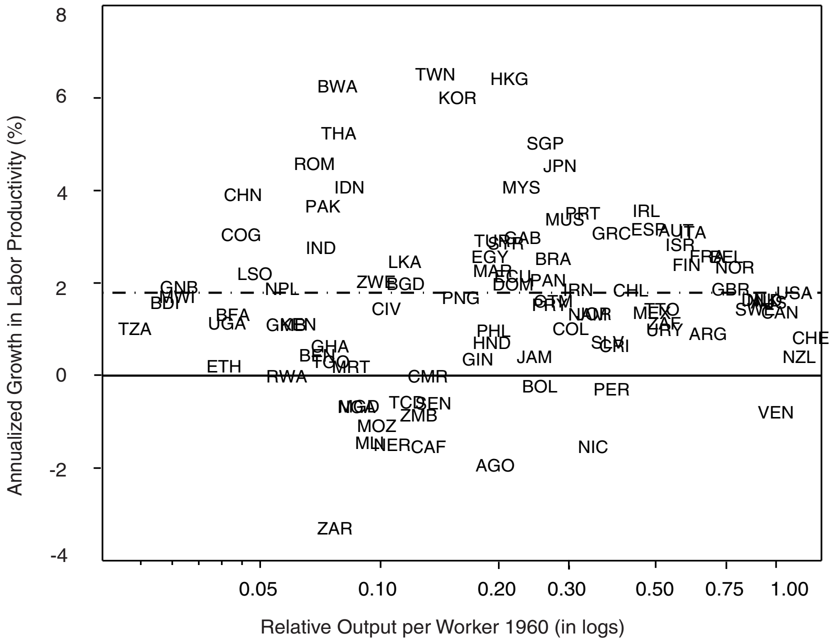
Figure 5 illustrates that individual countries have moved substantially in the distribution of relative labor productivity during this period. Particularly noticeable are the movements in relative productivity of countries such as Hong Kong, Taiwan, Korea, Botswana, the Democratic Republic of Congo, Angola, and Venezuela.[12]

Finally, a summary statistic of the performance of individual countries during the period from 1960 to 1996 is the annualized growth rate of output per worker. Figure 6 shows that there are important differences in this growth rate across countries.[13] Output per worker in several countries deteriorated relative to that in the United States. Countries that experienced this situation were both rich and poor in 1960. Relative rich countries that observed negative performances include New Zealand, Switzerland, Venezuela, Canada, Sweden, the Netherlands, and Argentina. The most notorious negative performers

[12] Using 1985 as the end year implies much less dispersion in relative productivity around the 45-degree line. This fact suggests that there were substantial movements in relative productivity between 1985 and 1996. Particularly noticeable are Thailand, China, Tanzania, and Ethiopia.

[13] Growth rate differences are not systematically related to the level of relative productivity in 1960. For a documentation of this finding, see, for instance, Mankiw, Romer, and Weil (1992) and Chari, Kehoe, and McGrattan (1996).

Figure 6 Growth in Output per Worker (1960–1996)



Notes: The dotted-dashed line is the annualized growth rate of output per worker between 1960 and 1996 in the United States.

of the poor countries in 1960 are Angola, Central African Republic, and the Democratic Republic of Congo in Africa, and Nicaragua, Peru, and Bolivia in Latin America. We find that in a surprisingly large number of countries, such as Venezuela, Nicaragua, and many African countries, output per worker fell in absolute terms from 1960 to 1996. The explanation for these disparate growth experiences is a fundamental question for future research.[14]

A large number of countries gained position in the distribution of relative output per worker. These included relatively rich countries in 1960, such as Ireland, Spain, Austria, Italy, France, Belgium, and Norway, as well as relatively poor countries, such as Taiwan, Hong Kong, Singapore, Japan, Botswana, Thailand, and Romania. Again, understanding the factors that explain these remarkable growth performances is of first-order importance in

[14] See some related work in Bello and Restuccia (2003); Cole, Ohanian, Riascos, and Schmitz (2005); Gollin, Parente, and Rogerson (2002); and Restuccia, Yang, and Zhu (2006).

development economics.[15] We note, however, that there may be other relevant growth experiences that are not captured by average growth because the experiences begin later than 1960. For instance, China, Ireland, and India are undergoing a miracle growth process that started later than 1960. In the next section, we study systematically remarkable growth experiences in the data.

3. MIRACLES AND DISASTERS

Within the period between 1960 and 1996, there have been substantial movements of individual countries over time in the distribution of relative output per worker. These movements are of interest because they provide opportunities and challenges to theories of development. Our documentation thus far has focused on countries with high and low annualized growth rates of output per worker during the entire period from 1960 to 1996. However, the time series of individual countries in output per worker show episodes of substantial positive and negative growth within this period. Therefore, growth as summarized by the growth rate in output per worker between 1960 and 1996 may hide interesting growth episodes that occur within this period. For this reason, we seek to systematically identify episodes of substantial and sustained growth or decline in relative productivity during our sample period.

For each country, we record a miracle or disaster episode if trended output per worker in a country relative to that of the United States grows or declines by more than 2 percent per year for at least 15 consecutive years. That is, a miracle episode is one in which output per worker grows at about 4 percent or more per year since trended output per worker in the United States grows at roughly 2 percent per year. Similarly, a disaster episode is one in which output per worker is stagnant or declines. Our view is that countries that are lagging behind the technology frontier should be able to double the growth rate of world knowledge in a miracle experience, while disaster experiences would feature no growth or decline in output per worker for a sustained period of time.

For each growth episode, we record the starting and ending years of the episode, the relative output per worker in the starting and ending years, and the implied annualized growth rate of relative output per worker during the episode. Tables 6 and 7 report the countries for which the recorded growth episodes satisfy the two conditions specified above for a miracle and a disaster. Notice that the changes in relative output reported in these tables focus only on the period of substantial growth or decline. However, for many of these countries, the process of growth or decline may have started earlier or continued later than reported but at lower rates. Moreover, many of the episodes

[15] See, for instance, Duarte and Restuccia (2006).

Table 6 Miracle Episodes

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Botswana	5.59	1965	26	0.07	0.30
Gabon	4.90	1960	15	0.21	0.42
Romania	4.80	1960	25	0.06	0.20
Taiwan	4.64	1960	36	0.12	0.63
Japan	4.56	1960	16	0.26	0.53
Hong Kong	4.54	1960	36	0.19	0.94
Greece	4.46	1960	15	0.34	0.66
Korea	4.20	1961	35	0.14	0.61
Singapore	4.10	1960	23	0.23	0.59
China	3.94	1978	18	0.04	0.08
Rep. of Congo	3.84	1960	24	0.04	0.10
Indonesia	3.62	1969	15	0.07	0.12
Thailand	3.39	1960	36	0.07	0.24

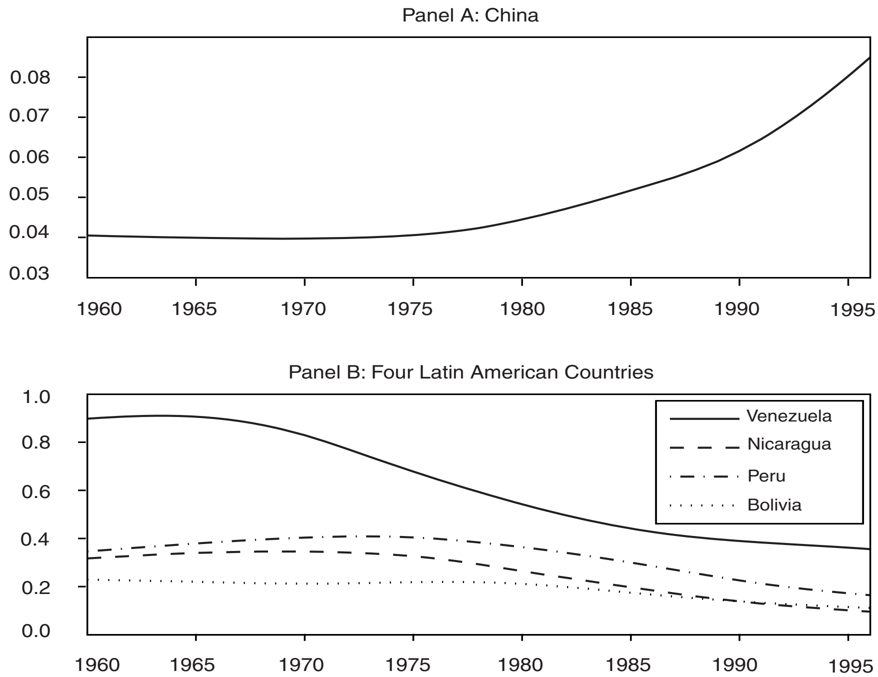
Notes: Annualized Growth is the growth rate in *relative* output per worker during the episode. To obtain an approximate annualized growth rate in output per worker, add 2 percent from growth in output per worker in the United States. Rel. Y/L is relative output per worker.

reported may be censored since the sustained process of growth or decline may have started before 1960 or may have continued after 1996.

As expected, Table 6 is composed mostly of Asian countries, such as Taiwan, Japan, Hong Kong, among others. Notice that in some of the episodes reported in this table, relative output per worker grew at an annualized rate greater than 4 percent. Given the long time span of the experiences, these countries improved their relative productivity dramatically. For instance, in Botswana, relative productivity increased from 7 percent in 1965 to 30 percent in 1991, and in Hong Kong, relative productivity increased by a factor of 5, from 19 percent in 1960 to 94 percent in 1996. Note that, excluding Hong Kong, these countries are still substantially below the level of U.S. labor productivity at the end of their miracle episode.

The latest miracle episode reported in Table 6 is China. Since 1978, labor productivity in China relative to that of the United States has grown at almost 4 percent per year, and by 1996, China doubled its relative productivity to 8 percent (see Figure 7, Panel A). However, this sustained period of growth in productivity relative to that of the United States did not start until 1978; before then, relative labor productivity was slightly declining or stagnant. While China is undergoing a sustained period of growth, its growth performance between 1978 and 1996 is not as remarkable as other miracle episodes, such as that experienced by Botswana and Hong Kong, especially considering

Figure 7 Relative Output per Worker Over Time



that China started its episode of growth by being only half as productive as Botswana and 20 percent as productive as Hong Kong.

It is worth emphasizing that our definition of miracle episodes (of at least 15 years) rules out those episodes that started after 1982. For instance, Chile, Ireland, and India had miracle experiences that started after 1982 and have continued at least until 1996. In Chile, relative output per worker grew at an average of 3.2 percent starting in 1990 (from 32 percent to 40 percent in 1996). In Ireland, relative output per worker grew at 3 percent starting in 1989 (from 63 percent to 81 percent in 1996), and in India, at 2.3 percent starting in 1992 (from 8 percent to 9 percent in 1996).

Table 7 reports the disaster experiences in our sample period. Note that all countries in this table are located either in Africa or in Latin America. A remarkable feature of these disaster experiences is the associated large and sustained declines in relative output per worker, with some countries seeing their relative output per worker fall by factors of 4 or more. While most countries in this table were relatively unproductive at the onset of these experiences, the Latin American countries were relatively productive. The most notable case is Venezuela, where relative productivity fell from 87 percent in 1969 to 40

Table 7 Disaster Episodes

Country	Annualized Growth (%)	Start Year	Number of Years	Rel. Y/L Start	Rel. Y/L End
Dem. Rep. of Congo	−6.45	1971	25	0.06	0.01
Mauritania	−6.14	1977	19	0.14	0.04
Nicaragua	−5.51	1974	22	0.33	0.10
Mali	−5.06	1980	16	0.06	0.03
Mozambique	−5.03	1971	16	0.08	0.03
Angola	−4.82	1969	27	0.17	0.05
Peru	−4.48	1977	19	0.39	0.16
Nigeria	−3.99	1980	16	0.06	0.03
Central African Rep.	−3.94	1973	23	0.09	0.04
Bolivia	−3.93	1980	16	0.21	0.11
Zambia	−3.74	1976	20	0.09	0.04
Venezuela	−3.69	1968	21	0.87	0.40
Niger	−3.23	1960	36	0.10	0.03
Ghana	−3.09	1978	15	0.08	0.05
Côte d'Ivoire	−3.06	1980	16	0.14	0.08
Chad	−2.91	1980	16	0.07	0.05
Madagascar	−2.72	1975	21	0.06	0.03

See notes in Table 6.

percent in 1989 (see Figure 7, Panel B). As in the case of miracles, a number of disaster experiences started later than 1982 and therefore are not reported in this table. However, we note that countries in this group include Cameroon, Rwanda, Kenya, Honduras, Madagascar, Trinidad and Tobago, Senegal, and South Africa.

4. DEPRESSIONS

In this section, we report depressions in our data set following the characterization of Kehoe and Prescott (2002). A depression is defined as a negative deviation from trend in output per worker that is fast (leading to a fall in output per worker relative to trend of at least 15 percent within ten years) and large (leading to a fall in output per worker relative to trend of at least 20 percent during the depression period). For this section, we also follow Kehoe and Prescott (2002) in defining trend as the average annual growth rate of labor productivity of the United States in the post-war period—about 2 percent. We emphasize that to characterize depressions, we use the raw time series of output per worker for each country relative to a trend growth of 2 percent. This procedure differs from our characterization of miracle and disaster episodes in the previous section, where we use trended data for each country relative to that for the United States. Hence, depressions can be short- or medium-run

Table 8 Depressions—Europe and Latin America

Country	Year at (%) 100	85	80	Lowest Level (%)	Year
Denmark	1972	1980	1990	75	1992
the Netherlands	1976	1983	1992	75	1994
Switzerland	1972	1978	1983	61	1996
Argentina	1979	1982	1985	59	1990
Chile	1970	1975	1975	67	1983
Colombia	1989	1992	1992	71	1993
Costa Rica	1977	1981	1982	57	1996
Dominican Rep.	1980	1990	1990	77	1991
Ecuador	1979	1986	1987	66	1996
El Salvador	1977	1980	1980	58	1989
Guatemala	1979	1984	1986	70	1996
Jamaica	1970	1976	1976	48	1996
Mexico	1980	1986	1987	65	1995
Panama	1981	1987	1988	70	1989
Paraguay	1990	1994	1994	72	1994
Uruguay	1979	1983	1983	73	1985

Notes: Depressions are characterized using raw output per worker relative to a 2 percent trend. The second to fourth columns report the approximate year the depression started, the year in which output per worker relative to trend falls below 85 percent, and the year in which output per worker relative to trend falls below 80 percent. The last two columns report the level and year of the lowest output per worker relative to trend during the depression episode.

episodes (closer to business cycles), while miracles and disasters are long-run characterizations that abstract from business-cycle movements.

We find that depressions are quite common, both among rich and poor countries. Even in our relatively small sample period, we find 53 depression episodes. In Tables 8 and 9, we report 29 depressions in our panel data. We exclude from these tables 24 depression episodes of countries that also faced disaster episodes, as discussed in the previous section. We report the country name and the approximate years in which the depression began, in which output per worker fell below 85 percent (relative to its level in the starting year), and in which output per worker fell below 80 percent (second to forth columns). We also report the lowest level of output per worker relative to trend and year during the depression period in the last two columns.

Table 8 summarizes the depression episodes of countries located in Europe and Latin America during our sample period. Depressions in Denmark, the Netherlands, and Switzerland started in the 1970s, and during these experiences, output per worker relative to trend fell by as much as 25 percent in Denmark and the Netherlands and 39 percent in Switzerland. Many Latin

Table 9 Depressions—Rest of the World

Country	Year at (%) 100	85	80	Lowest Level (%)	Year
New Zealand	1973	1977	1979	59	1992
Benin	1964	1974	1975	74	1980
Congo	1984	1989	1989	57	1996
Ethiopia	1982	1985	1991	60	1992
Gabon	1977	1981	1982	62	1988
Gambia	1982	1990	1992	64	1996
Guinea	1960	1967	1968	64	1984
Iran	1975	1980	1980	55	1989
Jordan	1985	1989	1989	65	1991
Namibia	1978	1980	1980	52	1996
Papua New Guinea	1972	1980	1981	65	1990
Philippines	1980	1984	1985	62	1994
Togo	1980	1986	1987	50	1996

See notes in Table 8.

American economies experienced depressions in the 1970s and early 1980s and saw declines of output per worker relative to trend of up to 50 percent.[16]

Table 9 summarizes the remaining depression experiences in our panel data. With the exception of New Zealand, these are relatively poor economies. However, the depression in New Zealand looks remarkably similar to the other episodes reported in this table. In particular, New Zealand has experienced a long depression, starting around 1973, with a fall in output per worker relative to trend as large as 41 percent in 1992.

5. DISCUSSION

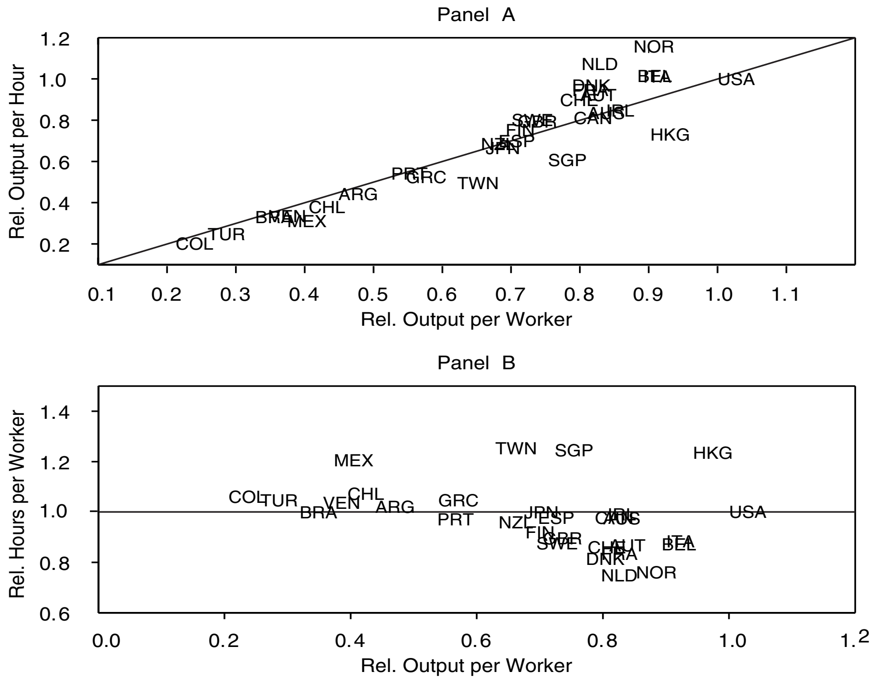
In this section, we discuss our findings relative to (i) a measure of labor productivity that includes hours per worker, (ii) a restricted set of countries for which price data is collected to compute PPP-conversion factors (Benchmark countries in PWT6.1), and (iii) a commonly used measure of income across countries—output per capita.

Hours per Worker

We focused on output per worker as our measure of labor productivity across countries. We chose this measure because of the lack of systematic data on hours per worker for a large set of countries and time periods. However, there

[16] Bergoeing et al. (2002) study the depression episodes of Mexico and Chile in the 1980s.

Figure 8 Output per Worker, Output per Hour, and Hours per Worker (1996)



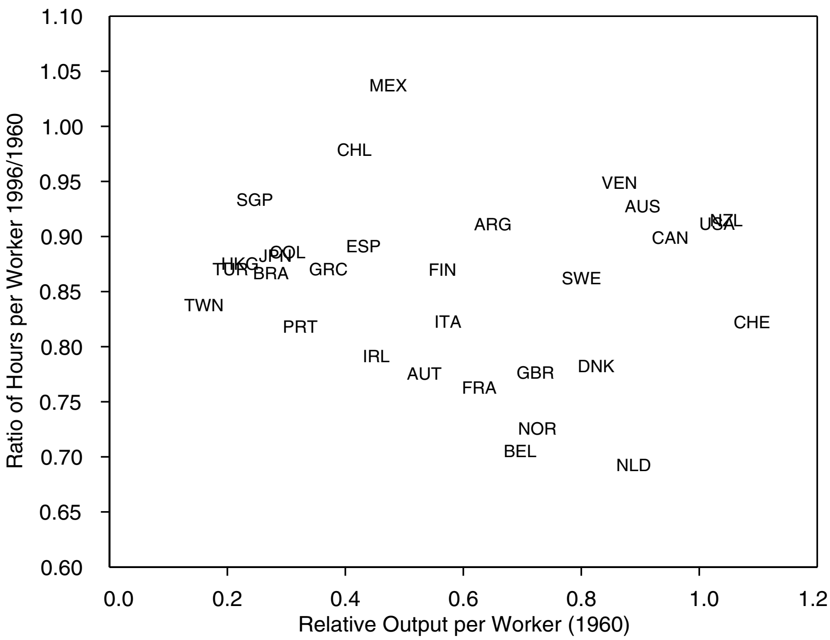
Notes: Output per worker from PWT6.1 is divided by (average) annual hours per worker from GGDC (see Appendix). For this comparison, the data are not trended.

are data on hours per worker for some countries and some time periods. We discuss the available evidence on hours per worker and how this evidence may affect our findings about dispersion and mobility in labor productivity. We combine the PWT6.1 data with the available data on hours per worker from the Conference Board and Groningen Growth and Development Centre (2006) to obtain output per hour.[17] We report the two measures of relative labor productivity for 1996 in Figure 8, Panel A.

In Figure 8, Panel A, countries on the 45-degree line represent those in which hours per worker do not differ from the hours in the United States. This is the case for most countries with some notable but perhaps well-known exceptions. First, European countries tend to have lower hours per worker than

[17] See the Appendix for a description of the data on hours per worker.

Figure 9 Changes in Hours per Worker



does the United States. In particular, output per worker tends to understate labor productivity for these countries by roughly 10 percent.[18] Second, there are countries where hours per worker are higher than in the United States, such as Hong Kong, Singapore, Taiwan, Mexico, and Chile.

To illustrate the importance of differences in hours per worker more directly, we decompose output per hour as the product of output per worker and the inverse of hours per worker. In Figure 8, Panel B, we plot hours per worker relative to that of the United States across countries in 1996. Although differences in hours per worker across countries are not too large, these differences are systematically related to income, with poorer countries observing higher hours per worker than richer countries. Hence, dispersion in output per worker actually understates dispersion in labor productivity (output per hour).

In Figure 9 we plot the ratio of hours per worker, 1996/1960, against the level of hours per worker in 1960. This figure suggests that changes in hours per worker during the 1960–1996 period are not related to the level of development. Hence, our summary statistics of changes in dispersion in labor

[18] For instance, Prescott (2004) and Rogerson (2005) study the implication of tax differences for labor supply levels in Europe and the United States.

productivity over time are not affected by the exclusion of hours per worker. It is worth emphasizing, though, that for some countries in the upper end of the income distribution, changes in hours per worker are substantial. Therefore, growth in output per worker may understate growth in labor productivity for these countries (see some European countries, such as the Netherlands, Belgium, and Norway, in Figure 9).

Benchmark Countries

The PWT6.1 uses detailed price data across countries to construct and price a common international basket of goods. These international prices are then used to convert aggregate measures of output in domestic prices to aggregate measures of output in international prices that are comparable across countries. The factors of conversion are typically called purchasing power parity (PPP). However, actual goods and services prices are collected for a subset of countries (from the ICP studies), called Benchmark countries. Data for the remaining countries are filled in using a variety of statistical techniques, perhaps rendering PPP-converted data for these countries less reliable.

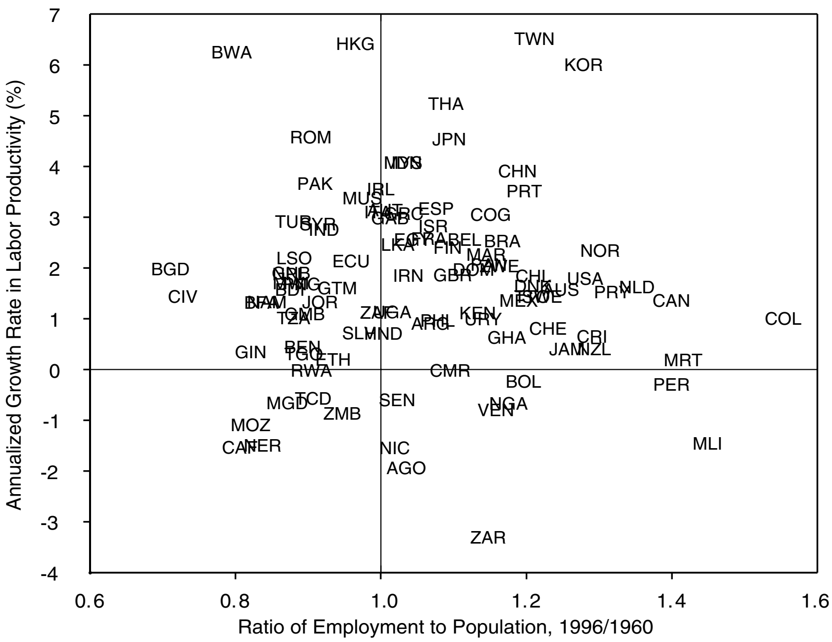
The most comprehensive and recent price collection was in 1996. We restrict our sample to Benchmark countries in 1996 in order to assess the importance of countries with lower quality data for our main findings on labor productivity. Out of 99 countries in our sample, 67 are Benchmark countries in 1996.[19] We restrict our panel data to only these 67 countries and recompute our baseline statistics. Our findings hold for the restricted sample. In particular, we find that there is a large disparity in relative productivity across countries at any point in time in our sample, that disparity has increased since the mid-1980s, and that there have been substantial movements of individual countries in the distribution of relative output per worker.

Output per Capita

We have focused our analysis on output per worker as opposed to output per capita. Our motivation is that facts on output per worker relate more directly to theories of labor productivity. Nevertheless, we recognize that measures of output per capita are more widely available. For instance, Maddison (2001) documents long time series of comparable measures of output per capita for 124 countries, while he offers only limited time series (at most 6 years) of

[19] See the Appendix for the list of these countries.

Figure 10 Changes in Productivity and Employment to Population



output per worker for only 45 countries. Hence, it is of interest to document how different our characterization of labor productivity across countries would be if instead we use data on output per capita. Noticing that output per capita can be decomposed as the product of output per worker and the employment-to-population ratio, we can establish two main findings about the relationship between output per worker and output per capita. First, while there are substantial differences in the employment-to-population ratio across countries, these differences are not systematically related to development. Therefore, our summary statistics characterizing output per worker over time are roughly similar to statistics on output per capita. Second, there are substantial changes in employment-to-population ratios for individual countries over time, and these changes are not systematically related to development or growth in relative productivity (see Figure 10). Therefore, changes in output per capita can severely overstate or understate changes in labor productivity for individual countries.

6. CONCLUSIONS

We have documented three remarkable facts about the distribution of labor productivity across countries: there is a large disparity in labor productivity across countries in the world, this disparity has increased substantially since the mid-1980s, and there is substantial mobility of individual countries in the distribution of labor productivity over time.

Substantial progress has been made by confronting theories of development to facts. By extending and updating the development facts, we attempt to provide new opportunities and challenges to theories of development. In documenting a number of individual growth experiences, we intend to direct research efforts to explore a number of relevant questions in development. Why have China and India been able to start a miracle episode of growth in the 1980s and 1990s but not other countries such as those in Latin America? What accounts for China's and India's recent growth miracle? Why is labor productivity in Africa falling behind that of the United States since the 1980s if it was catching up until then? Why is labor productivity in Latin America stagnant or falling behind that of the United States? Why is labor productivity in Europe slowing down to levels below that of the United States? Why has dispersion in relative labor productivity increased so much since the mid-1980s? Is there a common factor explaining this fact or is it related to a variety of country-specific factors?

APPENDIX: DATA SOURCES AND DEFINITIONS

We use data from Penn World Tables V6.1 (see Heston, Summers, and Aten 2002) to construct annual time series of PPP-adjusted GDP per worker in chained 1996 prices (variable RGDPWOK). We focus on countries that have data for every year from 1960 to 1996 and that have at least one million in population in 1996. These restrictions render a set of 99 countries, which includes (with country code in parentheses): Angola (AGO), Argentina (ARG), Australia (AUS), Austria (AUT), Burundi (BDI), Belgium (BEL), Benin (BEN), Burkina Faso (BFA), Bangladesh (BGD), Bolivia (BOL), Brazil (BRA), Botswana (BWA), Central African Republic (CAF), Canada (CAN), Switzerland (CHE), Chile (CHL), China (CHN), Côte d'Ivoire (CIV), Cameroon (CMR), Republic of Congo (COG), Colombia (COL), Costa Rica (CRI), Denmark (DNK), Dominican Republic (DOM), Ecuador (ECU), Egypt (EGY), Spain (ESP), Ethiopia (ETH), Finland (FIN), France (FRA), Gabon (GAB), United Kingdom (GBR), Ghana (GHA), Guinea (GIN), Gambia (GMB), Guinea-Bissau (GNB), Greece (GRC), Guatemala (GTM), Hong Kong (HKG), Honduras (HND), Indonesia (IDN), India (IND), Ireland (IRL), Iran (IRN), Israel (ISR), Italy (ITA), Jamaica (JAM), Jordan (JOR), Japan (JPN), Kenya (KEN), Korea (KOR), Sri Lanka (LKA), Lesotho (LSO), Morocco (MAR), Madagascar (MGD), Mexico (MEX), Mali (MLI), Mozambique (MOZ), Mauritania (MRT), Mauritius (MUS), Malawi (MWI), Malaysia (MYS), Namibia (NAM), Niger (NER), Nigeria (NGA), Nicaragua (NIC), the Netherlands (NLD), Norway (NOR), Nepal (NPL), New Zealand (NZL), Pakistan (PAK), Panama (PAN), Peru (PER), Philippines (PHL), Papua New Guinea (PNG), Portugal (PRT), Paraguay (PRY), Romania (ROM), Rwanda (RWA), Senegal (SEN), Singapore (SGP), El Salvador (SLV), Sweden (SWE), Syria (SYR), Chad (TCD), Togo (TGO), Thailand (THA), Trinidad & Tobago (TTO), Turkey (TUR), Taiwan (TWN), Tanzania (TZA), Uganda (UGA), Uruguay (URY), United States (USA), Venezuela (VEN), South Africa (ZAF), Democratic Republic of Congo (ZAR), Zambia (ZMB), and Zimbabwe (ZWE).

In Section 5 we use data on hours worked obtained from the Total Economy Database of the Conference Board and Groningen Growth and Development Centre (2006). We use data on annual hours worked per employee from 1960 to 1996 for the following 30 countries: Argentina, Australia, Austria, Belgium, Brazil, Canada, Switzerland, Chile, Colombia, Denmark, Spain, Finland, France, United Kingdom, Greece, Hong Kong, Ireland, Italy, Japan, Mexico, the Netherlands, Norway, New Zealand, Portugal, Singapore, Sweden, Turkey, Taiwan, United States, and Venezuela. We divide our measure of output per worker from PWT by hours to obtain a measure of output per hour. We make the implicit assumption that employees and self-employed people work the same number of hours. Clearly self employment differs across sectors and therefore countries; whether this assumption is valid or not is an open question. There is some evidence from household surveys in the United States that employees and self-employed people work roughly the same amount of hours.

The Benchmark 1996 countries in our data set are: Argentina, Australia, Austria, Belgium, Benin, Bangladesh, Bolivia, Brazil, Botswana, Canada, Switzerland, Chile, Cote d'Ivoire, Cameroon, Republic of Congo, Denmark, Ecuador, Egypt, Spain, Finland, France, Gabon, United Kingdom, Guinea, Greece, Hong Kong, Indonesia, Ireland, Iran, Israel, Italy, Jamaica, Jordan, Japan, Kenya, Korea, Sri Lanka, Morocco, Madagascar, Mexico, Mali, Mauritius, Malawi, Nigeria, the Netherlands, Norway, Nepal, New Zealand, Pakistan, Panama, Peru, Philippines, Portugal, Romania, Senegal, Singapore, Sweden, Syria, Thailand, Trinidad & Tobago, Turkey, Tanzania, Uruguay, United States, Venezuela, Zambia, and Zimbabwe.

REFERENCES

Becker, Gary, Tomas Philipson, and Rodrigo Soares. 2005. "The Quantity and Quality of Life and the Evolution of World Inequality." *American Economic Review* 95 (1): 277–91.

Bello, Omar, and Diego Restuccia. 2003. "Venezuela's Growth Experience." Manuscript, University of Toronto.

Bergoeing, Raphael, Patrick Kehoe, Timothy Kehoe, and Raimundo Soto. 2002. "A Decade Lost and Found: Mexico and Chile in the 1980s." *Review of Economic Dynamics* 5 (1): 166–205.

Bourguignon, François, and Christian Morrison. 2002. "Inequality Among World Citizens: 1920–1992." *American Economic Review* 92 (4): 727–44.

Caselli, Francesco. 2005. "Accounting for Cross-Country Income Differences." In *Handbook of Economic Growth* volume 1A, ed. P. Aghion and S. Durlauf. Elsevier North-Holland.

Chari, V.V., Patrick J. Kehoe, and Ellen R. McGrattan. 1996."The Poverty of Nations: A Quantitative Exploration." NBER Working Paper No. 5414 (January).

Cole, Harold, and Lee Ohanian. 1999."The Great Depression in the United States from a Neoclassical Perspective." Federal Reserve Bank of Minneapolis *Quarterly Review* 23 (1): 2–24.

Cole, Harold, Lee Ohanian, Alvaro Riascos, and James Schmitz. 2005. "Latin America in the Rearview Mirror." *Journal of Monetary Economics* 52 (1): 69–107.

Conference Board and Groningen Growth and Development Centre. 2006. Total Economy Database. Available at: http://www.ggdc.net (accessed on July 20, 2006).

Duarte, Margarida, and Diego Restuccia. 2006. "The Role of the Structural Transformation in Aggregate Productivity." Manuscript, Federal Reserve Bank of Richmond.

Gollin, Douglas, Stephen Parente, and Richard Rogerson. 2002. "The Role of Agriculture in Development." *American Economic Review Papers and Proceedings* 92 (2): 160–64.

Heston, Alan, Robert Summers, and Bettina Aten. 2002. Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP). Available at: http://pwt.econ.upenn.edu (accessed on July 20, 2006).

Jones, Charles. 1997. "On the Evolution of the World Income Distribution." *Journal of Economic Perspectives* 11 (3): 19–36.

Kaldor, Nicholas. 1961. "Capital Accumulation and Economic Growth." In *The Theory of Capital*, ed. F.A. Kutz and D.C. Hague. New York: St. Martins.

Kehoe, Timothy, and Edward C. Prescott. 2002. "Great Depressions of the 20th Century." *Review of Economic Dynamics* 5 (1): 1–18.

Klenow, Peter, and Rodríguez-Clare, Andrés. 1997. "The Neoclassical Revival in Growth Economics: Has It Gone Too Far?" In *NBER Macroeconomics Annual*, ed. Ben S. Bernanke and Julio J. Rotemberg. Cambridge, MA: MIT Press.

Kuznets, Simon. 1966. *Modern Economic Growth*. New Haven, Conn.: Yale University Press.

Maddison, Angus. 1995. *Monitoring the World Economy: 1820–1992*. Development Centre Studies. Paris: Organization for Economic Cooperation and Development.

______________. 2001. *The World Economy: A Millenial Perspective*. Development Centre Studies. Paris: Organization for Economic Cooperation and Development.

Mankiw, N. Gregory, David Romer, and David N. Weil. 1992. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* 107 (2): 402–37.

Parente, Stephen, and Edward C. Prescott. 1993. "Changes in the Wealth of Nations." Federal Reserve Bank of Minneapolis *Quarterly Review* 17 (2).

Prescott, Edward C. 2002. "Prosperity and Depression." *American Economic Review* 92 (2): 1–15.

______________. 2004. "Why Do Americans Work So Much More Than Europeans?" Federal Reserve Bank of Minneapolis *Quarterly Review* 28 (1).

Restuccia, Diego, Denis Yang, and Xiaodong Zhu. 2006. "Agriculture and Aggregate Productivity: A Quantitative Cross-Country Analysis." Manuscript, Federal Reserve Bank of Richmond.

Rogerson, Richard. 2005. "Structural Transformation and the Deterioration of European Labor Market Outcomes." Manuscript, Arizona State University.

Sala-i-Martin, Xavier. 2006. "The World Distribution of Income: Falling Poverty and ... Convergence, Period." *Quarterly Journal of Economics* 121 (2): 351–97.

Inflation Uncertainty and the Recent Low Level of the Long Bond Rate

Yash P. Mehra

Many analysts and policymakers have been intrigued by the recently observed low levels of long-term interest rates. Figure 1 charts the actual and predicted levels of the nominal yield on ten-year U.S. Treasury bonds over 1994Q1 to 2005Q1; the predicted values were generated using the historical relationship that had existed between the long bond yield and several of its macroeconomic determinants including long-term inflation expectations, near-term outlook for the economy, and the stance of monetary policy. The prediction errors are also charted there. As one can see, for the past few years the actual long bond rate has remained consistently below what is predicted using these standard economic determinants.[1] Other analysts using somewhat different economic determinants have come to the same conclusion that the long bond rate has recently been substantially lower than can be explained by macroeconomic conditions.[2]

In order to explain the recent puzzling behavior of long-term interest rates, two alternative hypotheses have received prominent attention in the financial

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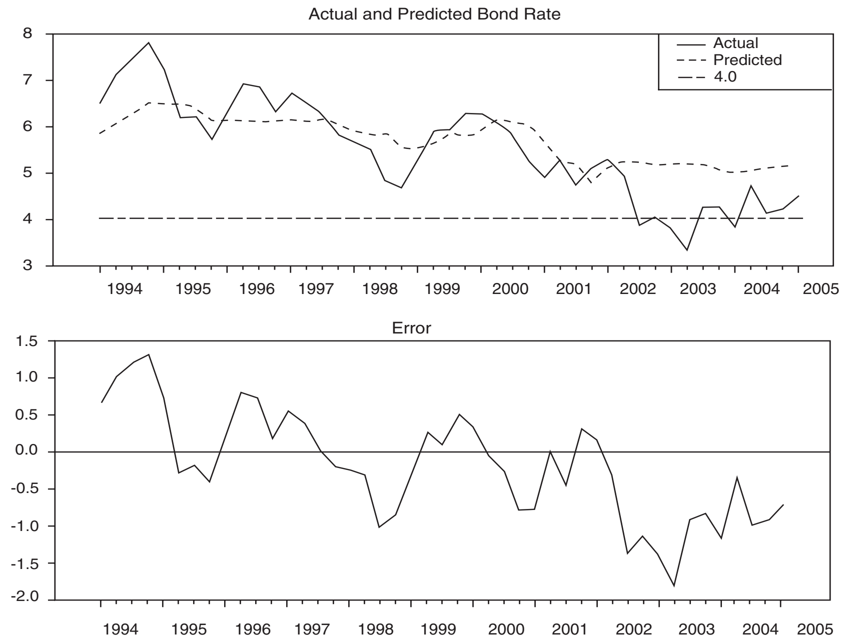
[1] As discussed fully later, the reduced-form long bond equation used to generate the predicted values relate the long bond rate to long-term inflation expectations, near-term forecasts of real growth and inflation, and the surprise component of change in the fed funds rate target, denoted here as the baseline bond rate equation. This equation is estimated over 1984Q1 to 2004Q3 and simulated dynamically over 1994Q1 to 2005Q1, conditional on actual values of macroeconomic determinants and assuming the Fisher coefficient is unity. The predicted values charted in Figure 1 are the simulated values.

[2] See, for example, Warnock and Warnock (2005). Chairman Bernanke (2006) in his recent testimony to the U.S. Congress also notes that long-term interest rates have remained relatively low given recent strong real growth and rising short-term interest rates.

Figure 1 Baseline Bond Equation



press.[3] The first one attributes the current low level of the long bond rate to the lowering of the inflation risk premium. In particular, this hypothesis posits that as a result of the improved inflation performance of the U.S. economy, inflation uncertainty has declined, leading to lowering of inflation risk premiums, which is reflected in lower real and nominal bond yields.[4] The other hypothesis

[3] Some other hypotheses that have surfaced in the financial press have not been considered serious enough to warrant much attention. For example, one hypothesis involves the behavior of pension funds. This hypothesis attributes the recent decline in the long bond rate to increased demand for longer-term bond portfolios by pension funds and insurance companies that are needed to replenish their underfunded retirement plans. However, these funding shortfalls are not considered large enough to be able to explain the recent behavior of long-term interest rates. Another hypothesis posits that the current low level of the long bond rate may be signaling economic weakness. Most reduced-form interest rate models usually control for the influence of future real growth on current bond yields, yet those models still cannot account for the recent low level of the long bond rate.

[4] See, for example, Greenspan (2005), Kim and Wright (2005), Dudley (2006), and Bernanke (2006). Although several analysts attribute the low level of the long bond rate to lower bond risk premiums, they differ with respect to reasons for the collapse in risk premiums. Chairman Greenspan has focused on increased globalization and integration of financial markets as sources of the favorable inflation performance in many countries including the United States, whereas others (for example, Dudley 2006) attribute the favorable inflation performance to monetary policy. In contrast, Kim and Wright have emphasized the potential role of increased demand for U.S. Treasury

attributes recent declines in long-term interest rates to increases in purchases of U.S. Treasury securities by foreign central banks.[5]

This article develops an empirical test of the first hypothesis, using a reduced-form interest rate equation that links the long bond rate directly to macroeconomic variables, including an empirical proxy for inflation uncertainty. I focus on the first hypothesis for two reasons. First, despite the popularity of the first hypothesis in the financial press, it has not yet been formally investigated. In most previous research, the evidence in favor of the first hypothesis comes from the term structure model, indicating that term premiums have declined and that part of this decline is attributed to a decline in the inflation risk premium. This article, however, constructs a direct empirical measure of inflation uncertainty and examines whether the recent behavior of the long bond rate can be linked to the recent reduction in inflation uncertainty. Second, some previous research has indicated that the empirical evidence favoring the second hypothesis is fragile in the sense that the empirical evidence—the long bond rate is influenced by direct foreign capital inflows—is due to the most recent data.[6] In view of these considerations, I focus on the first hypothesis, but I do examine the robustness of results with respect to inclusion of foreign official purchases of U.S. Treasury securities in the list of macroeconomic determinants.

It is widely understood that investors holding long-term U.S. Treasury bonds bear an inflation risk, because actual inflation that is higher or lower than what they forecasted when they bought bonds would make their holding of bonds significantly less or more valuable. Hence, if there is considerable uncertainty about long-term inflation forecasts in the sense that the probability distribution of long-term inflation forecasts is widely dispersed, investors demand compensation for bearing the inflation risk, and hence long bond rates contain risk premiums.

Since we do not have a direct empirical measure of uncertainty about long-term inflation forecasts, this article constructs an empirical proxy making two identifying assumptions. The first assumption is that uncertainty about long-term inflation forecasts is positively correlated with uncertainty about short-term inflation forecasts, so that when investors become more uncertain about their short-term inflation forecasts, their uncertainty about long-term inflation forecasts also increases. The second assumption is that uncertainty about short-term inflation forecasts can be approximated by the mean squared error

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securities relative to supply. The empirical work here focuses on domestic factors that might be at the source of the favorable inflation performance.

[5] See, for example, Wu (2005) and Warnock and Warnock (2005). Chairman Bernanke (2006) has focused instead on increased capital inflows arising as a result of an excess of desired global savings over the quantity of global investment opportunities that pay historically normal returns. The examination of the global savings glut hypothesis is beyond the scope of this article.

[6] See, for example, the evidence in Wu (2005) and Warnock and Warnock (2005).

(MSE) of short-term inflation forecasts, so that uncertainty about short-term inflation forecasts rises when the variance (in particular, the MSE) of ex-post short-term inflation forecast errors increases. Given these two assumptions, I examine the MSE of short-term inflation forecasts, using survey data on private-sector GDP inflation expectations. In particular, the article creates a time series on uncertainty about short-term inflation forecasts, using rolling three-year windows on the MSE of short-term inflation forecasts over 1984Q1 to 2004Q3.[7]

The resulting time series on uncertainty about short-term inflation forecasts has a clear downward trend over 1984 to 2004, which is consistent with the downward trend in mean and variance of short-term inflation forecasts. This trend suggests that reduction in short-term inflation uncertainty may reflect the good inflation performance of the U.S. economy; namely, short-term inflation uncertainty declined because inflation both steadily declined and became more predictable.

The article then estimates a reduced-form bond rate equation that links the long bond rate to macroeconomic variables, including the aforementioned empirical measure of uncertainty about short-term inflation forecasts. The results indicate the long bond rate is positively correlated with short-term inflation uncertainty over the full sample period of 1984Q1 to 2004Q3, suggesting that an increase in uncertainty about short-term inflation forecasts raises uncertainty about long-term inflation forecasts and hence may account for the presence of the inflation risk premium in the bond rate. However, the results also indicate that the estimated coefficient that measures the response of the long bond rate to short-term inflation uncertainty has declined since 2001Q4, implying that in recent years an increase in short-term inflation uncertainty is associated with a small-to-negligible increase in uncertainty about long-term inflation forecasts. In fact, the results are consistent with the hypothesis that the inflation risk premium embedded in the long bond rate has disappeared, thereby accounting in part for the current low level of the long bond rate.

As stated above, one of the identifying assumptions in the empirical work here is that uncertainty about long-term inflation forecasts is positively correlated with uncertainty about short-term inflation forecasts and that the magnitude of this positive correlation is stable over the sample period being studied. However, the result above—the correlation of the long bond rate with short-term inflation uncertainty has weakened in recent years—may be interpreted to mean that the identifying assumption made above does not hold for the complete sample period of 1984 to 2004; namely, while in the past an increase in short-term inflation uncertainty may have increased uncertainty about long-term inflation forecasts, it no longer does so. This development may be the

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[7] Tulip (2005) uses this approach to investigate whether output has become predictable, using Greenbook forecasts.

consequence of increased Fed credibility. It is only recently that investors have become more confident that the current low and stable short-term inflation will continue in the long run so that a given increase in short-term inflation uncertainty now leads to a small-to-negligible increase in uncertainty about long-term inflation forecasts, and hence investors demand lower inflation risk premiums than before. This consequence of increased Fed credibility can be seen in the fact that it is only recently that both short- and long-term inflation forecasts have become fully anchored, in contrast to the early part of the sample period when they were not anchored.

The empirical work here that attributes the current low level of the long bond rate to a lower inflation risk premium is robust to the inclusion of foreign official capital inflows in the list of macroeconomic determinants of bond yields. The results do indicate the long bond rate is negatively correlated with this measure of foreign official capital inflows, however, this correlation is marginally significant and fragile, being absent in the period prior to the recent episode of increased capital inflows. Together, these results favor the hypothesis that attributes the recent low level of the long bond rate mostly to lowering of inflation risk premiums.

The rest of the article is organized as follows. In Section 1, I examine the behavior of uncertainty about short-term inflation forecasts, constructed using private-sector, ex-post inflation forecast errors. Section 2 contains discussion of a reduced-form interest rate equation that relates the long bond rate to macroeconomic variables. Section 3 presents empirical results, and concluding remarks are in Section 4.

1. A PRELIMINARY ANALYSIS: SOURCES OF DECLINE IN UNCERTAINTY ABOUT SHORT-TERM INFLATION FORECASTS

As indicated at the outset, if there is considerable uncertainty about long-term inflation forecasts, holders of long-term U.S. Treasury bonds bear an inflation risk and hence long bond yields have embedded in them inflation risk premiums. Since one does not have a direct empirical measure of uncertainty about long-term inflation forecasts, the article proceeds under the assumption that uncertainty about long-term inflation forecasts is positively correlated with uncertainty about short-term forecasts. This section constructs the empirical measure of uncertainty about short-term inflation forecasts and analyzes its behavior over the sample period of 1984Q1 to 2004Q3.

Measuring Uncertainty about Short-Term Inflation Forecasts

If inflation had been harder to forecast in the past, then it is likely to raise uncertainty about agents' current forecasts of expected future inflation rates.

Given this basic idea, the article examines ex-post inflation forecast errors, focusing on the MSE of one-to-four-quarters-ahead inflation forecasts. If the MSE of inflation forecasts increases over time, then it is likely to raise the variance of agents' current forecasts of expected future inflation rates and hence will lead to increased uncertainty about their mean inflation forecasts. For inflation forecasts, I use private-sector GDP inflation forecasts from the Philadelphia Fed's Survey of Professional Forecasters (denoted hereafter as SPF).[8] I use survey data because recent evidence indicates that surveys perform much better than some standard reduced-form inflation forecasting models in predicting future inflation.[9] Despite the evidence in Romer and Romer (2004) that Greenbook inflation forecasts are more accurate relative to private-sector forecasts, I use the latter because Greenbook forecasts are released to the public with a five-year delay, and hence bond yields are likely to reflect private-sector inflation expectations. Since surveys are used, I compute forecast errors using real-time data on actual inflation as in Romer and Romer (2004). I create time series on the MSE of one-to-four-quarters-ahead inflation forecasts, using rolling three-year windows over 1984Q1 to 2005Q3.[10] This time series is an empirical proxy measuring uncertainty about short-term inflation forecasts, denoted hereafter as short-term inflation uncertainty.

Figure 2 charts the rolling MSE of contemporaneous, one-quarter- and four-quarter-ahead inflation forecasts over 1984Q1 to 2004Q3.[11] As can be seen, the evidence of a decline in short-term inflation uncertainty is quite clear, as the MSE of inflation forecasts has drifted down intermittently since 1984. In particular, focusing on the MSE of the four-quarter-ahead inflation forecasts, short-term inflation uncertainty declined significantly first during the latter half of the 1980s, increased somewhat in the first half of the 1990s, and then again drifted lower beginning in the late 1990s.

Low Inflation, Great Moderation, and Short-Term Inflation Uncertainty

One plausible explanation of the decline observed in short-term inflation uncertainty over 1984Q1 to 2005Q3 is the good inflation performance of the U.S. economy due to Federal Reserve policy during this period. In particular, this explanation posits that, under Chairman Volcker and Chairman Greenspan,

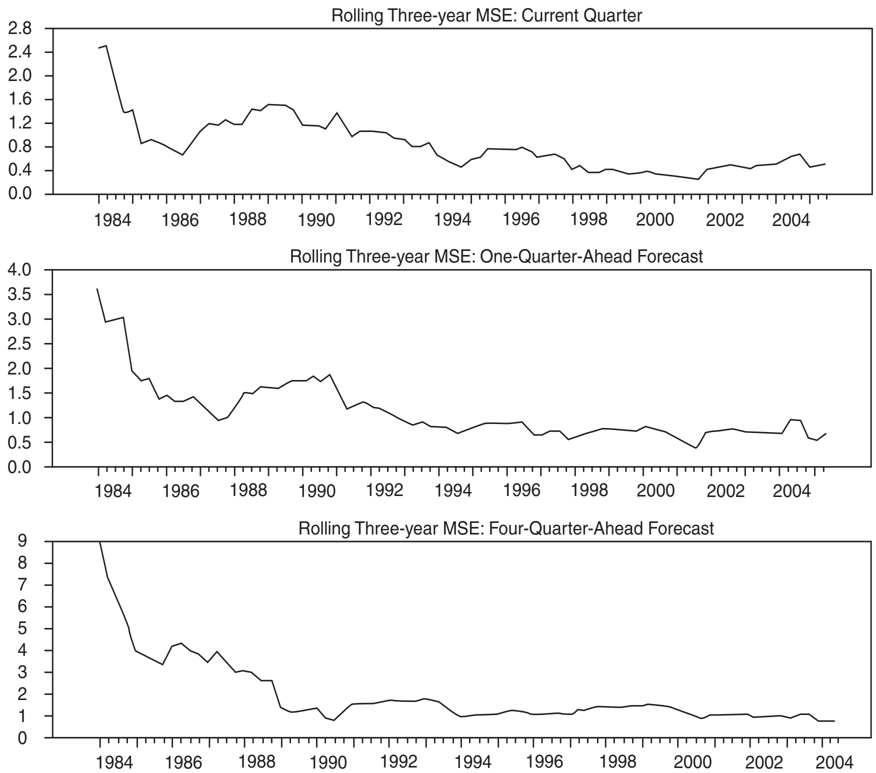
[8] Ideally, one needs to examine the MSE of ten-year-ahead Consumer Price Index (CPI) inflation forecasts. However, for the sample period 1984 to 2005Q3 studied here, it is not possible to generate enough observations on the forecast error. Hence, I focus on the MSE of short-term GDP inflation forecasts, assuming reduction in inflation uncertainty at short-term forecast horizons will lead to reduction in uncertainty at the long-term forecast horizon.

[9] Ang, Bekaert, and Wei (2006).

[10] I get qualitatively similar results using somewhat longer four-year rolling windows.

[11] Because I use lead data in generating forecast errors, the sample period ends in 2004Q3.

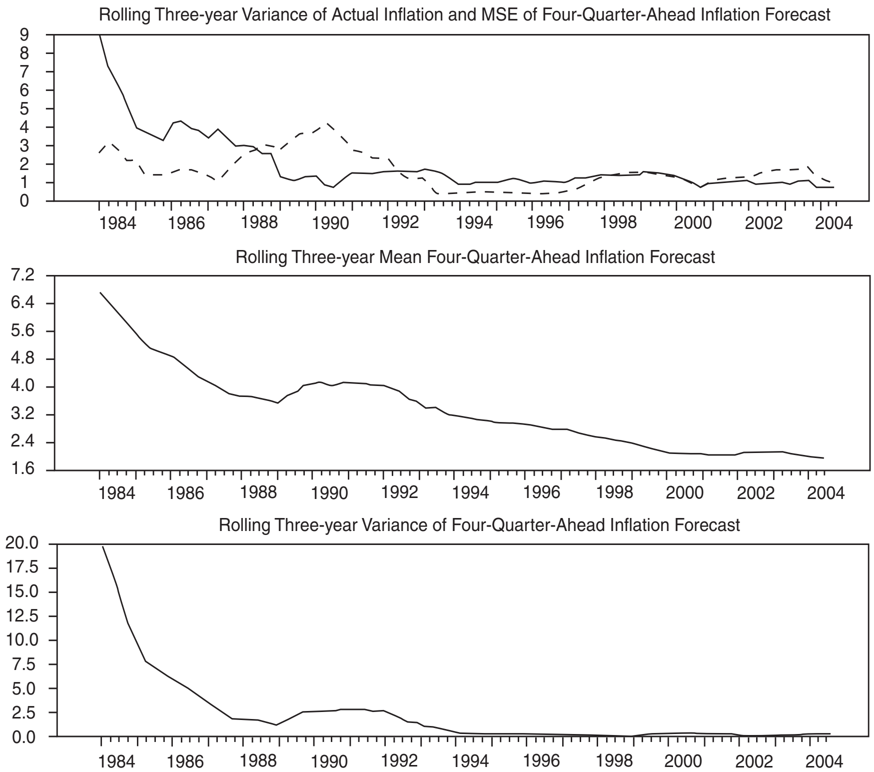
Figure 2 Uncertainty about GDP Inflation Forecasts



the Federal Reserve gradually had moved toward a policy framework that places a heavy weight on the requirement that the central bank keep inflation low and stable and hence the public's expectations of inflation under control. In addition, during this sample period the Fed has taken a number of steps toward increased transparency meant to reduce the public's uncertainty about the Fed's long-term inflation objective (Bernanke 2003, 2004). As a result, inflation has trended down and stabilized at low levels, thereby making inflation more predictable and contributing to lower short-term inflation uncertainty.

Figure 3 provides a visual confirmation of the hypothesis that decline in short-term inflation uncertainty is related to good inflation performance of the U.S. economy over 1984Q1 to 2005Q3. Focusing on the behavior of the four-quarter-ahead actual inflation and its forecast, the top panel in Figure 3 charts the variance of actual future inflation and the MSE of its forecast, calculated as before using rolling three-year windows. The middle panel charts the rolling mean of inflation forecasts, whereas the bottom panel charts the

Figure 3 GDP Inflation Volatility and Uncertainty



rolling variance of GDP inflation forecasts. The top and middle panels indicate that the series measuring the MSE of the inflation forecast has a downward trend that is shared by the series measuring the mean forecast but not by the series measuring the variance of actual inflation. This suggests that short-term inflation uncertainty declined not because inflation was less volatile but because inflation trended down.[12] Furthermore, the bottom panel indicates that variance of the predictable component of inflation also declined significantly during this period, suggesting increased predictability of inflation. Figure 3 thus provides a visual confirmation of the hypothesis that short-term inflation

[12] The argument that, over the sample period 1984Q1 to 2005Q3, the series measuring the variance of inflation does not depict a downward trend is not inconsistent with the evidence in previous research that volatility of inflation (measured by the variance of inflation) observed in the sample period since 1984 has been low relative to the one observed in the period before.

uncertainty declined because inflation both trended down and became more predictable.[13]

Current Low Short-Term Inflation Uncertainty and Anchoring of Long-Term Inflation Expectations

Figure 4 highlights another key feature of the recent favorable inflation performance: the current low level of short-term inflation uncertainty has accompanied decline in volatility of long-term inflation expectations. The top panel in Figure 4 plots the rolling MSE of four-quarter GDP inflation forecasts as before, and the other panel charts the rolling standard deviation of the ten-year-ahead CPI expected inflation. As one can see, during the past few years the standard deviation of the ten-year CPI inflation forecast has been zero, suggesting the recent stabilization and anchoring of long-term inflation expectations.

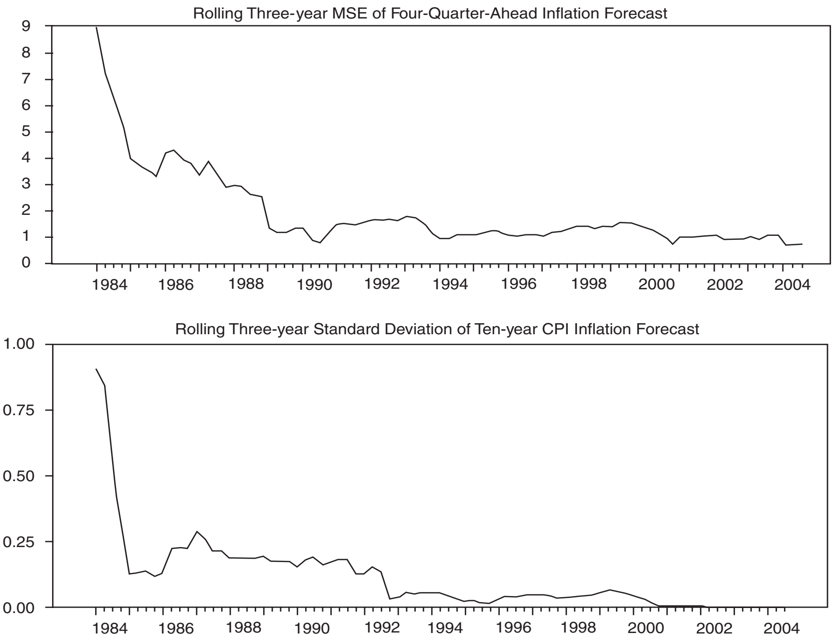
One simple explanation of this recent anchoring of long-term inflation expectations is that the recent period of low short-term inflation uncertainty has increased confidence that inflation will remain low and stable in the long run, which was absent before. This outcome may be the consequence of increased Fed credibility that occurred near the end of the sample period. During the early part of the sample period 1984 to 2005, though short-term inflation uncertainty declined to lower levels, long-term inflation expectations did not stabilize, reflecting the lack of Fed credibility. As one can see, during the early part of this sample period, both short-term and long-term inflation forecasts were not stabilized (see the bottom panel in Figure 3 and the lower panel in Figure 4). One implication of this different behavior of long-term inflation expectations is that the correlation of the long bond rate with short-term inflation uncertainty is likely to be weaker near the end of the sample period than it is during the early part, meaning a given rise in short-term inflation uncertainty is unlikely to raise uncertainty about long-term inflation forecasts as much as it did previously. This implication is confirmed by the empirical work in the following section, which attributes the recent decline

[13] As noted in Tulip (2005), the variance of actual future inflation is algebraically related to MSE as shown below.

$$\underbrace{\frac{1}{n}\sum_{n=1}^{12}(\pi_{t+4}-\bar{\pi})^2}_{Variance} = \underbrace{\frac{1}{n}\sum_{n=1}^{12}(e_{t+4})^2}_{MSE} + \underbrace{\frac{1}{n}\sum_{n=1}^{12}(f_{t+4}-\bar{\pi})^2}_{Predicted\ Variation} + \underbrace{\frac{2}{n}\sum_{n=1}^{12}(f_{t+4}-\bar{\pi})e_{t+4}}_{Covariance},$$

where π_{t+4} is actual four-quarter-ahead inflation, f is the survey forecast, e is the forecast error, and $\bar{\pi}$ is the sample mean. Hence, in the top panel, the distance between the line plotting variance and the line plotting MSE equals the sum of the last two terms. If we ignore the last term, the second term on the right-hand side of the equation above measures variance of the predictable component of inflation. The bottom panel in Figure 3 has charted the second term.

Figure 4 Stabilization of Inflation Expectations



in the inflation risk premium to reduced sensitivity of the long bond rate to uncertainty about long-term inflation forecasts.[14]

2. A REDUCED-FORM EMPIRICAL MODEL OF THE LONG BOND RATE

In this section, I discuss a reduced-form empirical equation that links the long bond rate to macroeconomic variables, including the empirical proxy for short-term inflation uncertainty. I also describe the data used to estimate the reduced-form equation.

[14] Figure 4 indicates that, for most of the 1990s, short-term inflation uncertainty remained low and stable, while long-term inflation expectations were stabilized. In order to uncover the relationship between the long bond rate and inflation uncertainty, one needs a period during which the potential explanatory variables, including the empirical measure of short-term inflation uncertainty, have varied considerably, as was the case during the early part of the sample period.

Long Run: The Fisher Equation

The reduced-form interest rate equation that underlies the empirical work here has two parts: a long-run and a short-run part. The long-run part, based on the Fisher equation, relates the level of the bond rate to long-term inflation expectations, risk premiums, and a risk-free long real rate, as in (1.3).

$$(1 - T_t)BR_t = rr_t + a_\pi \pi_t^e;\ a_\pi = 1, \tag{1.1}$$

$$rr_t = rr^* + a_r RP_t + \mu_t, \tag{1.2}$$

$$BR_t = (1/1 - T_t)[rr^* + a_r RP_t + a_\pi \pi_t^e + \mu_t];\ a_\pi = 1, \tag{1.3}$$

where BR is the long bond rate; T_t is the marginal tax rate on interest income in period t; rr_t is the after-tax expected long real rate; rr^* is the after-tax, risk-free expected long real rate; RP is a risk premium variable; π^* is long-term inflation expectations; and μ is the stationary disturbance term. Equation 1.1 is just the long-run Fisher equation that relates the after-tax long bond rate to the expected long real rate and inflation expectations. Equation 1.2 says the expected long real rate is mean stationary once we account for the presence of risk premiums in bond yields. If we substitute (1.2) into (1.1), one gets equation (1.3), which relates the level of the bond rate to long-term inflation expectations, risk premiums, and a risk-free long real rate.

The coefficient a_π is the after-tax Fisher coefficient that measures the response of the after-tax bond rate to inflation expectations and is generally assumed unity. The key point to note is that in the presence of taxes on interest income, the long bond rate should rise during an inflation episode by an amount that exceeds expected inflation sufficiently to compensate lenders both for their loss of capital due to inflation and for the taxation of interest income. Hence, in the presence of the tax effect, the before-tax Fisher coefficient $(a_\pi/(1-T_t))$ is likely to exceed unity, its exact magnitude varying with the marginal tax rate on interest income.[15] Furthermore, a significant component of risk premiums embedded in bond yields is likely to be inflation risk, arising as a result of unpredictable movements in long-term expected inflation.

Short Run: Short-Run Changes in the Bond Rate are Dominated by Changes in the Outlook for the Economy and the Stance of Monetary Policy

The bond rate equation given in (1.3) is long run and is motivated using the Fisher equation, in which the level of the long bond rate is related to the risk-

[15] Tanzi (1980).

adjusted expected long real rate and expected inflation. The expected long real rate is, however, unobservable. Recent research that has expanded term structure models of bond yields to include macroeconomic factors suggest that changes in the expected long real rate reflect changes in expected future short rates, which in turn are likely to be correlated with changes in the outlook for the economy and changes in the current and future stance of monetary policy.[16] In order to control for influences of other macroeconomic variables on the long bond rate, I consider the following short-run, error-correction specification of the bond rate equation (Mehra 1984, 1994):

$$\Delta(1-T_t)BR_t = f_0 + f_{\Delta rp}\Delta RP_t + f_{\Delta\pi}\Delta\pi_t^e + \sum_{h=1}^{k} f_{1rs}\Delta\dot{y}_{t+h}^e \qquad (2)$$

$$+\sum_{h=1}^{k} f_{2rh}\Delta\dot{P}_{t+h}^e + f_{3r}u\Delta FFR_t - f_{ec}\mu_{t-1} + \varepsilon_t,$$

$$\text{where } \mu_{t-1} = (1-T_{t-1})BR_{t-1} - rr^* - a_r RP_{t-1} - a_\pi \pi_{t-1}^e$$

where h is the forecast horizon, $\Delta\dot{y}_{t+h}^e$ is change in the h-quarter-ahead forecast of real growth, $\Delta\dot{P}_{t+h}^e$ is change in the h-quarter-ahead forecast of the inflation rate, and $u\Delta FFR$ is the surprise component of the change in the federal funds rate. Equation 2 relates short-run changes in the after-tax bond rate to three sets of economic variables: the first set contains first differences of economic variables that enter the long-run Fisher equation here (ΔRP_t, $\Delta\pi_t^e$); the second set contains variables measuring changes in the outlook for the economy and stance of monetary policy ($\Delta\dot{y}_{t+h}^e$, $\Delta\dot{P}_{t+h}^e$, $u\Delta FFR_t$); and the third set contains only a lagged error-correction variable (μ_{t-1}), measured as a gap between the actual level of the long rate and the level consistent with the long bond equation. The coefficient on the error-correction variable in (2) is hypothesized to be negative, meaning the bond rate declines if in the previous period the actual bond rate was high relative to the level consistent with its long-run determinants specified in (1.3).

In the empirical bond equation (2), changes in the outlook for the economy are measured as changes in private-sector forecasts of real growth and inflation. The expected signs of coefficients that appear on changes in anticipated real

[16] The reduced-form empirical bond rate equation estimated here is in spirit based on the recent empirical work that links bond yield dynamics to macroeconomic variables. To explain it further, as in finance literature, bond yields are modeled as risk-adjusted averages of expected future short rates. Expectations of future short rates, however, depend in part on expectations of future macroeconomic variables, which are generated using either a structural or a VAR model of the economy. This methodology thus relates bond yield dynamics to macroeconomic variables. See Clouse (2004) and Hordahl, Tristani, and Vestin (2006) for an empirical illustration of this joint econometric modeling of macroeconomic and term-structure dynamics and Diebold, Piazzesi, and Rudebusch (2005) for a summary of this literature.

growth and inflation variables in (2) are positive, suggesting that accelerated future real growth or inflation is likely to lead to higher future short real rates and hence to a higher long real rate. The positive correlation between the long real rate and higher anticipated real growth or inflation may arise as a result of "lean-against-the-winds" monetary policy strategy; namely, the private sector expects the Federal Reserve to raise the funds rate target when real growth or inflation is anticipated to accelerate, leading to higher future short real rates.

The impact of monetary policy actions on the expected long real rate is captured by the "surprise" component of changes in the funds rate target. Recent research indicates that bond yields respond to this surprise component and that the nature of the yield curve response depends crucially on the interpretation of market participants' reasons behind the policy move. If the policy move is interpreted to reveal "new" information about the outlook for inflation and real growth, interest rates of all maturities, including the long end, move in the same direction as the funds rate target. If, on the other hand, market participants view the policy move as driven by changes in the central bank's preferences (such as a shift to a more inflation-averse policy), long and short rates move in opposite directions (Ellingsen and Soderstrom 2001, 2004; Gurkaynak, Sack, and Swanson 2005). Thus, this literature suggests that the response of the long bond rate to policy is time varying, and the bond rate may actually fall if bond market participants interpret policy tightening as resulting in lower inflation in the long run.

Combining Long- and Short-Run Parts

Equation (2) is the short-term bond equation that relates changes in the bond rate to (a) "changes" in the private-sector outlook for real growth and inflation; (b) the surprise component of changes in the funds rate target; (c) changes in long-term inflation expectations and risk premiums; and (d) the lagged value of an error-correction variable, measuring discrepancies between the actual level of the bond rate and the level consistent with the long-run Fisher equation (1.3). If we substitute the expression for the error-correction variable into (2), we get a reduced-form long bond equation as in (3).

$$\Delta(1-T_t)BR_t = f_0 + f_{\Delta rp}\Delta RP_t + f_{\Delta\pi}\Delta\pi^e_t + \sum_{h=1}^{k} f_{1rh}\Delta\dot{y}^e_{t+h} + \sum_{h=1}^{k} f_{2rh}\Delta\dot{P}^e_{t+h} \tag{3}$$

$$+ f_{3r}u\Delta FFR_t - f_{ec}(1-T_{t-1})BR_{t-1} + f_{ec}rr^* + f_{ec}a_r RP_{t-1} + f_{ec}a_\pi\pi^e_{t-1} + \varepsilon_t$$

$$\Delta BR = (1/(1-T_t))[\delta_0 + f_{\Delta rp}\Delta RP_t + f_{\Delta\pi}\Delta\pi^e_t + \sum_{h=1}^{k} f_{1rh}\Delta\dot{y}^e_{t+h} + \sum_{h=1}^{k} f_{2rh}\Delta\dot{P}^e_{t+h}$$

$$+ f_{3r}u\Delta FFR_t - f_{ec}(1-T_{t-1})BR_{t-1} + f_{ec}a_r RP_{t-1} + f_{ec}a_\pi\pi^e_{t-1}] + \varepsilon_t$$

$$\text{where } \delta_0 = f_0 + f_{ec} rr^* .$$

Three key features of the short-term bond equation (3) need to be highlighted. The first is the equation relates changes in the bond rate to changes and levels of some macro variables, in particular long-term inflation expectations. As a result, it is possible to recover estimates of the coefficients of the long-run Fisher equation from the short-run, reduced-form equation. Thus, if we estimate the unrestricted reduced-form (3), the after-tax Fisher coefficient a_π is recovered as the estimated coefficient ($f_{ec}a_\pi$) on lagged inflation expectations (π^e_{t-1}) divided by the absolute value of the estimated coefficient (f_{ec}) on the lagged bond rate (BR_{t-1}).[17] The second feature to highlight is that the short-run response of the long bond rate to macroeconomic variables is likely to vary over time, as the marginal tax rate on interest income is not constant over time. The third feature to note is that in a steady state where the private sector's near-term real growth and inflation expectations are stabilized and where there are no monetary policy surprises, the long bond rate will converge to the level determined by the Fisher equation.[18]

Estimating the Bond Rate Equation: Description of the Data

The long bond equation (3) is estimated using quarterly data over 1984Q1 to 2005Q3. The long bond rate (*BR*) is the nominal yield on ten-year U.S. Treasury bonds observed in the third month of the quarter. The measure of monetary policy is the funds rate observed in the third month of the quarter. The survey forecast of the ten-year-ahead CPI expected inflation rate (π^{10}_t) is used as a proxy for long-term inflation expectations. The private-sector outlook for the economy is measured by the Survey of Professional Forecasters' (SPF) near-term forecasts of real growth and inflation, currently conducted by the Philadelphia Fed and released by the end of the second month of the quarter. Inflation uncertainty is measured by the series on inflation unpredictability, discussed in the previous section. The tax rates used are from the series on the (average) marginal tax rate on interest income given in the NBER's TAXSIM model.[19]

In some previous research, the surprise component of the change in the funds rate has been calculated using data from the fed funds futures market (Kuttner 2001). I, however, follow the strategy in Romer and Romer (2004)

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[17] Estimate of the constant term in the long Fisher equation is not identified.

[18] To be specific, consider a steady state in which coefficients in (3) assume values given below: $f_{\Delta rp} = f_{\Delta\pi} = f_{1rs} = f_{2rs} = f_{3r} = a_{rp} = 0,\ f_{ec} = 1$, then the long bond rate equals the risk-free long expected real rate and expected inflation.

[19] See Feenberg and Coutts (1993) for more details. The tax series used is the one that measures the federal marginal tax rates on interest income.

and construct a different measure of monetary policy surprise. Romer and Romer develop a measure of policy shocks by removing the component of changes in the funds rate target that are due to past and anticipated developments in the economy, and they capture the effect of anticipated developments on the funds rate target using Greenbook forecasts of real growth and inflation. So, Romer and Romer's measure of policy shocks is free of movements anticipated by the Federal Reserve.

However, what one needs here is a measure of policy shocks that are free of movements anticipated by bond market participants. Hence, I purge the funds rate target of anticipated movements by using private-sector forecasts of real growth and inflation. In particular, I purge the endogenous and anticipated movements in the funds rate by running the following regression.

$$\Delta FFR_t = \alpha_0 + \sum_{h=1}^{k} \alpha_{1s} \Delta \dot{y}^e_{t+h} + \sum_{h=1}^{k} \alpha_{2h} \dot{P}^e_{t+h} + \alpha_3 \dot{y}^e_t + \alpha_4 \dot{p}^e_t + \sum_{s=1}^{k} \alpha_{3s} \Delta y_{t-s} \quad (4)$$

$$+ \sum_{s=1}^{k} \alpha_{6s} \Delta P_{t-s} + \alpha_7 FFR_{t-1} + u\Delta FFR_t,$$

where *FFR* is the actual funds rate, y is actual real growth, p is actual inflation rate, $u\Delta FFR$ is the residual, and the rest of the variables are defined as before. The residual $u\Delta FFR$ from the estimated regression (4) is the measure of the surprise component of changes in the funds rate target. Since the funds rate target is the average value of the actual funds rate observed in the third month of the quarter, the regression (4) provides estimates of changes in the funds rate anticipated based on the latest information available to bond market participants.

The funds rate equation (4) is estimated over 1983Q1 to 2005Q3 and is reproduced below:

$$\Delta FFR_t = \underset{(3.4)}{-.63} + \sum_{h=0}^{4} \underset{(0.2)}{.03} \Delta \dot{y}^e_{t+h} + \sum_{h=0}^{4} \underset{(2.6)}{.63} \Delta \dot{P}^e_{t+h} + \underset{(4.4)}{.19} \dot{y}^e_t \quad (5)$$

$$+ \underset{(2.0)}{.17} \dot{P}^e_t + \underset{(1.6)}{.04} \Delta y_{t-1} + \underset{(2.2)}{.10} \Delta P_{t-s} - \underset{(1.9)}{.06} FFR_{t-1} + u\Delta FFR_t$$

$$\text{Adjusted } R^2 = .44,$$

where all variables are defined as before. As one can see, changes in the funds rate target are significantly correlated with changes in forecasts of GDP inflation, besides being correlated with changes in lagged inflation and real growth. Changes in the funds rate target are also correlated with forecast levels of GDP inflation and real growth. In the empirical work here, the residual from the estimated funds rate equation (5) is used as a proxy for the surprise component of change in the funds rate target.[20]

As indicated above, the bond equation (3) allows for the presence of the tax effect. Hence, the equation is estimated using data observations on variables that have been pre-multiplied by the time-varying tax series $(1/(1 - T_t))$.[21] The bond rate equation is estimated by ordinary least squares.

3. EMPIRICAL RESULTS

This section discusses estimates of the bond equation (3) over 1984Q1 to 2004Q3. In order to examine robustness of results, I also estimate the bond equation over a shorter sample period, 1984Q1 to 2000Q4, excluding observations pertaining to the most recent sub-period of low bond yields and increased foreign official inflows into U.S. Treasury securities.

Estimates of the Bond Rate Equation: With and Without Inflation Uncertainty

Table 1 contains estimates of the bond rate equation (3) over two sample periods, 1984Q1 to 2000Q4 and 1984Q1 to 2004Q3. The columns labeled (1.1) and (1.2) contain estimates of what is denoted hereafter as the "baseline" bond equation. In the baseline bond equation, the long-run part contains long-term inflation expectations and the short-run part includes macroeconomic variables measuring changes in the outlook for the economy and monetary policy. If we focus on estimates of the baseline equation for the shorter period of 1984Q1 to 2000Q4, they suggest the following observations. First, short-term changes in the bond rate are significantly correlated with changes in long-term inflation expectations and the short-term outlook for real growth and GDP inflation. The estimated coefficients that appear on these macroeconomic variables are statistically significant and correctly signed, indicating that accelerations in long-term expected inflation and short-term forecasts of real growth and inflation are associated with a higher bond rate.

Second, the long bond rate is positively correlated with the surprise component of the change in the funds rate, suggesting that policy tightening is associated with a rising bond rate. The estimated coefficient on policy surprises has a positive sign, suggesting that on average policy surprises have conveyed new information about the state of the economy.

[20] The first four estimated autocorrelation coefficients of the monetary policy surprise series are .20, .15, .06, and .02, which are insignificantly different from zero, suggesting that time series in fact do measure policy surprises.

[21] See Tanzi (1980) and Mehra (1984) for details.

Table 1 Estimates of the Bond Rate Equation

	Dependent Variable: ΔBR_t Sample Period Ending in					
Independent Variables	(1.1) 2000Q4	(1.2) 2004Q3	(2.1) 2000Q4	(2.2) 2004Q3	(3.1) 2004Q3	(3.2) 2004Q3
$const.$						
BR_{t-1}	-.18 (2.6)	-.21 (3.2)	-.24 (3.4)	-.25 (3.8)	-.30 (4.4)	-.27 (4.3)
π^{10}_{t-1}	.28 (2.6)	.32 (3.0)	.23 (2.3)	.26 (2.5)	.27 (2.6)	.27 (4.3)
RP_{t-1}			.09 (2.4)	.09 (2.3)	.10 (2.8)	.10 (3.5)
$DU * RP_{t-1}$					-.34 (2.2)	-.10 (3.5)
$\Delta\pi^{10}_t$	.28 (1.9)	.30 (2.1)	.23 (1.6)	.24 (1.7)	.27 (1.7)	.24 (1.8)
Δy^e_{t+s}	.24 (1.8)	.18 (1.6)	.25 (1.9)	.18 (1.7)	.22 (2.1)	.20 (1.9)
$\Delta \dot{P}^e_{t+s}$	.45 (2.3)	.41 (2.2)	.48 (2.5)	.43 (2.4)	.45 (2.5)	.44 (2.5)
$u\Delta FFR_t$	.28 (2.4)	.19 (1.8)	.27 (2.4)	.20 (2.0)	.16 (1.6)	.19 (1.9)
a_π	1.57	1.54	1.0	1.0	.92	1.0
a_r			.39	.35		.35; 0.0[a]
R^2	.25	.20	.31	.25	.28	.28
SER	.530	.537	.509	.522	.509	.510

Notes: The reported coefficients (with t-values in parenthesis) are from the bond rate equation (4) of the text estimated over the sample period that begins in 1984Q1 but ends as indicated above. BR is the ten-year bond rate, π^{10} is the ten-year-ahead survey inflation forecast, RP is an inflation risk variable measured as the MSE of forecast errors, Δy^e_{t+s} is the average of zero-to-four-quarter-ahead (survey) real growth forecasts, $\Delta \dot{P}^e_{t+s}$ is the average of zero-to-four-quarter-ahead (survey) GDP inflation forecasts, $u\Delta FFR_t$ is the surprise component of change in the funds rate, DU is a dummy variable defined as unity over 2001Q4 to 2005Q3 and zero otherwise, R^2 is adjusted-R squared, and SER is the standard error of estimate. a_π is the long-term after-tax coefficient on ten-year expected inflation (Fisher coefficient) and a_r is the long-term coefficient on the inflation-related risk variable. All equations are estimated by ordinary least squares, using time series data pre-multiplied by (1/(1-Tax_t)), where Tax_t is the marginal tax rate on interest income.

a: post-break a_r

Third, the estimated after-tax Fisher coefficient a_π that measures the long-term response of the bond rate to inflation expectations is positive and far above unity. Since the baseline bond equation is estimated without controlling for the potential influence of inflation uncertainty on the long bond rate, the estimated Fisher coefficient may be biased upward, capturing in part the inflation risk premium embedded in the long bond yield.[22]

Finally, the above-noted three observations about the relationship between the long bond rate and macroeconomic variables continue to hold if we con-

[22] The sign of bias in the estimated Fisher coefficient is positive because inflation risk, which is omitted from the regression, is likely to be positively correlated with the level of expected inflation; namely, inflation uncertainty is large if expected inflation is high and variable.

sider estimates of the baseline equation over the full sample period given in the column labeled (1.2).

The columns labeled (2.1) and (2.2) in Table 1 contain estimates of the baseline equation augmented to include the empirical measure of short-term inflation uncertainty. Three results need to be highlighted. The first one is that the long bond rate is positively correlated with short-term inflation uncertainty, as the estimated coefficient on the pertinent variable is positive and statistically different from zero.[23] The estimated coefficient on short-term inflation uncertainty has a positive sign, suggesting that an increase in uncertainty about short-term inflation forecasts raises uncertainty about long-term inflation forecasts and hence may account for the presence of the inflation risk premium in the bond rate. The second result to note is that estimates of coefficients on other macroeconomic variables remain mostly unaffected when the bond equation is estimated controlling for the influence of inflation uncertainty, with the exception of the coefficient that appears on the lagged level of inflationary expectations (compare estimates across columns labeled [1.1] through [2.2]). The estimated after-tax Fisher coefficient is now close to unity (the p-value of the null hypothesis that $a_\pi = 1$ is .90, leading to the acceptance of the hypothesis), suggesting that failure to control for the presence of the inflation risk premium yields an unduly large estimate of the Fisher coefficient. Finally, the results appear robust across two sample periods considered here. In particular, the estimated coefficient on short-term inflation uncertainty remains positive and statistically significant in both sample periods, suggesting the result that inflation uncertainty matters in determining the long bond yield is not due to the most recent data.

Testing Stability of the Bond Rate Equation: Disappearance of the Inflation Risk Premium

Even though estimates of the baseline equation augmented with inflation uncertainty as reported in Table 1 appear similar across two sample periods, I now formally test parameter stability of the bond equation. As discussed earlier, one popular explanation of the current low level of the bond rate is that bond market participants are now demanding lower inflation risk premiums than before. Figures 2 and 3 indicate that uncertainty about short-term inflation forecasts declined steeply during the early part of the sample period 1984Q1 to 2004Q3 and so did variances of both GDP and long-term CPI inflation forecasts. However, during the early part, both short-term inflation

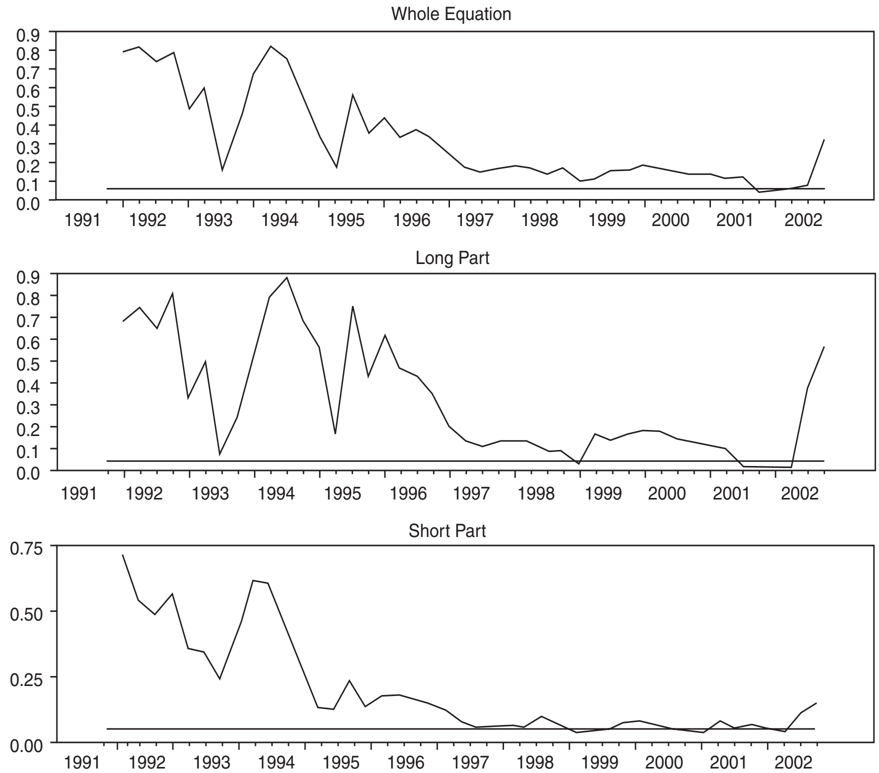
[23] The preliminary empirical work indicated that the long bond rate is positively correlated with the lagged level of the empirical measure of inflation uncertainty. First differences of this variable do not enter the bond equation. Together these results imply that inflation uncertainty enters the long-run part of the bond equation.

uncertainty and variances of both GDP and long-term CPI inflation forecasts remained fairly high, meaning uncertainty about long-term inflation forecasts remained high and long-term inflation expectations remained highly variable. Since then, short-term inflation uncertainty has declined, although modestly, and this modest decline in short-term inflation uncertainty has been accompanied by a significant reduction in the volatility of inflation expectations. In particular, the standard deviation of the ten-year-ahead CPI expected inflation has hovered around zero during the past few years, suggesting that market participants expect inflation to remain low and stable in the long run (see Figure 4). These considerations suggest that correlation of the long bond rate with short-term inflation uncertainty, which is a proxy for its correlation with uncertainty about long-term inflation forecasts, may not be stable over the sample period, 1984Q1 to 2004Q3. In particular, the coefficient a_r that measures the long-term response of the bond rate to short-term inflation uncertainty may have declined in recent years, because an increase in short-term inflation uncertainty may not raise uncertainty about long-term inflation forecasts as much as it did previously. Hence, I formally test parameter stability, using the Chow test with the break date treated as unknown over 1994Q1 to 2002Q4.

Figure 5 plots p-values of a Chow test for stability of different coefficients in the augmented bond equation as a function of the break date over 1994Q1 to 2002Q4. Panel A in Figure 5 plots the p-value of a Chow test where the null hypothesis is that all coefficients of the long bond rate equation are stable against the alternative that they have changed at the given date; panel B plots the p-value for stability of coefficients in the long-run part (coefficients on the constant term, inflation uncertainty, and long-term inflation expectations); and panel C plots the p-value for stability of coefficients in the short-run part (coefficients on changes in anticipated real growth and inflation and the surprise component of the change in the funds rate). The dashed line indicates a p-value of .05. In Figure 5, one main observation is that there is evidence of parameter instability only in the long-run part of the bond equation, suggesting that coefficients that appear on inflation uncertainty and long-term inflation expectations have changed, with the break date being 2001Q4. I assume the after-tax Fisher coefficient a_π has not changed and equals unity, because bond investors must be compensated for expected inflation even if they expect inflation to remain low and stable forever. Hence, I capture the break in the long-run part of the equation by allowing a different coefficient on short-term inflation uncertainty, because bond market participants may demand a lower inflation risk premium if they expect inflation to remain low and stable in the long run.[24]

[24] The alternative—that investors would not want to be compensated for expected inflation—is not reasonable.

Figure 5 P-Values for Chow Test: Baseline Equation With Inflation Uncertainty



Columns (3.1) and (3.2) in Table 1 present the estimated augmented bond equation that allows for the presence of a break in the coefficient on inflation uncertainty, captured here by including a dummy variable interacting with lagged inflation uncertainty. Column (3.1) contains unrestricted estimates, whereas column (3.2) contains estimates under the restrictions that the after-tax Fisher coefficient a_π is unity and that the coefficient on inflation uncertainty is positive before 2001Q4 but zero thereafter. The p-value for the null hypothesis that the Fisher coefficient a_π equals unity and the risk coefficient a_r is zero is .28, which is large, leading to the acceptance of the null. As shown, the estimated coefficient on the slope dummy variable is negative and statistically different from zero, suggesting that the long bond rate has become less sensitive to inflation uncertainty in recent years. In fact, estimates are consistent with the disappearance of the inflation risk premium in the long bond rate. In the pre-break period of 1984Q1 to 2001Q3, the average inflation risk premium is estimated to be about .98 of a percentage point, whereas, in the post-break period, the average risk premium is zero.[25]

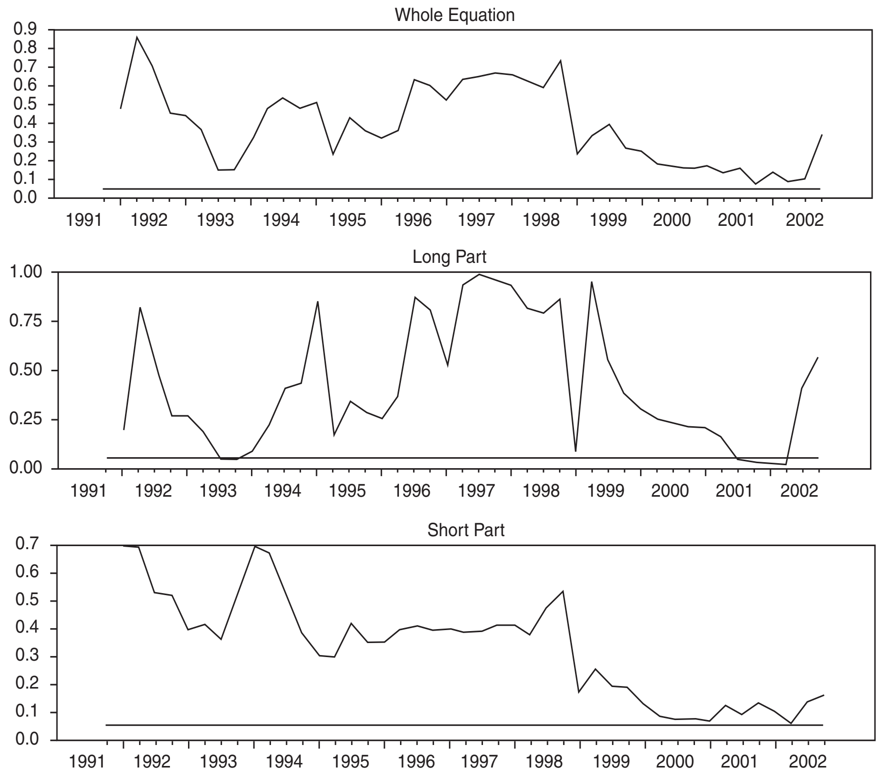
An Alternative Test of Lower Inflation Risk Premiums: Testing for a Shift in the Fisher Coefficient

The key result here is that the long bond rate is no longer correlated with the empirical measure of short-term inflation uncertainty, indicating the disappearance of inflation risk premiums from bond yields. But the aforementioned result is derived using the bond rate equation in which inflation uncertainty is measured by the MSE of short-to-medium-term GDP inflation forecasts. I now consider an alternative test of the hypothesis that inflation risk premiums have declined, using only the baseline bond equation. The basic idea behind the test is that if the bond rate equation is estimated without including a direct empirical measure of inflation uncertainty, then the estimated after-tax Fisher coefficient is likely to be above unity, because bond market participants must be compensated for inflation as well as for inflation-related risk. Hence the hypothesis inflation risk premiums that have declined can be tested by examining the temporal stability of the after-tax Fisher coefficient. Under the null hypothesis that inflation risk premiums have disappeared in recent years, the after-tax Fisher coefficient should now be closer to unity than it has been before.

For the full sample period 1984Q1 to 2004Q3, the estimated baseline bond equation is already reported in the column labeled (1.2) in Table 1. As one can see, the estimated after-tax Fisher coefficient is 1.5, far above unity, reflecting in part the presence of inflation-related risk premiums. Figure 6, which is similar to Figure 5, re-examines parameter stability of the baseline equation and plots p-values of a Chow test for stability of different coefficients as a function of the break date over 1994Q1 to 2002Q4. As can be seen, there is evidence of parameter instability not in the short-run part but in the long-run part of the bond rate equation, suggesting that the coefficient on long-term expected inflation has changed, with the break date being 2001Q4. Given such evidence of instability, I re-estimate the bond equation over 1984Q1 to 2004Q3, allowing the presence of a different Fisher coefficient since 2001Q4 and using a slope dummy. The estimated baseline bond equation is reported

[25] The magnitude of the inflation-related risk premium at time t is simply the long-term coefficient on inflation uncertainty times period t value of the time series measuring inflation uncertainty. In the pre-break period, the long-term coefficient on inflation uncertainty is .35 and the sample mean of the MSE of the four-quarter-ahead inflation forecast is 2.8 percentage points, suggesting that the average inflation risk premium over 1984Q1 to 2001Q4 is about 98 basis points. In the post-break period, however, the long-term coefficient on inflation uncertainty is not different from zero, suggesting that the inflation risk premium has disappeared.

Figure 6 P-Values for Chow Test: Baseline Bond Equation



below in (6).

$$\Delta BR_t = \underset{(0.4)}{.04} + \underset{(3.4)}{.32}\pi^{10}_{t-1} - \underset{(2.4)}{.10}(\pi^{10}_{t-1} * DU_{t-1}) - \underset{(3.5)}{.23} BR_{t-1} \quad (6)$$

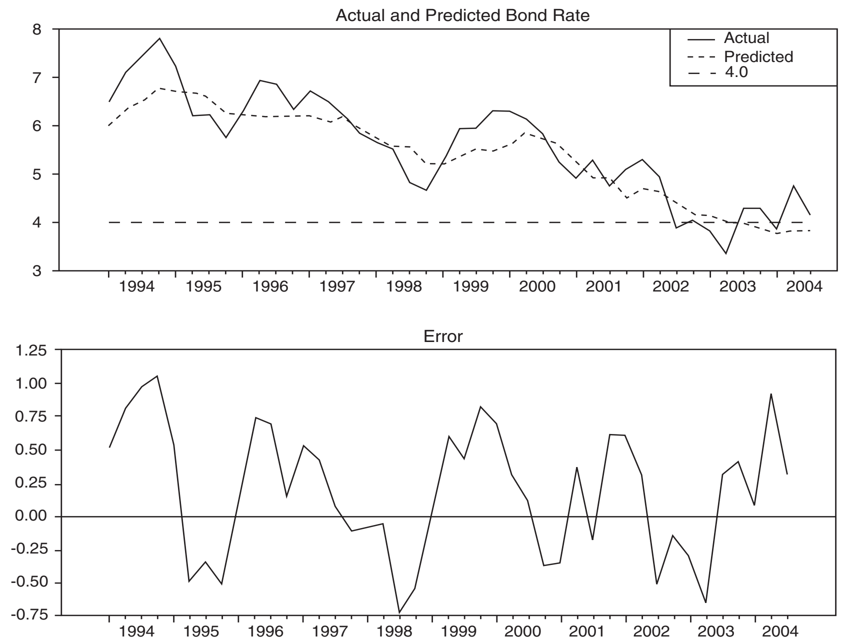
$$+\underset{(2.1)}{.29}\Delta\pi^{10}_t + \underset{(1.8)}{.19}\Delta\dot{y}^e_t + \underset{(2.1)}{.38}\Delta\dot{P}^e_t + \underset{(1.8)}{.19}u\Delta FFR_t.$$

Fisher Coefficient: $a_\pi = 1.42$(Pre-break) Adjusted $R^2 = .22$ $SER = .526$

=1.00(Post-break),

where DU is a dummy variable defined as unity over 2001Q4–2005Q1 and zero otherwise and where other variables are defined as before (see Table 1). As shown, the estimated after-tax Fisher coefficient is now unity and is consistent with the reduced magnitude of the inflation risk premium. Since the bond rate equation is estimated in first difference form, this reduction in the magnitude of the Fisher coefficient will result in reducing the level of the

Figure 7 Baseline with Lower Fisher Coefficient

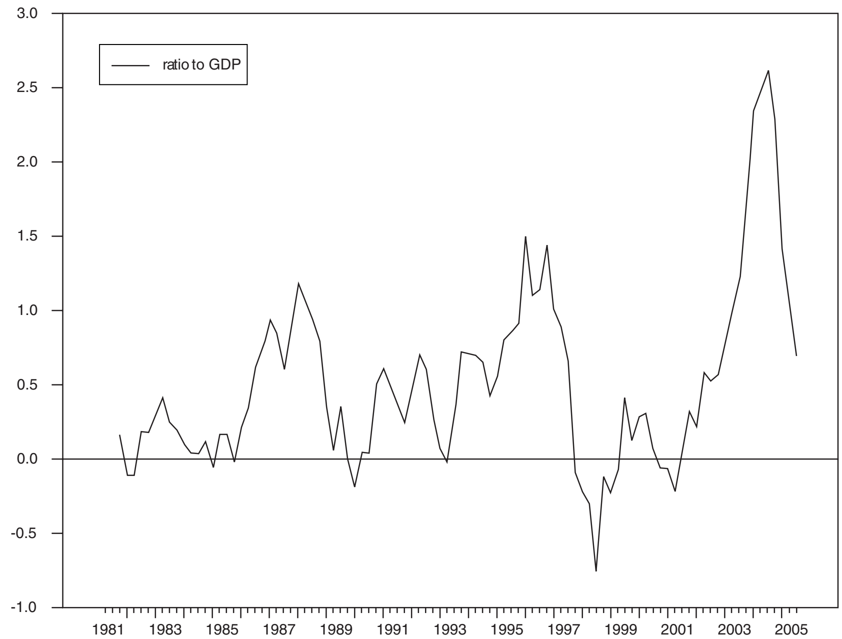


long real rate associated with long-term inflation expectations. The survey forecast of the ten-year-ahead CPI inflation rate has hovered around a narrow 2 percent to 2.5 percent range in recent years. Given that the magnitude of the Fisher coefficient declined by about 40 basis points, the reduction in after-tax real and nominal bond yields that can be attributed to reduction in inflation-related risk premiums may range between .8 of a percentage point to about 1.1 percentage points.

Predicting the Recent Low Level of the Long Bond Rate

I now present evidence that the bond equation that allows for the presence of a downward shift in the Fisher coefficient as in equation (6) is consistent with the actual behavior of the long bond rate in recent years. In particular, I estimate the bond equation (6) over 1984Q1 to 2004Q3 and simulate it dynamically over 1994Q1 to 2004Q3. Figure 7 charts the simulated values generated using actual values of right-hand-side explanatory variables. Actual values of the bond rate and the forecast errors are also charted there. This figure suggests two observations. First, this equation predicts reasonably well the

Figure 8 Foreign Official Purchase of U.S. Treasury Securities



actual path of the bond rate over 1994Q1 to 2004Q3. The mean prediction error is small and equals .20, and the root mean squared error is one-half of a percentage point. Second, during the past two-and-a-half years, the ten-year bond rate has hovered around 4 percent, and this behavior of the bond rate seems consistent with economic fundamentals, once we allow for a break in the Fisher coefficient.

Robustness: Assessing the Potential Role of Increased Foreign Purchases of U.S. Treasury Securities

As indicated at the beginning, another popular explanation of the current low level of long-term interest rates is that increased purchases of U.S. Treasury securities by foreign individuals and foreign central banks may have contributed to the recent declines in long bond rates. Figure 8 charts foreign official net purchases of U.S. securities (summed over four quarters) as a percentage of lagged U.S. GDP, and this chart clearly indicates a significant increase in foreign official net purchases during the past few years.

One preliminary test of the above-noted explanation is to augment the baseline bond equation (4) to include the level and/or change in foreign official

Table 2 Estimates of the Bond Rate Equation, Including Foreign Official Holdings of U.S. Treasury Securities

	Dependent Variable: ΔBR_t Sample Period Ending in			
Independent Variables	(4.1) 2000Q4	(4.2) 2004Q3	(5.1) 2000Q4	(5.2) 2004Q3
$const.$				
BR_{t-1}	-.19 (2.6)	-.22 (3.4)	-.25 (3.3)	-.27 (3.9)
π^{10}_{t-1}	.29 (2.5)	.34 (3.1)	.22 (1.9)	.28 (2.5)
RP_{t-1}			.10 (2.6)	.09 (2.4)
rk_{t-1}	.03 (0.2)	-.01 (0.1)	.10 (0.8)	.02 (0.2)
Δrk_t	-.20 (1.0)	-.28 (1.6)*	-.18 (0.9)	-.30 (1.8)*
$\Delta\pi^{10}_t$	.30 (2.0)	.33 (2.2)	.24 (1.7)	.28 (1.9)
Δy^e_{t+s}	.20 (1.5)	.14 (1.3)	.20 (1.6)	.15 (1.4)
ΔP^e_{t+s}	.42 (2.0)	.37 (1.9)	.41 (2.1)	.38 (2.1)
$u\Delta FFR_t$	.26 (2.2)	.17 (1.6)	.24 (2.1)	.18 (1.7)
a_π	1.53	1.50	.90	1.0
a_r			.41	.35
R^2	.25	.21	.31	.26
SER	.533	.535	.508	.517

Notes: rk is foreign official holdings of U.S. Treasury securities, expressed as a proportion of lagged GDP; other variables are defined as in Table 1. See notes in Table 1. * significant at the .10 level.

purchases and examine whether the long bond rate is negatively correlated with foreign official inflows over 1984Q1 to 2004Q3. In order to determine whether results are due to the most recent large foreign inflows, I also estimate the bond equation over a shorter sample period, 1984Q1 to 2000Q4.

Table 2 presents estimates of the augmented baseline bond equations over two sample periods. The columns labeled (4.1) and (4.2) present estimates of the baseline equation augmented to include foreign official capital inflows, whereas the columns labeled (5.1) and (5.2) contain estimates of the baseline equation augmented to include both foreign inflows and the empirical measure of inflation uncertainty. If we focus on estimates from the baseline equation with foreign inflows over the shorter sample period 1984Q1 to 2000Q4, they suggest the long bond rate is not significantly correlated with foreign official inflows. The estimated coefficients that appear on empirical measures of foreign inflows are not statistically different from zero (the p-value for the null hypothesis—coefficients on the level and change in foreign official inflows are zero—is .45, which is large and leads to the acceptance of the null hypothesis). The result that the long bond rate is not correlated with foreign capital inflows continues to hold if we augment the baseline equation to include both capital inflows and the empirical measure of inflation uncertainty. As can be seen, the estimated coefficient on foreign official inflows remains statistically insignificant, whereas the estimated coefficient on inflation uncertainty is correctly signed and statistically significant (compare coefficients across columns labeled [4.1] and [5.1] in Table 2).

If we consider estimates of the augmented baseline equations over the full sample period that spans the recent period of large foreign inflows, the results are mixed. The estimated coefficient that appears on the level of foreign inflows is still not statistically different from zero. However, the estimated coefficient that appears on the variable measuring change in foreign inflows turns negative and is marginally significant, suggesting part of the decline observed in the long bond rate in recent years may be due to increased foreign purchases (see the coefficient on foreign capital inflows in columns labeled [4.2] and [5.2] in Table 2). But these results also imply that negative correlation between changes in the long bond rate and changes in foreign official purchases found in the full sample period are mainly attributed to the most recent period and hence are not indicative of the presence of a consistent relation between bond yields and increased foreign purchases of U.S. Treasury securities. Thus, the hypothesis that the current low level of the long bond rate is in part due to increased foreign official purchases of U.S. Treasury securities must be considered tentative.[26]

4. CONCLUDING OBSERVATIONS

One suggested explanation of the current low level of the long bond rate is that inflation risk premiums have declined. This explanation posits that, as a result of the good inflation performance of the U.S. economy and increased confidence that the Federal Reserve will keep inflation low and stable, investors are now demanding lower inflation risk premiums than before. This lowering of inflation risk premiums is reflected in lower real and nominal yields on bonds. This article develops an empirical test of the aforementioned explanation.

Since we do not have a direct empirical measure of uncertainty about long-term inflation forecasts, the article develops an empirical proxy for uncertainty about short-term inflation forecasts, assuming uncertainty about long-term inflation forecasts is positively correlated with uncertainty about short-term ones. Another assumption is that if inflation had been harder to forecast in the past, it would raise the variance of current forecasts of expected future

[26] The evidence in previous research on the role of foreign official purchases of U.S. Treasury securities in explaining the current low level of the long bond rate is also mixed. Wu (2005) reports evidence indicating the long bond rate is not at all correlated with foreign official purchases. Warnock and Warnock (2005) report mixed evidence; they also find the estimated coefficient on the foreign official capital inflows in their reduced-form interest rate equation is not statistically different from zero over the estimation period that excludes the surge in inflows of the past few years.

inflation rates, leading to increased uncertainty about future expected inflation. Given these basic assumptions, the article examines the MSE of short-to-medium-term inflation forecasts, using survey data on private-sector GDP inflation expectations. In particular, the article creates a time series on the MSE of short-term inflation forecasts, using rolling three-year windows over 1984Q1 to 2004Q3. This time series can be viewed as measuring uncertainty about short-term inflation forecasts and hence may provide information on uncertainty about long-term inflation forecasts. The time series measuring uncertainty about short-term inflation forecasts has a downward trend that appears to be consistent with the downward trend in mean and variance of forecast inflation, suggesting inflation uncertainty declined over this period because inflation both steadily declined and became more predictable.

The results indicate the long bond rate is positively correlated with the empirical measure of short-term inflation uncertainty over the full sample period 1984Q1 to 2004Q3, which suggests that an increase in uncertainty about short-to-medium-term inflation forecasts raises uncertainty about long-term inflation forecasts and hence may account for the presence of the inflation risk premium in the bond rate. However, the results also indicate that the estimated coefficient that measures the response of the long bond rate to short-term inflation uncertainty has declined since 2001Q4, implying that an increase in uncertainty about short-term inflation forecasts has not raised uncertainty about long-term inflation forecasts as much as it did previously. In fact, the results are consistent with the hypothesis that the inflation risk premium embedded in the long bond rate has disappeared, thereby explaining the current low level of the long bond rate.

Another competing explanation of the recent low level of the long bond rate is increased purchases of U.S. Treasury securities by foreign central banks, which may have contributed to reducing nominal yields on long-term bonds. The empirical work here indicates the long bond rate is in fact negatively correlated with foreign capital inflows over the full sample period. However, this negative correlation between the long bond rate and foreign official inflows found in the data is marginally significant and fragile, arising mainly as a result of most recent capital inflows and hence may not be indicative of the presence of a consistent relation between foreign capital inflows and bond yields. Hence, the second hypothesis must be considered tentative. Together, these results by far favor the explanation that attributes the recent low level of the long bond rate mostly to the reduction in inflation uncertainty.

REFERENCES

Ang, Andrew, Geert Bekaert, and Min Wei. 2006. "Do Macro Variables, Asset Markets, or Surveys Forecast Inflation Better?" Finance and Economic Discussion Series, Federal Reserve Board, Washington, D.C.

Bernanke, Ben S. 2003. "A Perspective on Inflation Targeting." Remarks at the Annual Washington Policy Conference of the National Association of Business Economists, Washington, D.C.

__________. 2004. "Fedspeak." Remarks at the Meetings of the American Economic Association, San Diego, California.

__________. 2006. "Testimony of Chairman Ben S. Bernanke." Semiannual Monetary Policy Report to the Congress.

Clouse, Jim. 2004. "Reading the Minds of Investors: An Empirical Term Structure Model for Policy Analysis." Finance and Economic Discussion Series, Federal Reserve Board, Washington, D.C.

Diebold, Francis X., Monika Piazzesi, and Glen D. Rudebusch. 2005. "Modeling Bond Yields in Finance and Macroeconomics." *American Economic Review* 95 (2): 415–20.

Dudley, Bill. 2006. "Low Bond Risk Premia: The Collapse of Inflation Volatility." *U.S. Economics Analyst*, U.S. Economic Research Group, Goldman Sachs (January).

Ellingsen, Tore, and Ulf Soderstrom. 2001. "Monetary Policy and Market Interest Rates." *American Economic Review* 91 (5): 1594–1607.

__________. 2004. "Why Are Long Rates Sensitive to Monetary Policy?" Sveriges Riksbank Working Paper 160.

Feenberg, Daniel, and Elisabeth Coutts. 1993. "An Introduction to the TAXSIM Model." *Journal of Policy Analysis and Management* 12 (1): 189–94.

Greenspan, Alan. 2005. "Remarks by Chairman Alan Greenspan." Central Bank Panel Discussion, International Monetary Conference, Beijing, People's Republic of China. June 6.

Gurkaynak, Refet S., Brian Sack, and Eric T. Swanson. 2005. "Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements." *International Journal of Central Banking* (May): 55–93.

Hordahl, Peter, Oreste Tristani, and David Vestin. 2006. "A Joint Econometric Model of Macroeconomic and Term-Structure Dynamics." *Journal of Econometrics* 131 (1–2): 405–44.

Kim, Don H., and Jonathan H. Wright. 2005. "An Arbitrage-Free Three-Factor Term Structure Model and the Recent Behavior of Long-Term Yields and Distant-Horizon Forward Rates." Finance and Economics Discussion Series Paper No. 33.

Kuttner, Kenneth N. 2001. "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market." *Journal of Monetary Economics* 47: 523–44.

Mehra, Yash. 1984. "The Tax Effect, and the Recent Behavior of the After-tax Real Rate: Is it Too High?" Federal Reserve Bank of Richmond *Economic Review* 70 (4): 8-20.

______________. 1994. "An Error-Correction Model of the Long-term Bond Rate." Federal Reserve Bank of Richmond *Economic Quarterly* 80 (4): 49–67.

Romer, Christina and David Romer. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." A paper presented at Economic Fluctuations and Growth Research Meeting, NBER, July 17.

Tanzi, Vito. 1980. "Inflationary Expectations, Economic Activity, Taxes, and Interest Rates." *American Economic Review* (March): 12–21.

Tulip, Peter. 2005. "Has Output Become More Predictable? Changes in Greenbook Forecast Accuracy." Finance and Economic Discussion Series, Federal Reserve Board, Washington, D.C.

Warnock, Francis E., and Veronica Cacdac Warnock. 2005. "International Capital Flows and U.S. Interest Rates." Finance and Economic Discussion Series Federal Reserve Board, Washington, D.C.

Wu, Tao. 2005. "The Long-Term Interest Rate Conundrum: Not Unraveled Yet?" Federal Reserve Bank of San Francisco *Economic Letter* (April).

Making the Systematic Part of Monetary Policy Transparent

Robert L. Hetzel

Since the 1990s, central banks have made monetary policy increasingly transparent. In February 1994, in a statement released after the Federal Open Market Committee (FOMC) meeting, the FOMC began to announce whether it had changed its funds rate target. In August 1997, the FOMC began to announce a quantitative target for the funds rate. In May 1999, it began to offer information about the likely near-term behavior of the funds rate. However, the FOMC's ability to continue down this route is limited. Signaling the future behavior of the funds rate is limited by the difficulty of forecasting economic activity.

Continued significant progress toward broader transparency will require the FOMC to explain funds rate behavior using state-contingent language. That is, apart from forecasting the future behavior of the funds rate, the FOMC will need to explain how it varies the funds rate in response to incoming data. A description by the FOMC of its behavior in terms of state-contingent language would emerge as a by-product of explicitness about objectives and the strategy for achieving those objectives. Such explicitness would also require the FOMC to flag publicly departures from standard procedures for changing the funds rate. Although nothing in an attempt by the FOMC to clarify the underlying consistency in its behavior requires commitment, the attempt does imply a high degree of public communication and dialogue.

The views in this article are the author's own, not those of the Federal Reserve Bank of Richmond. Specifically, the characterizations of FOMC behavior contained in the article do not represent an official view of the Federal Reserve System but are inferences drawn by the author. The author's manuscript, *The Monetary Policy of the Federal Reserve System: An Analytical History*, provides an overview of the evolution of the monetary policy procedures summarized in this article. I thank Andreas Hornstein, Yash Mehra, Pierre Sarte, and Alexander Wolman for critical comments and Christopher Herrington and Brian Minton for research assistance.

All the issues raised by the perennial rules versus discretion debate would be on the table. Is Lucas (1981) correct that the consistent behavior required to influence expectations reliably is a prerequisite for predicting the effect of monetary policy actions and thus for a stabilizing monetary policy? In contrast, is the flexibility to depart from established procedures in response to unusual events a prerequisite for a stabilizing monetary policy? Would state-contingent language be a desirable move toward rules or an undesirable move away from discretion?

Section 1 reviews how the desire of Volcker's and Greenspan's FOMCs to reshape the inflationary expectations inherited from the prior period of stop-go monetary policy imposed an underlying consistency on monetary policy. Empirical support for the conduct of monetary policy by a rule derives from the overall consistency of policy in this period.[1] Section 2 offers an empirical overview of monetary policy in the Volcker-Greenspan (V-G) era. Section 3 reviews the argument for transparency about the systematic part of policy. Of course, articulating a state-contingent approach would require a common understanding of that approach by members of the committee. I propose that the FOMC organize its discussion to elucidate the systematic part of policy. Section 4 suggests a policy rule intended to capture the systematic way in which the FOMC sets the funds rate and discusses the ongoing monitoring necessary to assess the credibility of the rule. Section 5 uses a model to understand how the rule would work. Section 6 discusses the feasibility of incorporating asset prices into a simple rule.

1. AN EXPECTATIONS-FOCUSED MONETARY POLICY

A persistent attempt to change the inflationary expectations conditioned by the stop-go era defined the V-G era. Documentary evidence attests to the importance that Volcker and Greenspan attached to restoring nominal expectational stability. Specifically, they wanted to 1) lower the inflation premium in long-term interest rates, 2) eliminate the positive correlation between above-trend real growth and expected trend inflation, and 3) eliminate the positive correlation between inflation shocks and expected trend inflation. As a result of this emphasis upon restoring expectational stability, Volcker and Greenspan largely behaved in a consistent way over their tenure. Taken together with the reduced variability in both inflation and real output relative to the stop-go period, this consistency favors a policy rule rather than a discretionary policy undisciplined by explicit objectives and strategy.

Formula (1) summarizes the article's hypothesis about what constitutes the consistent part of the V-G monetary policy procedures:

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[1] Consistency does not imply commitment the way a rule does.

$$i_t = i_{t-1} + \alpha(\pi_t^e - \pi^*) + \beta \Delta R_t^{RU} \quad \alpha, \beta > 0, \tag{1}$$

where i_t is the funds rate, π_t^e is expected inflation, π^* is the inflation target, and ΔR_t^{RU} is an estimate of persistence in the change in the rate of resource utilization. The variable ΔR_t^{RU} measures the extent to which output is growing faster than potential output in a sustained way, that is, $(\Delta y_t^S - \Delta y_t^P) > 0$, where (the log of) real output is y_t. The superscript "s " indicates "smoothed" real output, that is, output purged of transitory factors. The superscript "p" indicates potential output and the first-difference operator is Δ.

The definition of potential output requires a model. With the New Keynesian model used in Section 5, potential output is the output that would obtain with perfectly flexible prices. However, that definition lacks operational content. The hypothesis here is that the FOMC does not work off estimates of the level of or change in potential output, but rather looks for evidence of a sustained change in the rate of resource utilization. Although macroeconomic shocks cause changes in the optimal degree of resource utilization, the working assumption of policy is that rates of resource utilization cannot indefinitely increase or decrease. With (1), the funds rate moved in response to evidence of sustained changes in the degree of resource utilization. Also, it raised the funds rate above its prevailing value if evidence from the bond market indicated that expected inflation exceeded its implicit target.

The importance Volcker and Greenspan attached to expectations showed in their description of a Kydland-Prescott (1977) world where expectations frustrate the effect of stimulative policy on output.[2] Volcker (1980) observed

> [T]he idea of a sustainable "trade off" between inflation and prosperity... broke down as businessmen and individuals learned to anticipate inflation, and to act in this anticipation.... The result is that orthodox monetary or fiscal measures designed to stimulate could potentially be thwarted by the self-protective instincts of financial and other markets. Quite specifically, when financial markets jump to anticipate inflationary consequences, and workers and businesses act on the same assumption, there is room for grave doubt that the traditional measures of purely demand stimulus can succeed in their avowed purpose of enhancing real growth.

Greenspan (Senate 1993, 55–6) made the same point:

> The effects of policy on the economy depend critically on how market participants react to actions taken by the Federal Reserve, as well as on expectations of our future actions.... [T]he huge losses suffered by bondholders during the 1970s and early 1980s sensitized them to the

[2] See also Goodfriend and King (2004) and Lindsey, Orphanides, and Rasche (2005).

> slightest sign. . .of rising inflation. . . . An overly expansionary monetary policy, or even its anticipation, is embedded fairly soon in higher inflationary expectations and nominal bond yields. Producers incorporate expected cost increases quickly into their own prices, and eventually any increase in output disappears as inflation rises.

In commenting on the slow recovery from the 1990 recession, Greenspan (Senate 1993) attested to the sensitivity of policy to expected inflation:

> [S]ome have argued that monetary policy has been too cautious, that short-term rates should have been lowered more sharply. . . . [T]hese arguments miss the crucial features of our current experience: the sensitivity of inflation expectations. . . . Lower inflation and intermediate- and long-term interest rates are essential to the needed structural adjustments in our economy, and monetary policy thus has given considerable weight to encouraging the downtrend of such rates.

In building credibility, the FOMC was sensitive to how a positive growth gap could exacerbate inflationary expectations.[3] For that reason, it behaved preemptively with respect to inflation. Greenspan (House 1994, 11) testified,

> [C]ritics of our latest policy actions have noted that we tightened policy even though inflation had not yet picked up. That observation is accurate, but is not relevant. . . . [T]hrough much of this nation's history, we had periods of tightened labor and product markets with only transitory effects on the general price level. In these periods the discipline on credit expansion provided by the gold standard. . .limited the potential for prices to spiral upward and thus kept long-term inflation expectations from rising. After World War II, however, with those disciplines no longer in place, tightened markets became increasingly associated with rising inflation expectations. . . . There remains a significant inflation premium embodied in long-term interest rates, reflecting a still skeptical world financial market view that American fiscal and monetary policies retain some inflation bias.

In 1994, the association of a positive growth gap with expected inflation motivated the decisive increase in the funds rate. Greenspan (House 1994, 44–45, 49) testified after the first 25-basis-point increase,

> [M]arkets appear to be concerned that a strengthening economy is sowing the seeds of an acceleration in prices. . . . [A] clear lesson we have learned

[3] The reduction in inflation in the last half of the 1990s followed the generally restrictive policy followed from 1989 through 1995. That is, it followed the continuation of the soft-landing strategy that kept real interest rates unusually high during the recovery from the 1990 recession (the "jobless recovery") and the sharp rise in rates in 1994 and early 1995.

> over the decades since World War II is the key role of inflation expectations in the inflation process. . . . The test of successful monetary policy in such a business-cycle phase is our ability to limit the upward movement of long-term rates. . . . When we take credible steps to head off inflation before it can begin to intensify, the effects on long-term rates are muted. By contrast, when Federal Reserve action is seen as lagging behind the need to counter a buildup of inflation pressures, long rates have tended to move sharply higher. . . . Failure to tighten in a timely manner will lead to higher than necessary nominal long-term rates as inflation expectations intensify.

The testimony of former FOMC Chairman Greenspan in defense of preemptive interest rate increases is consistent with the view that the FOMC raises the funds rate in response to a persistent positive growth gap. However, it does not assign significance to particular measures of the level of excess capacity, output gap, or unemployment rate as predictors of inflation. The emphasis on changing measures of resource utilization, evidenced by the use of terms like "stress" and "imbalances," eliminates the need to make a numerical assessment of the level and growth rate of potential output or growth gap.

A "flexible" relationship between measures of excess capacity and inflation makes such measures unreliable indicators of inflation.[4] Greenspan (Senate 1995, 4–5) explained the interest rate increases in 1994 as a response to the *increase* in resource utilization rates.[5]

> It is possible for the economy to exceed so-called "potential" for a time without adverse consequences by extending work hours, by deferring maintenance, and by forgoing longer-term projects. . . . History shows clearly that given levels of resource utilization can be associated with a wide range of inflation rates. Accordingly, policymakers must monitor developments on an ongoing basis to gauge when economic potential is actually beginning to become strained, irrespective of where current unemployment rates and capacity utilization rates may lie.

Greenspan then listed various indicators of increased resource utilization such as purchasing managers' reports of slower supplier deliveries, shortages of workers, and anticipatory inventory building that produced increases in raw materials prices accompanied by anecdotal reports of firms' markup of final

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[4] The word is Greenspan's (see the following Greenspan references). See Orphanides (2001, 2003a, 2003b, 2003c, 2004), and Orphanides and van Norden (2002, 2004) for discussion of the problems raised by use of an output gap as a monetary policy indicator.

[5] See also Greenspan (House 1999, 57) and his reply to Rep. Frank's (p. 19) question, "What is the potential output growth rate of the economy?" "We cannot tell at any particular point in time what the actual potential is. . . . But it shouldn't be our concern. Our concern should be the imbalances that emerge."

goods prices over these increased costs. In other testimony, he mentioned average weekly hours worked.[6]

Employment growth that exceeds labor force growth is a commonly referenced indicator of a positive growth gap. Greenspan (Senate 2000, 14) explained to Sen. Bunning:

> The question of how fast this economy grows is not something the central bank should be involved in.... What we are looking at is basically the indications that demand chronically exceeds supply.... The best way to measure that is to look at what is happening to the total number of people who, one, are unemployed or, two, are not in the labor force but want a job, from which we are getting increased production.... [W]hat it is that we are concerned about is not the rate of increase in demand or the rate of increase in supply, but only the difference between the two.... The difference between the two is measurable by...the amount of goods that are produced as a consequence of the unemployment rate falling....

2. AN EMPIRICAL SUMMARY OF THE VOLCKER-GREENSPAN ERA

The policy summarized by formula (1) implies a positive relationship between funds rate changes and two variables: (1) a growth gap, which is the difference between "actual" and "sustainable" real growth, and 2) a credibility gap, which is the difference between expected inflation and an implicit inflation target. I constructed proxies for these variables. For the growth gap, the "actual" variable used Greenbook GDP forecasts.[7] The "sustainable" variable expresses the path for real growth that the FOMC believed would bring actual growth in line with trend real growth. Hence, this notion of sustainability allows for growth to be faster or slower when an output gap is being closed, but represents growth that does not close the gap "too fast." To proxy for sustainable growth, I used the midpoint of the "central tendency" range of forecasts of real output growth that the FOMC chairman presents in biannual congressional oversight hearings (see "Appendix: FOMC Data"). Because FOMC members make these forecasts based on an assumption of "appropriate" monetary policy, they implicitly assume a funds rate path estimated to

[6] See Greenspan (Senate 1995, 18; House 1994, 12).

[7] If an FOMC meeting was in the first or second month of the quarter, I used the forecast of growth for the contemporaneous quarter. If the meeting was in the last month of the quarter, I used the forecast for the succeeding quarter. Greenbook data are confidential for five full calendar years after an FOMC meeting. See "Appendix C: FOMC Data" for a discussion of the Greenbook and the data.

bring real output growth in line with trend growth.[8] The forecasts thus proxy for the growth considered compatible with a path moving to trend.[9]

In Figure 1, the diamonds mark episodes (derived from visual examination) of funds rate behavior unexplained by the growth gaps. In each case, the behavior of the bond rate offers an explanation. The diamonds on the graph of the bond rate in Figure 2 correspond to those on Figure 1. Of the ten episodes marked, eight correspond to instances when the FOMC raised the funds rate in the absence of predicted strength in economic activity. As shown in Figure 2, they correspond to "inflation scares," discrete increases in the bond rate (Goodfriend 1993). In the remaining two episodes, the FOMC failed to lower the funds rate despite projected weakness in economic activity. They correspond to bond rates indicating relatively high levels of expected inflation.[10] The diamonds thus mark FOMC policy actions taken to bring the public's expectation of inflation into line with the FOMC's implicit inflation target.[11]

The episodes marked by diamonds illustrate the FOMC's concern with inflationary expectations. FOMC procedures were preemptive in that the FOMC responded to expected inflation, not to realized inflation. For example, when the funds rate rose dramatically in 1984, CPI inflation had already fallen to 4 percent. In 1994, when the FOMC also raised the funds rate dramatically, CPI inflation was falling to around 2.5 percent from the prior 3 percent level. Greenspan (House 1998, 12) likened responding to realized inflation ("what inflation is now") to "looking in a rearview mirror." I therefore used changes in bond rates as a proxy for the behavior of the credibility gap.[12]

The Taylor rule offers a different summary of monetary policy than formula (1). The latter is less demanding in its assumption that the FOMC needed

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[8] The word "appropriate" is contained in the instructions sent by the FOMC secretary to FOMC members. Volcker (7/28/83, 283) commented: "[T]hose projections reflect a view as to what outcome should be both feasible and acceptable... otherwise monetary policy targets would presumably be changed."

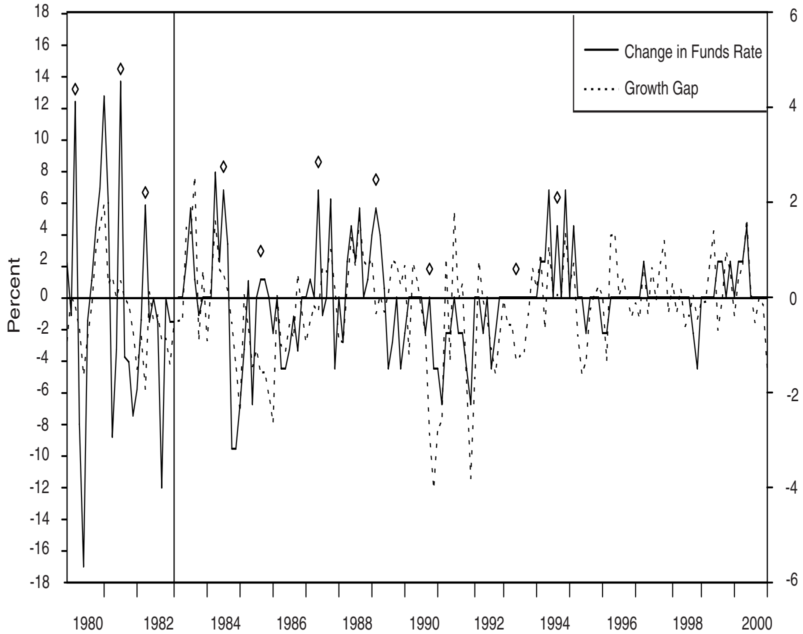
[9] For the FOMC meetings in the first five months of the year, I used the central tendency range from the February oversight hearings. For the remainder of the meetings, the range came from the July oversight hearings. These predictions are for the calendar year. The proxy for sustainable growth for the last half of the year is the midpoint of the central tendency range for the year divided by the annualized growth rate predicted in the Greenbook for the first half.

[10] These two episodes relate to the FOMC's "soft-landing" strategy to restore price stability. The FOMC had brought inflation down to 4 percent in 1983. In 1988, it decided to continue with the restoration of price stability. See the Greenspan (Senate 1993) quote above. The sharp funds rate reduction in August 1982 reflected the onset of the LDC debt crisis. The funds rate reductions in the last half of 1989, which do not correspond to economic weakness, reflected the problems, which came to a head at this time with the S&Ls and some large regional banks.

[11] The "implicit" language is from former Board Governor Laurence Meyer. For example, Meyer (2004, 201) wrote, "[I]n the second half of the 1990s, inflation was above the FOMC's implicit target.... Core inflation (measured by the 12-month inflation rate for the core CPI) declined from 2.5 percent in late 2002. This was still at or above the FOMC's implicit target."

[12] Specifically, I used inter-meeting changes in the bond rate (30-year through 1999 and 10-year thereafter).

Figure 1 Growth Gap and Funds Rate Changes

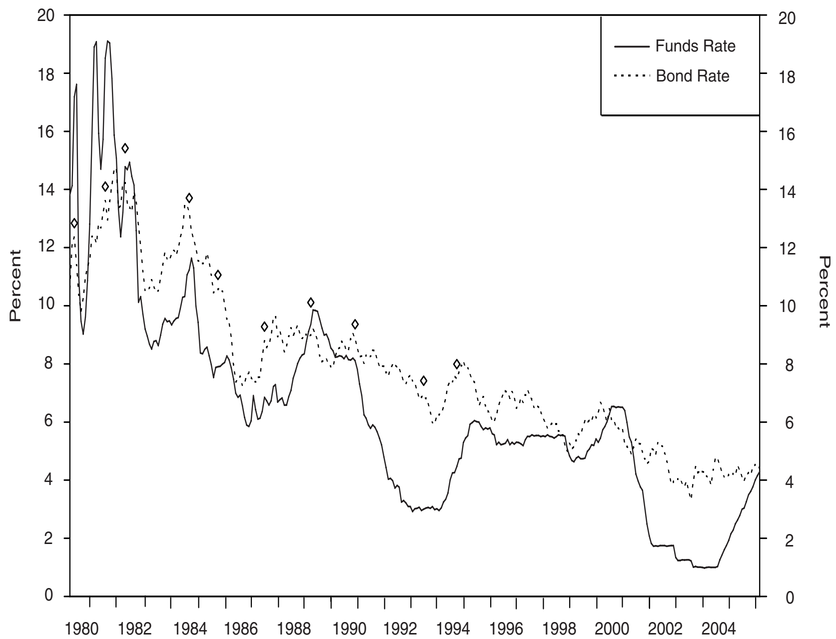


Notes: Observations are for FOMC meetings. The growth gap is the difference between contemporaneously available forecasts of real growth from the Greenbook and sustainable growth proxied for by the midpoint of the central tendency figure for real growth presented by the FOMC chairman in the prior February or July congressional oversight (Humphrey-Hawkins) hearings. Left scale is for the 1980–1982 period and right scale is for the subsequent period. The funds rate is the "target" set at FOMC meetings (see footnote 12). Changes in the funds rate are multiplied by three. Diamonds mark the following dates: March 1980, May 1981, February 1982, July 1984, August 1985, May 1987, February 1989, October 1990, May 1993, and August 1994. Tick marks indicate December FOMC meetings.

only make a decision about the change in resource utilization rather than decide upon the extent of idle resources (an output gap). Also the Taylor rule implies that the FOMC controlled inflation in the V-G era through a willingness to increase the funds rate more than increases in inflation. However, the Taylor rule does not express the preemptive way in which the FOMC raised the funds rate in response to increases in expected inflation, even when actual inflation remained quiescent.[13] As a test of the Taylor rule, I included an infla-

[13] Hetzel (2000) argues that empirically estimated Taylor rules are not identified. That is, they fit primarily because of common trends in inflation and the funds rate.

Figure 2 The Funds and Bond Rate



Notes: Monthly observations of the funds rate and the bond rate. Prior to 2000, the bond rate is the 30-year Treasury constant maturity series; thereafter, it is the 10-year series. Diamonds mark the following dates: March 1980, May 1981, February 1982, July 1984, August 1985, May 1987, February 1989, October 1990, May 1993, and August 1994. Tick marks indicate December meetings.

tion gap variable: the gap between actual inflation and the FOMC's implicit "interim" target for inflation, where "interim" is analogous to "sustainable" real growth. The interim target keeps inflation on a path compatible with a longer-run target.

Because the FOMC controls inflation (apart from transitory fluctuations), forecasting inflation for FOMC members is not like forecasting the weather. A forecast of a high or rising inflation rate would imply inappropriate monetary policy (as long as inflation was not *lower* than desired). In congressional testimony, Greenspan (U.S. Congress, February 24, 1998, p. 266) commented, "[T]he policymakers' forecasts also reflect their determination to hold the line on inflation."[14] As a proxy for an interim inflation target, I, therefore, used

[14] In 2000, the European Central Bank (ECB) debated public release of the inflation forecasts that its own and member bank staffs make biannually. That debate raised the obvious problem with a central bank making a "forecast" of inflation when inflation is the variable that it targets

Table 1 Funds Rate Correlations

$$\Delta FR = .11\ GG + .03\ MISSI + .32\ \Delta BR + .14\ \Delta\ BRL1 + \hat{u}$$
$$\quad (5.5) \qquad (2.3) \qquad (5.3) \qquad (2.4)$$

CRSQ = .41 SEE = .25 DW=1.6 DF = 144 date: 2/83 to 12/00

Notes: ΔFR is the change in the funds rate following FOMC meetings. GG is the growth gap, the difference between actual and sustainable real output growth. MISSI is the difference between actual and targeted inflation. ΔBR is the change in the bond rate observed the day prior to FOMC meetings (30-year through 1999 and 10-year thereafter) and is set equal to zero after 1994. ΔBRL1 is the lagged value of the change in the bond rate.

CRSQ is the corrected R-squared; SEE, the standard error of estimate; DW, the Durbin-Watson statistic; and DF, degrees of freedom. Absolute value of t-statistics is in parentheses.

the midpoint of the central tendency figure given by the chairman in biannual congressional oversight hearings (analogously to the proxy for sustainable real output growth). I constructed the proxy for actual inflation in the same way as the proxy for actual output growth.

In the regression of Table 1, the dependent variable is changes in the funds rate between FOMC meetings, and the independent variables are the proxies for the growth gap, the inflation miss, and the credibility gap. Because the bond rate variable loses explanatory power after 1995, it is set to zero from 1996 onward. The credibility the FOMC gained in 1994 and 1995 apparently meant that the FOMC did not need to look to bond rates as a measure of expected inflation. The regression also includes misses of actual inflation from target, where the actual and targeted values are calculated analogously to the growth gap.[15]

The regression runs from February 1983, when the FOMC abandoned its nonborrowed reserves procedures, through December 2000, after which Greenbook forecasts are confidential. A statistically significant relationship exists between changes in the funds rate target and the independent variables.[16] However, the F-statistic from an F-test of the significance of the inflation-miss term is barely significant at the 5 percent level, while the growth gap and bond

and controls. The central bank cannot forecast an inflation rate that is different from its target, explicit in the case of the ECB. A forecast of an inflation rate higher than the central bank's target could make labor unions or bond holders set prices inappropriately (*Financial Times* 2000).

[15] We are hence modelling behavior as if the FOMC was following the rule (1) with sustainable output growth and targeted inflation calculated from semi-annual forecasts.

[16] Problems with the proxy for the growth gap lower its correlation with changes in the funds rate. For example, the Greenbook forecast of real output growth may incorporate transitory factors to which the FOMC does not respond. The FOMC need not accept the Board staff forecast. Many factors involving the timing of funds rate changes introduce noise. At an inflection point in the funds rate, the FOMC changes the funds rate only after enough data have accumulated that a near-term reversal is highly unlikely.

rate terms are highly significant.[17] Figure 3 shows within-sample simulated values from the regression. The growth gap is the dominant independent variable. Simulated values are largely unchanged with omission of the bond-rate and inflation-miss terms.

The continuity in FOMC procedures is evident in recent funds rate increases. Although the recovery from recession began in November 2001, the FOMC started moving away from its 1 percent funds rate target only in May 2004 when it became clear that real output growth was exceeding potential.[18] In March 2004, at 5.7 percent, the unemployment rate was still near its cyclical 6 percent peak. However, the release of strong payroll employment data in April and May made it seem likely that the economy was growing faster than potential.

Moreover, the FOMC faced a small inflation scare. Core PCE inflation (the PCE deflator excluding food and energy) had averaged an annualized .8 percent over the first eight months of 2003. Over the six months from October 2003 through March 2004, it jumped to 2.1 percent. In response, the inflation compensation number calculated from the ten-year nominal and inflation-indexed Treasury yield spread, which had been as low as 1.6 percent in June 2003, began to rise and reached 2.6 percent by May 2004. The FOMC advertised its commitment to control inflation through the steady stream of increases in the funds rate, despite episodes of apparent developing weakness in economic activity in summer and fall 2004 and in spring 2005 (Appendix A: Fluctuations in Economic Activity).

3. MAKING THE CONSISTENCY IN FOMC BEHAVIOR EXPLICIT

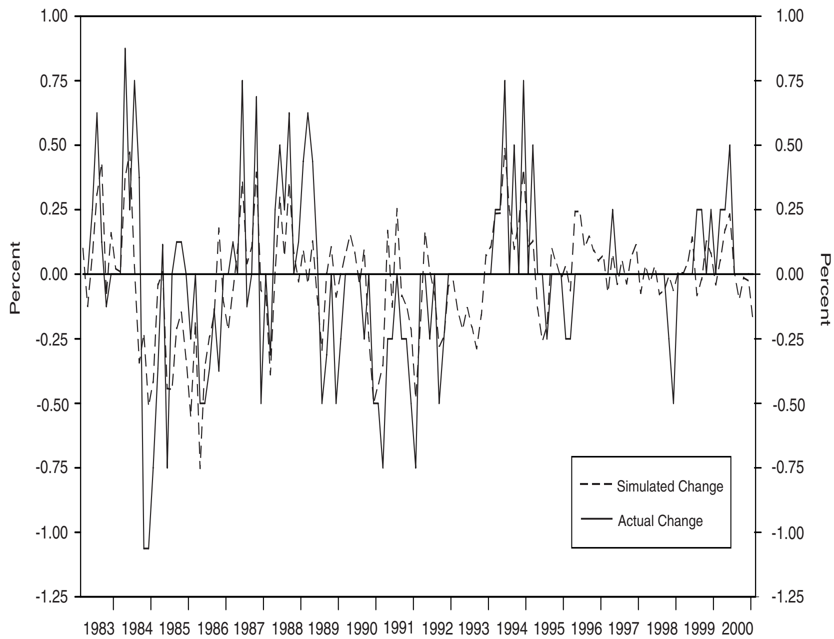
Transparency refers to the clarity with which central banks state their objectives and their strategy for achieving those objectives. State-contingent language would represent the practical working out of explicit transparent procedures. Woodford (2005) summarizes the professional consensus for explicitness about the systematic part of monetary policy:

> Because the key decision-makers in an economy are forward-looking, central banks affect the economy as much through their influence on *expectations* as through any direct, mechanical effects of central bank trading in the market for overnight cash. As a consequence, there is good reason for a central bank to commit itself to a systematic approach to

[17] The F-statistic for the 5 percent level of significance is 3.8. The F-statistic for the growth gap is 30.0 and for the bond rate 16.1. For the inflation-miss term, it is 5.4.

[18] It changed the directive language from "[T]he Committee believes that it can be patient in removing its policy accommodation" to "[T]he Committee believes that policy accommodation can be removed at a pace that is likely to be measured."

Figure 3 Actual and Simulated Funds Rate Change



Notes: Predicted values are within sample simulations. Tick marks indicate December FOMC meetings.

> policy that not only provides an explicit framework for decision-making within the bank, but that is also used to explain the bank's decisions to the public. The signals that have been given thus far through the post-meeting [FOMC] statements all attempt to say something about the likely path of the funds rate for the next several months; . . . they do not speak of the way in which future policy should be *contingent* on circumstances that are not already evident. If the statements are interpreted as *commitments* to particular non-state-contingent paths for the funds rate. . .then they are likely to constrain policy in ways that are not fully ideal. For while an optimal policy commitment will generally imply that policy should be *history-dependent*. . . , it will also generally imply the policy should be *state-contingent* as well. [italics in original]

Woodford distinguishes between two kinds of transparency. With the first—policy-rule transparency—the central bank articulates the consistent part of its procedures and commits to maintaining that consistency. With the second—forward policy-action transparency—it forecasts the funds rate.

There are inherent limitations to the latter.[19] The ability of the FOMC to forecast funds rate changes requires an ability to forecast the economy, and the difficulties associated with forecasting are well known.[20] Policy-rule transparency, on the other hand, complements the market's forecasts of the economy. In order for the yield curve to move in a stabilizing way in response to incoming information, financial markets must understand the way that the central bank responds to that information. Because systematic errors in predicting funds rate behavior impose costs, market participants will base funds rate forecasts on their understanding of the consistent part of central bank behavior. The clearer that the central bank is about the systematic part of its policy, the more stabilizing will be the behavior of the yield curve.

Adopting a format at FOMC meetings that elucidates how policy actions emerge out of new information about the economy could aid in developing a consensus among FOMC members about the systematic part of policy. Under Chairman Greenspan, FOMC meetings began with a discussion of the economy. Greenspan then initiated a policy go-around focused on acceptance or rejection of his proposal for the funds rate target.[21] This format did not elucidate whether the funds rate decision represented a consistent response over time to new information or a departure from past behavior.

As a practical way of moving toward thinking about policy strategically, that is, as a consistent way of responding to new information to achieve given objectives, the FOMC could maintain a record of its discussions designed to facilitate generalization about the consistency of policy. The Board staff

[19] Paul Volcker (Senate 1982), former FOMC chairman, criticized Fed interest-rate forecasts on two grounds. First, they would reduce the information about the economy contained in market interest rates. Second, they would create the temptation to move the yield curve opportunistically, that is, in a "desirable" way that avoids actually having to change the funds rate target.

> I do strongly resist the idea of the Federal Reserve as an institution forecasting interest rates. No institution or individual is capable of judging accurately the myriad of forces working on market interest rates over time. Expectational elements play a role—fundamentally expectations about the course of economic activity and inflation, but also, in the short run, expectations about Federal Reserve action. We could not escape the fact that a central bank forecast of interest rates would be itself a market factor. To some degree, therefore, in looking to interest rates and other market developments for information bearing on our policy decisions, we would be looking into a mirror. Moreover, the temptation would always be present to breach the thin line between a forecast and a desire or policy intention, with the result that operational policy decisions could be distorted.

[20] The recent tightening cycle, which began with a slightly negative short-term real rate, is unusual in that the real funds rate clearly had to rise when the economic recovery became established.

Also, the ability of the FOMC to forecast future funds rate changes depends upon the smoothing constraints it imposes upon those changes. If the FOMC always moved the funds rate to a level that it believed made the next funds rate change equally likely to be an increase or a decrease, it would always forecast no change in the funds rate. The bond market would remain unaffected by this lack of rate smoothing. The only difference would be additional volatility in short-term interest rates.

[21] See Meyer (2004, Ch. 2) for a discussion of FOMC meetings.

and FOMC members could submit to the FOMC secretary suggested reaction functions summarizing FOMC behavior. These functions would distill past behavior and embody desirable theoretical properties. In the initial part of the policy go-around, the FOMC chairman could lead a discussion organized around the suggested reaction functions. Are any of them useful for summarizing the evidence for changing the funds rate? Can the FOMC reach a consensus over the values of the indicators employed in these reaction functions? For example, is the output gap an operational concept in that the FOMC can reach a consensus over its sign and magnitude? If not, can the FOMC agree over the sign of the growth gap, that is, whether the degree of resource utilization is increasing, steady, or falling?

The FOMC secretary would maintain an account assessing the usefulness of the various reaction functions for organizing discussion and explaining the actual funds rate action. In particular, is it possible to summarize the information used by the FOMC in its funds rate decision with a small number of indicators? Is there some acknowledged ranking in order of importance of the economic variables used by the FOMC to construct these indicators? Are outside observers likely to be able to reproduce the FOMC decision? Just as important, the FOMC secretary would assess how often special factors, such as asset price volatility, prompted a departure from the benchmark reaction functions.

4. A PROPOSED POLICY RULE AND ITS MONITORING

In Section 1, I argue that the focus on changing the character of the inflationary expectations inherited from the stop-go era endowed the Volcker-Greenspan era with an overall consistency summarized in Formula (1). Based on (1), I propose a (prescriptive) monetary policy rule (2):[22]

$$i_t = i_{t-1} + .125(\pi_t^{TR} - \pi^*) + .25 I_t^{RU}, \tag{2}$$

where now trend inflation π_t^{TR} replaces expected inflation π_t^e.

With rule (2), the FOMC would respond to discrepancies between estimated trend inflation and the target for trend inflation.[23] At an individual

[22] I reserve the term "policy rule" for a reaction function that assumes credibility rather than the Volcker-Greenspan reaction function that restored credibility. With a credible rule and rational expectations, expectations are an equilibrium outcome based on the policy rule, the structure of the economy, and shocks. With (2), the policymaker does not control expectations by making them arguments in a rule.

[23] Inflation in the flexible price sector, which includes commodities, such as oil, minerals, and food, varies with cyclical strength in the world economy. With (2), the FOMC would respond

meeting, the FOMC need not respond in a quantitatively strong way to the emergence of a gap between actual and targeted inflation. What is important to assure stabilizing behavior of the yield curve is that financial markets believe that the FOMC will raise the funds rate in a persistent way as long as a positive miss of the inflation gap exists and conversely for a negative gap.

In rule (2), the terms $i_t = i_{t-1} + .25 I_t^{RU}$ capture the lean-against-the-wind part of policy where the FOMC raises the funds rate above its prevailing value in a measured, persistent way as long as the rate of resource utilization is rising. I_t^{RU} is an indicator variable showing whether resource utilization is increasing or decreasing in a sustained way.[24] It takes on the value 1 if the resource utilization rate is increasing, -1 if it is decreasing, and zero otherwise. In the first case, output is growing faster than potential output in a sustained way.[25] The coefficient on I_t^{RU} of .25 is the standard size of funds rate changes. As with the inflation-miss term, what is important is the public's belief that the FOMC will raise the funds rate in a persistent way as long as the growth gap is positive, and conversely for a negative gap.[26]

Even though with rule (2) the FOMC would not respond to expectations, it would monitor them to ascertain the rule's credibility. The remainder of this section discusses the kind of behavior the FOMC would expect with a credible rule. Credibility implies that the yield curve responds in a stabilizing way in response to macroeconomic shocks. Although the proposed rule is simple, its implementation and the ongoing monitoring involved in assessing its credibility would require considerable sophistication in reading the economy and in following financial markets.

The ability of the economy to return to a balanced growth path after a macroeconomic shock rests on the ability of markets to move the yield curve in a stabilizing fashion in response to such shocks. That ability, in turn, rests on a credible rule, where credibility is the belief by markets that the central

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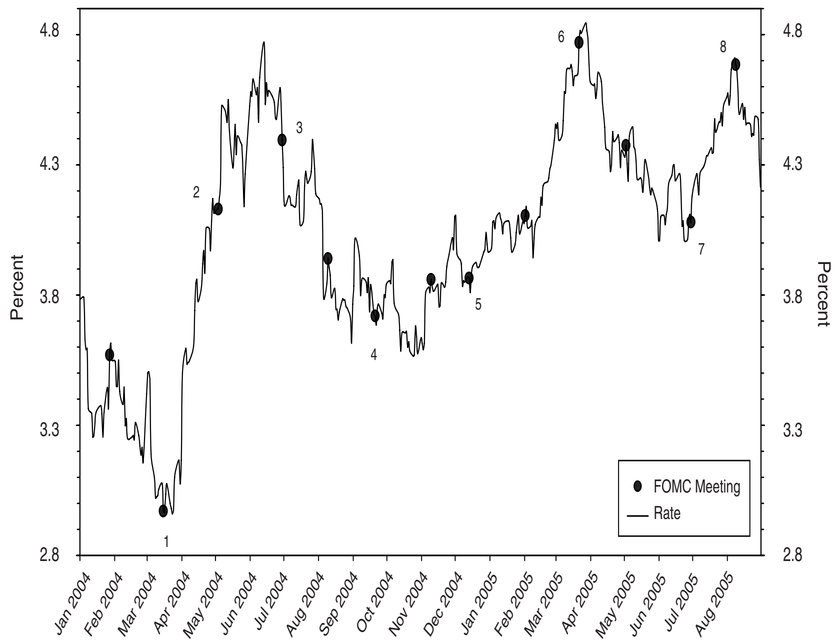
to that inflation (as opposed to inflation in the sticky-price sector) only if it passes through to trend inflation. Core PCE deflator inflation removes energy and food prices, which are volatile and contain a cyclical component. The core measure is usually considered a better measure of trend inflation than the broader measure because trend inflation excludes transitory and cyclical components.

[24] FOMC discussion does not produce an explicit numerical estimate for the rate of change of resource utilization. There are no clearly satisfactory proxies. A simple proxy would be payroll employment growth (purged of transitory factors) in excess of the trend given by demographics. Of course, the FOMC looks at an extensive array of statistics. A forward-looking measure would be desirable. However, the difficulty of forecasting would render difficult formation of a consensus around a forward-looking measure of resource utilization.

[25] See the discussion of ΔR_t^{RU} in formula (1), Section 1.

[26] If a rule is to condition expectations, the market must be able to infer the values of its arguments. In Section 2, I used Greenbook forecasts, which are not publicly available, in construction of a proxy for a growth gap. What is important, however, is whether Fed watchers, who have available basically the same information as policymakers in the form of data releases and Beige Book surveys of regional economic conditions, make the same inferences about the economy as the FOMC.

Figure 4 Rates Implied by Eurodollar Futures



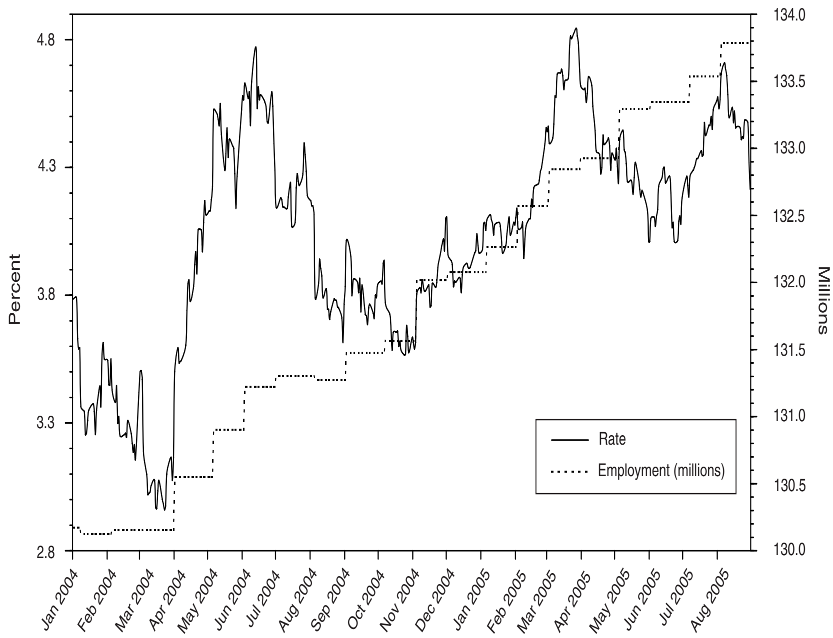
Notes: Eurodollar-implied rates are calculated from the two-year exchange-traded options on three-month futures contracts. The daily data are from Bloomberg.

bank will maintain an unchanged, low inflation rate.[27] With credibility, all the change in forward rates that occurs in response to shocks is real. In effect, after a shock, markets forecast the cumulative change in the funds rate required to align actual with potential output growth, where again this balanced growth appears as the absence of persistent change in resource utilization.

What does a credible central bank see in response to a real shock? It sees a stabilizing movement in the yield curve comprising movement exclusively in forward real rates. Figure 4 and the commentary in Appendix A (Fluctuations in Economic Activity) suggest how a credible rule allows the price system to offset macroeconomic shocks. Figure 4 shows the interest rate on the three-month Eurodollar futures contract 24 months in the future. Because of the close relationship between Libor and the funds rate, it is a forecast of the funds

[27] Alternatively, a credible central bank possesses instrument independence in that markets believe that the political system will allow it to raise the funds rate in response to shocks to whatever extent is required to maintain unchanged trend inflation.

Figure 5 Eurodollar-Futures-Implied Rates and Employment Levels



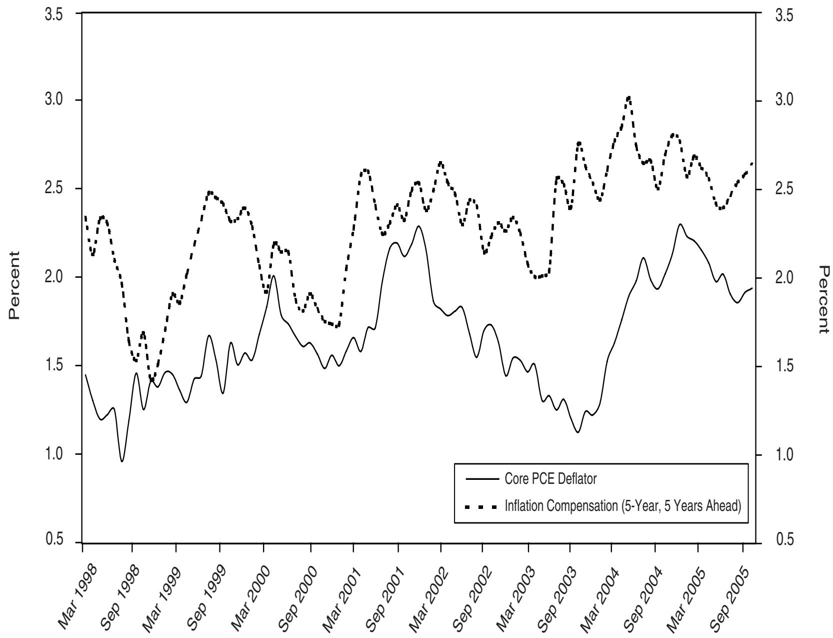
Notes: Eurodollar-implied rates are calculated from the two-year exchange-traded options on three-month futures contracts. The daily data are from Bloomberg. Observations on employment are the civilian payroll employment numbers initially released by the BLS. The steps correspond to the release dates.

rate two years in the future. When the economy strengthened (given that the FOMC constrains the magnitude of individual funds rate changes), the slope of the yield curve increased, and conversely. Figure 5 shows Eurodollar futures rates and the contemporaneously available level of payroll employment. When employment rose slowly, forward rates fell; and when it rose quickly, they rose.

Figure 4 also shows the dates of FOMC meetings, after which the FOMC announces the funds rate target, along with a statement containing forward-looking information about future funds rates. Variation in the expected future funds rate depends mostly upon incoming information on the economy rather than upon information provided in Fed announcements. For the latter, the standard deviation of the change in the two-year Eurodollar rate for the interval shown on the graph is only ten basis points, half the value associated with release of payroll employment numbers.[28]

[28] Changes are from close of business (COB) the day before the announcement to COB the day of the announcement. The major change in the expected funds rate associated with an FOMC

Figure 6 Core PCE Deflator Inflation and Inflation Compensation (Five-Year, Five Years Ahead)



Notes: Inflation compensation data are monthly numbers from the Division of Monetary Affairs of the Board of Governors of the Federal Reserve System. The core personal consumption expenditures data are from Haver Analytics. Observations for the core personal consumption expenditures (PCE) deflator are lagged two months. Inflation is annualized percentage changes in the monthly core PCE deflator. The five-year, five-year-ahead inflation compensation observations are implied by the five-year and ten-year inflation compensation numbers.

The existence of Treasury Inflation Protected Securities (TIPS) makes possible ongoing assessment of FOMC credibility. The difference (“inflation compensation”) between the yield on nominal Treasury securities and the real yield on TIPS of the same maturity provides a good measure of expected inflation (Appendix B: Are TIPS Inflation Compensation Numbers Biased?). A market assessment of Fed credibility is the degree of stability in the inflation compensation figure for the five-year period starting five years in the future

statement occurred at the May 4, 2004, FOMC meeting when the FOMC warned the markets that it would begin to raise the funds rate from its 1 percent level. Because the FOMC attempts to avoid closely spaced funds rate reversals, it moves the funds rate up after a cyclical low only when it is largely convinced that economic recovery is persistent. The market apparently has difficulty predicting the timing of such inflection points in the funds rate.

inferred from the yield gap between nominal Treasury and TIPS yields. Figure 6 shows this series along with core PCE inflation. Since early 2000, the inflation compensation figure has been stable at approximately 2.5 percent. This stability reflects the high degree of credibility enjoyed by the FOMC, despite the existence of a positive growth gap and an inflation shock that raised headline inflation numbers.[29]

The scatter diagrams of Figures 7, 8, and 9 (following Appendix C) illustrate how the FOMC can monitor whether the rule conditions the public's expectations in a stabilizing way. They plot the surprise in payroll employment numbers on the x-axis for the two-year period, August 2003 through September 2005. Figure 7 shows the associated change in the yield on the six-month fed funds futures contract. When the economy turns out to be stronger than anticipated, the yield curve rises.[30]

With credibility, the change in forward rates that occurs in response to shocks is all real. Investors, who make decisions based on real interest rates, need not guess about the extent to which yield curve changes reflect changes in expected inflation or changing uncertainty about future inflation rather than in real forward rates. Figure 8 exhibits a positive correlation between changes in the five-year real TIPS yield and the employment surprise. Figure 9 plots the change in inflation compensation for the five-year, five-year-ahead period. There is some positive correlation, although the slope of the regression line is smaller by a factor of 3 than that shown in Figure 8.[31] These results suggest near, but not complete, credibility.

Policymakers can routinely monitor the credibility of policy by observing the reaction of markets to "surprises" in the economic data releases. For a variety of data releases, they possess the median expectation of a sample of business forecasters. They can observe the reactions of the five-year TIPS yield and of the five-year inflation compensation number to the announcement surprises. For example, in response to the September 2, 2005, announcement of August payroll employment, the TIPS yield rose 5.3 basis points. Although

[29] The price of oil rose from $34 per barrel West Texas Intermediate (WTI) in early 2004 to around $65 per barrel in September 2005 (a relative price rise comparable to the 1973–1974 and 1979–1980 oil price increases). Over the 12 months through September 2005, CPI inflation was 4.7 percent, while CPI inflation excluding energy was only 2 percent over this latter period.

[30] If the FOMC possesses neither economic data nor a forecasting ability superior to the market's, it should ratify the market's expectation for the change in the funds rate at its meetings.

[31] A perception that the FOMC is willing to allow some drift in trend inflation could account for the positive slope of the regression line in Figure 9, as well as the fluctuations in inflation compensation in Figure 6 (Gurkaynak, Sack, and Swenson 2003). For example, consider the imprecision about the inflation rate the FOMC finds acceptable in the response by former Governor Ferguson (2006) to a question: "[I]f inflation threatens to fall much below 1 percent, the Fed clearly responds to that.... I[f] inflation rises much above 2, $2\frac{1}{2}$ percent—let's say 2 percent—on the core measures, the Fed finds that to be outside of the range of stable prices."

the figure came in somewhat below expectations, an upward revision in the prior month's numbers turned the release into a positive surprise.[32] Evidence of credibility appeared in the slight fall in the inflation compensation number while the TIPS yield rose.

5. PREDICTING HOW THE RULE WOULD WORK

A prediction of how rule (2) would work to control inflation requires a model. I use the New Keynesian sticky-price model.[33] Three elements of the model summarize the discipline imposed on the monetary policy process: one from price theory, one from monetary theory, and one from rational expectations. First, the real interest rate is a price. As summarized by the real business cycle core of the model, the real rate varies to smooth aggregate demand intertemporally. The price system works in that "moderate" changes in the real interest rate, say, in the range of 6 percentage points, are sufficient to reconcile aggregate demand with available resources. The central bank must respect the working of the price system.

Second, in a fiat money regime, the central bank, not the public, determines trend (steady-state) inflation. More generally, only the central bank can give money (nominal variables) a well-defined (determinate) value. It does so by providing a nominal anchor that stabilizes inflationary expectations.

Third, firms (price-setters) are "rational." Firms, which possess some monopoly power, set their prices to maintain an optimal markup (price over marginal cost). Because firms can change their dollar prices only infrequently, they set nominal prices to maintain this markup (a real variable) on average. They are forward-looking in their price-setting and use information efficiently. An implication is that firms set their dollar prices based on a forecast of inflation that reflects the consistent part of the central bank's behavior. Even though historically the erratic evolution of the monetary standard has made learning extremely difficult, the public does learn to conform its expectations of inflation to the consistent behavior of policy. As a result, the central bank cannot manipulate the markup in a predictable way. More broadly, it cannot raise the inflation rate to lower the unemployment rate in a sustained, significant way or increase its variability to reduce the variability of the unemployment rate (King and Wolman 1999).

The experiment yielded by the monetary policy of stop-go followed by the monetary policy of inflationary expectational discipline yielded results consistent with these implications of the New Keynesian model. First, the premise

[32] The 3-month annualized growth rate of payroll employment went from 1.5 percent for the July release to 1.8 percent for the September release.

[33] For an exposition, see Goodfriend and King (1997), Hetzel (2005), and Wolman (1997, 1998, 1999, and 2001).

of stop-go monetary policy was that government had to manage aggregate demand to offset the chronic failure of the price system to maintain full employment. As long as the unemployment rate exceeded the full employment rate, assumed to be 4 percent, stimulative monetary policy would supposedly raise output and lower unemployment without creating inflation.

In contrast, the discipline imposed in the V-G era by the desire to restore expectational stability for inflation precluded persistent intervals of stimulative policy. The FOMC had to raise the funds rate promptly in response to emerging positive growth gaps. Rather than attempting to manipulate the unemployment rate, the FOMC used *changes* in the unemployment rate as an *indicator* of changes of the degree of resource utilization useful for inferring the behavior of the markup. By allowing the price system to work rather than superseding it, the FOMC produced more, not less, economic stability.

Second, the control of inflation required central banks imbued with a mission to control inflation through monetary policy. Inflation is a monetary phenomenon in that central banks determine trend inflation. Fiscal policy and a plethora of programs involving direct intervention in price-setting all failed to control inflation (Hetzel 2004).

Third, the trade-offs predicted by Keynesian Phillips curves failed. With the high trend inflation of the 1970s, the negative relationship between the level of inflation and unemployment disappeared. In the 1980s and 1990s, not only did the reduced variability of inflation not require increased variability of unemployment, but also the variability of both fell. As predicted by the New Keynesian model, maintenance of low, stable inflation did not impose real resource costs.

As implied by the New Keynesian model, to maintain price stability, the FOMC must follow a rule for moving the funds rate, which keeps the real interest rate at whatever level is necessary to prevent increases in aggregate demand from compressing firms' markups (relative to the optimal value) and thus creating a general incentive to raise prices (Broaddus and Goodfriend 2004; Goodfriend 2004). The rule (2) achieves this prerequisite, but in a way that reflects the availability of information.[34] The FOMC knows that markup compression must occur if the growth rate of real output exceeds the growth rate of potential output. Determination of whether a positive growth gap exists

[34] The central bank does not possess sufficient information to solve the model of the economy under the assumption of flexible prices. If it did, it could set the real interest rate equal to the natural rate (the flexible-price real interest rate determined along with expected consumption growth). Another deficiency in the data is that observable measures of the markup are biased by the unobservable behavior of labor force utilization rates. As a result, direct measures of the markup can be misleading for policy. One measure of the change in the markup is the difference between inflation and the change in unit labor costs. After 1964, for example, expansionary monetary policy (measured by an increased M1 growth rate) apparently initially led to increased rates of labor force utilization. Because productivity rose while price and wage inflation remained unchanged, the markup increased. Only later with sustained expansionary monetary policy did unit labor costs rise, the markup fall, and inflation rise.

starts with observation of whether employment growth exceeds growth in the working age population. In this event, the FOMC looks for agreement in a wide variety of additional measures of changes in resource utilization such as the behavior of supplier delivery times and the prices of raw materials. The rule calls for an increase in the funds rate if this assessment implies an increase in resource utilization that is persistent.

Greenspan (House 1999, 6) observed,

> [W]hen productivity is accelerating, it is very difficult to gauge when an economy is in the process of overheating. In such circumstances, assessing conditions in the labor market can be helpful. . . . Employment growth has exceeded the growth in working-age population this past year by almost $\frac{1}{2}$ percentage point. . . . [T]his excess is...large enough to continue the further tightening of labor markets. It implies that real GDP is growing faster than its potential. . . . There can be little doubt that, if the pool of job seekers shrinks sufficiently, upward pressures on wage costs are inevitable, short...of a repeal of the law of supply and demand.

Shocks change the optimal degree of resource utilization, and the FOMC does not attempt to hold it constant. However, the basis of the rule is the fact that increases in resource utilization (markup compression) cannot persist indefinitely.

The rule rests on the assumption of how rational expectations condition the relationship between real and nominal variables (Hetzel 2004, 2005). Consider a macroeconomic shock in the form of a persistent increase in productivity. At the original real interest rate, real aggregate demand exceeds potential (flexible-price) output. Because individuals feel wealthier and want to smooth their consumption over time, contemporaneous demand for output exceeds the increase in supply. With sticky prices, output grows above potential and firms' markups are compressed below their profit-maximizing values.[35] As resource utilization rates rise, the central bank raises the (nominal and real) funds rate to restrain real aggregate demand. Credibility implies not only that firms believe that the markup compression is transitory, but also that they do not associate it with a sustained increase in inflation. Stated alternatively, when a real shock pushes output away from potential, firms do not associate that departure with a change in inflation.

When firms change their dollar prices, they do so to set the relative price of their product. Because of the central bank's credibility, the shock does not lead firms to believe that they need to raise their dollar prices to preserve their relative prices. With a credible inflation-targeting rule, real shocks can introduce fluctuations in the price level but not in trend inflation. The central bank never gets into the Kydland-Prescott (1977) or Barro-Gordon (1983)

[35] See the similar discussion of monetary policy in Broaddus and Goodfriend (2004).

predicament of having to shock the real economy to control expected and actual trend inflation. As long as the rule is credible (expectations are stable), there are no real costs to controlling trend inflation.

6. SHOULD A RULE INCLUDE ASSET PRICES?

Alan Greenspan (2004, 39) acknowledged the consistency in monetary policy: "In practice, most central banks...behave in roughly the same way. They seek price stability as their long-term goal. . . . All banks ease when economic conditions ease and tighten when economic conditions tighten." However, Greenspan then raised the issue of "the appropriate role of asset prices in policy."

In principle, the central bank should use the information contained in asset prices to set the funds rate. For example, a funds rate such that the real funds rate lies below the natural rate given by the flexible-price working of the price system results in excess money creation, which leads to portfolio rebalancing (Hetzel 2004, 2005). Although instability in money demand may hide this monetary stimulus, asset prices such as equities rise. However, the complexity of the forces affecting asset prices makes discerning this effect problematic and militates against an explicit state-contingent rule that contains asset prices. Rather than attempting to assess whether the level of equity prices is too high, the central bank is better off relying on the fact that a wealth effect will stimulate real output growth and increase resource utilization rates.

An answer to the question of whether asset prices offer useful information will depend upon assessment of the historical record. For example, at the time of the Asia crisis, the world suddenly appeared riskier and the risk premiums required for holding risky assets, especially emerging market debt, increased sharply. The FOMC made the judgment that the increase in risk premiums was large enough to become a source of economic instability without counteracting monetary stimulus. Such a judgment was necessarily subjective and not easily captured by a rule.[36]

From mid-1997 through mid-1999, the FOMC gave significant weight to financial market instability. (For a discussion of this period, see Greenspan in U.S. Congress, June 17, 1999.) Beginning in mid-1997, the FOMC stopped raising the funds rate in response to positive growth gaps. In fall 1998, it lowered the funds rate $\frac{3}{4}$ of a percentage point despite an essentially zero

[36] A commitment to lower the funds rate, say, in response to a sharp fall in some class of asset prices would also create moral hazard problems. A different issue is whether a rule would constrain the ability of the FOMC to control the short-term timing of funds rate changes. In particular, when the funds rate is at a cyclical low in the early stages of economic recovery, the FOMC waits until recovery is clearly established before raising the funds rate. In this way, it limits the possibility of an increase followed by a closely spaced reversal because of a faltering recovery.

growth gap. In 1998, the absence of a positive growth gap as measured in Figure 1 reflected Greenbook forecasts of moderate real growth. Forecasts of moderate real growth in turn depended significantly upon the repeated Board staff assumption of a decline in the stock market with an attendant reduction in consumption because of a decline in wealth.

However, real growth consistently exceeded predicted growth in the Greenbook. The steady decline in the unemployment rate suggests that the growth gap was positive throughout this period. In March 1997, when the FOMC raised the funds rate to 5.5 percent, the available figure for the unemployment rate was 5.3 percent (February 1997). In June 1999, when it raised the funds rate from 4.75 percent to 5 percent, the available figure for the unemployment rate was 4.2 percent (May 1999). Not until early 2000 and the passage of concerns over Y2K-related computer failures did the FOMC push the funds rate above the level prevailing before the reductions made in fall 1998.

The FOMC acted on the assumption that high rates of productivity growth would restrain inflation at least transitorily by lowering the growth rate of unit labor costs (Greenspan in House 1999; Hetzel 2006, Ch. 16–19; Meyer 2004, Ch. 4). Richmond Fed president, J. Alfred Broaddus (2004), challenged the consensus view that an increase in trend productivity growth made increases in the funds rate in response to rising resource utilization rates at least temporarily unnecessary. Beginning with the May 1997 FOMC meeting, he argued that increased productivity growth that made individuals feel wealthier required a higher real interest rate. The real interest rate would have to rise to restrain the extent to which individuals attempted to smooth consumption intertemporally through increases in contemporaneous consumption.

The failure of inflation to rise as the unemployment rate fell is consistent with the Friedman (1974) generalization that the extent to which stimulative monetary policy initially impacts real growth rather than inflation depends upon the behavior of expected inflation. Stock prices rose strongly over this period, but fell starting in 2000. Also, inflation drifted upward from 1999 through 2001. This assumption appeared to explain the combination of "low" unemployment and low inflation. However, these facts are consistent with the hypothesis that expansionary monetary policy exacerbated the rise in asset prices and strength in economic activity.

7. THE DESIRABILITY OF AN EXPLICIT RULE

A rule embodies a perceived commitment to consistent behavior that shapes expectations in a predictable way. Commitment to a rule makes monetary policy a source of stability in an uncertain world. For the economy to respond resiliently to large shocks, individuals must believe that government will allow the price system to reallocate resources. With regard to monetary policy, they must believe that, in response to shocks, the central bank will allow the real interest rate to vary sufficiently to maintain aggregate demand for resources equal to available supply. As a result, the yield curve will respond in a stabilizing way, that is, in a way that makes the change in forward rates entirely real. The belief that the central bank will move the funds rate by whatever amount is required for macroeconomic stability comes from a credible commitment to price stability.

The United States has received benefits from the rule-like behavior that has characterized most of the Volcker-Greenspan era. Those benefits have occurred without explicitness about monetary policy procedures. Nevertheless, there are reasons for explicitness and for commitment. In a constitutional democracy like the United States, the long-term viability of a rule depends upon the existence of a public consensus in its favor. Such consensus can arise only with a widespread understanding made possible by explicitness.

APPENDIX A: FLUCTUATIONS IN ECONOMIC ACTIVITY

The fluctuations in the market's estimate of future spot rates shown in Figure 4 and thus in the slope of the yield curve derive from fluctuations in the strength of economic activity. The Board staff's summary of the economy contained in FOMC minutes provides a useful assessment of economic activity. Dots mark FOMC meetings.

The slope of the yield curve rose between the March 16, 2004, and May 4, 2004, FOMC meetings (observations [obs.] 1 and 2). The March 16, 2004, minutes summarized prior relative weakness in economic activity: "[T]he increases in economic activity [in early 2004] had not yet generated sizable gains in employment." But, the May 4, 2004, minutes reported additional strength:

> [T]he economy expanded at a rapid pace in the first quarter. . . . The labor market displayed further signs of improvement during the quarter, capped by a significant increase in private payrolls in March.

The slope of the yield curve fell between the June 30, 2004, and September 21, 2004, FOMC meetings (obs. 3 and 4). The September 21, 2004, minutes (obs. 4) reported only moderate growth for this interval:

> [E]conomic growth regained some vigor in recent months after having slowed in late spring. The August labor market report showed a moderate gain in payrolls. After contracting in June, industrial production strengthened modestly on average in July and August.

The minutes of the December 14, 2004, meeting (obs. 5) reported continued moderate growth:

> [T]he economy expanded at a moderate pace over the third quarter and into the current quarter. . . . Manufacturing production increased at a modest pace, and employment gains in October and November indicated that the labor market continued to improve gradually.

The slope of the yield curve then rose between the December 14, 2004, and March 22, 2005, FOMC meetings (obs. 5 and 6). The March 22, 2005, minutes (obs. 6) reported relative strength for this interval:

> The information reviewed at this meeting suggested that the economy was expanding at a solid pace in the first quarter of the year. . . . Consumer spending still appeared to be growing briskly, and residential construction expenditures continued to move higher. Business spending on equipment and software showed notable gains early in the quarter. . . . Private nonfarm payrolls grew at a solid pace, and these gains were widespread across industries.

The slope of the yield curve then fell between the March 22, 2005, and June 30, 2005, FOMC meetings (obs. 6 and 7). The June 30, 2005, minutes (obs. 7) reported only moderate growth for this interval:

> The information received at this meeting suggested that the economy was expanding at a moderate pace in the second quarter.

But, the slope of the yield curve rose between the June 30, 2005, and August 9, 2005, FOMC meetings (obs. 7 and 8). The August 9, 2005, minutes (obs. 8) reported relative strength for this interval:

> The information received at this meeting suggested that final demand had expanded at a solid pace in the second quarter, led by a surge in net exports and another robust gain in residential investment.

APPENDIX B: ARE TIPS INFLATION COMPENSATION NUMBERS BIASED?

Two factors potentially bias the measure of expected inflation provided by TIPS inflation compensation numbers. First, investors may demand a risk premium to compensate for expected volatility in future inflation that renders uncertain the ex post real return from holding nominal bonds. If so, the measure of expected inflation offered by the inflation compensation numbers is biased upward. Given the low levels reached by yields on ten-year Treasury securities in recent years, at times below 4 percent, this source of bias cannot be large. The last time such low yields appeared on Treasury bonds was the first half of the 1960s, when an expectation of price stability prevailed. If this bias exists, the FOMC lacks credibility. Regardless of whether an inflation compensation number in excess of the FOMC's implicit inflation target arises from an expectation of inflation that lies above the target or from a lack of confidence in the FOMC's willingness to maintain stable trend inflation, the FOMC needs to reinforce its credibility.

The second source of possible bias works the other way, that is, to cause the inflation compensation number to underestimate expected inflation. A lack of liquidity could raise the real rate on TIPS relative to nominal securities and bias downward the inflation compensation numbers as a measure of expected inflation. In Figure 6, the inflation compensation numbers do rise to a higher trend level after June 2001. Plausibly, that rise reflects a decrease in the liquidity premium incorporated into TIPS yields. In any event, the low level of TIPS yields leaves little room for a liquidity premium.[37] If a small bias does remain, it will dissipate over time as the TIPS market grows.[38]

Survey data reinforce the view that the inflation compensation numbers offer a good approximation to expected inflation. The quarterly Survey of Professional Forecasters offers a ten-year forecast of CPI inflation. For 2005Q4, the survey comprised 51 economists who routinely forecast economic activity. They come from large commercial banks, brokerage houses, private corporations, and universities. There is no reason to believe that their inflation forecasts differ systematically from the forecasts implicit in nominal bond yields. Over the period since June 2001, the ten-year forecasts of CPI inflation from this survey have remained at 2.5 percent. Similarly, since December 2001, the Livingston Survey of business economists has reported a consensus estimate of 2.5 percent for CPI inflation over the succeeding ten years. This 2.5 percent number is basically the same as the average number for the

[37] On January 5, 2006, the ten-year TIPS yield was 2.07 percent.

[38] In 2005, there were about $200 billion in TIPS outstanding (Kwan 2005).

five-year, five-year-ahead inflation compensation numbers shown in Figure 6. This similarity indicates that the inflation compensation numbers are good measures of expected trend inflation.[39]

APPENDIX C: FOMC DATA

This Appendix discusses the data used in Figure 1. In his semiannual (February and July) congressional oversight hearings (formerly known as the "Humphrey-Hawkins" hearings), the FOMC chairman provides Congress with forecasts for the growth rate of nominal GDP, real GDP, and prices from the fourth quarter of the preceding year to the fourth quarter of the current year. Members of the FOMC make individual forecasts. The chairman presents these forecasts as a range that encompasses the majority of the forecasts submitted by the members. Since 1983, he has also presented a smaller range called the "central tendency." I use the midpoint of this "central tendency" for real output growth and inflation as proxies for potential real growth and the FOMC's inflation target.

The observations in the figures and regressions correspond to FOMC meeting dates. Starting in 1981, there have been eight FOMC meetings a year. FOMC meetings are usually held on a Tuesday. Forecasts of growth rates for real output and inflation are from the Greenbook, which is available as of an FOMC meeting. The Greenbook ("Current Economic and Financial Conditions") is prepared by the staff of the Board of Governors and is circulated prior to FOMC meetings. Part 1, "Summary and Outlook," contains quarterly forecasts for nominal and real output (GNP before 1992, GDP thereafter) as well as forecasts of many other series such as the unemployment rate. Greenbooks remain confidential for five full calendar years after the year in which they were published.

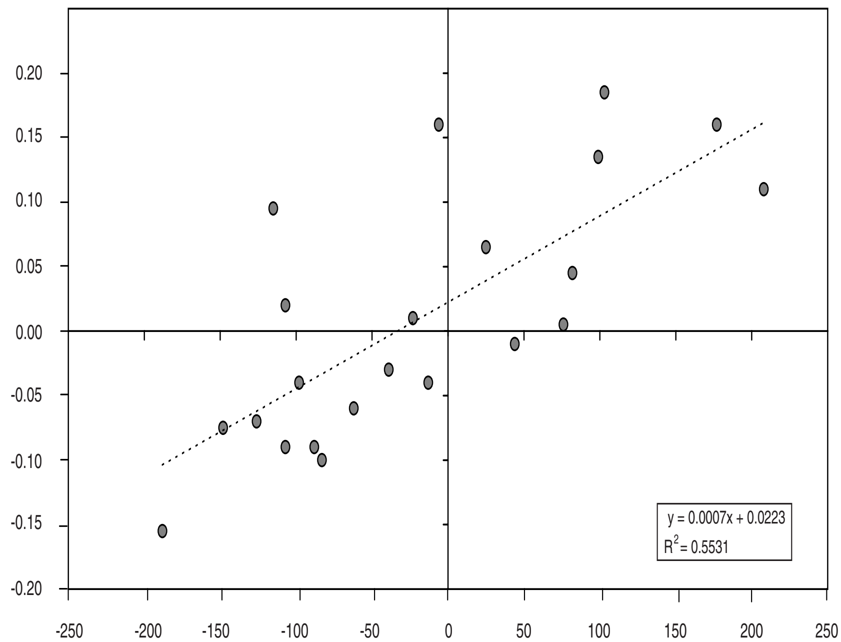
[39] It is possible that the Survey of Professional Forecasters' number is not a good measure of expected trend inflation because it incorporates the special factors affecting near-term inflation. However, the questionnaires for the last three quarters of 2005 asked about expected inflation for the coming five-year interval as well as the coming ten-year interval. The implied numbers for expected inflation for the five-year interval five years ahead were, respectively, 2.5 percent, 2.5 percent, and 2.4 percent, basically the same as the numbers for the entire ten-year period.

These quarterly surveys also asked for forecasts of inflation over the subsequent two-year interval as well as the subsequent one-year interval. Based on these numbers, the special factors that affect expected inflation one year out do not affect expected inflation much beyond this interval. The ten-year forecasts in the Survey of Professional Forecasters are, therefore, basically measures of expected trend inflation.

The inflation predictions from the Greenbook used in the regression are for the implicit GNP deflator prior to 1988, CPI excluding food and energy from 1989 through May 2000, and the PCE excluding food and energy chain-weighted price index thereafter. At FOMC meetings from June 1988 through March 1989, the FOMC had available forecasts of GNP growth adjusted for the effects of the 1988 drought. The details of the drought adjustment are found in the Greenbooks. The Commerce Department estimates of the differences between drought-adjusted GNP growth and actual GNP growth are 0.7 (1988Q2), 0.5 (1988Q3), 1.0 (1988Q4), and -2.2 (1989Q1) percentage points. For these meetings, to obtain predictions of drought-adjusted levels of GNP, the Board staff applied drought-adjusted growth rates to the initial 1988Q1 GNP figure, which was unaffected by the subsequent drought. The regression uses the drought-adjusted forecasts.

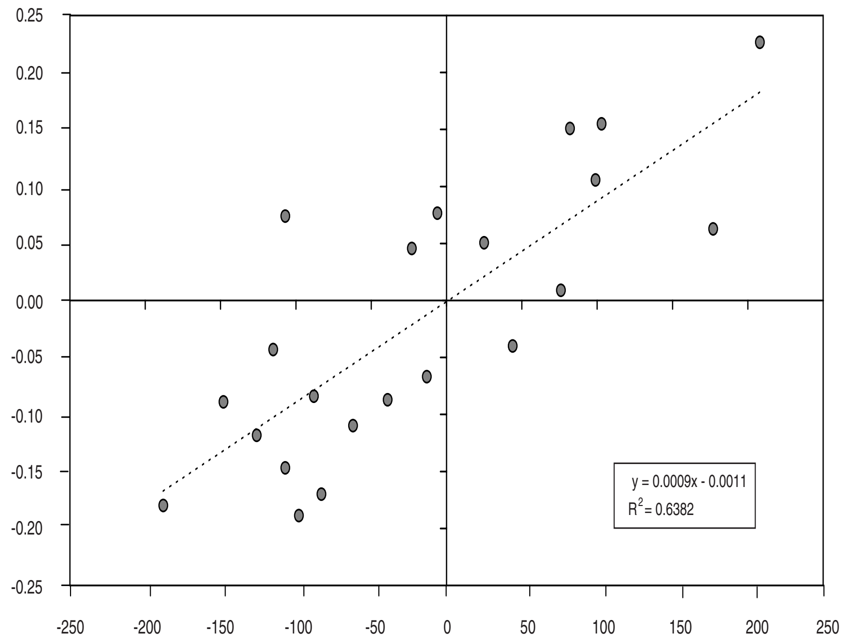
For the November 1970 through September 1979 meetings, the funds rate is the initial value set by the FOMC as reported in the Board staff document called the Bluebook ("Monetary Policy Alternatives"). For the last two meetings in 1979, 1980, 1981, and the first half of 1982, the funds rate is the actual funds rate prevailing in the first full statement week following an FOMC meeting. (For January 1980, May 1980, May and July 1981, and November 1981, it is possible to obtain a value expected to prevail by the Desk.) From the last half of 1982 through 1993, the funds rate is the value the New York Desk expected to prevail in the first full statement week after an FOMC meeting as reported in "Open Market Operations and Securities Market Developments," published biweekly by the New York Fed. Starting in 1994, the funds rate is the announced target. Actual funds rate data for the average funds rate that prevailed in the first full reserve settlement week ending Wednesday following an FOMC meeting along with other interest rates are reported in the Board of Governor's statistical release, G.13, "Selected Interest Rates." (The December 1980 meeting was held on a Thursday and Friday, so the funds rate figure used is the average of the daily-average values for the following Monday, Tuesday, and Wednesday. For the occasional meetings held on a Wednesday and Thursday, if the actual funds rate is used, it is the average of the daily-average values for the week beginning that Thursday.)

Figure 7 Daily Change in Fed Funds Futures (Six-Month) in Response to Employment Surprise



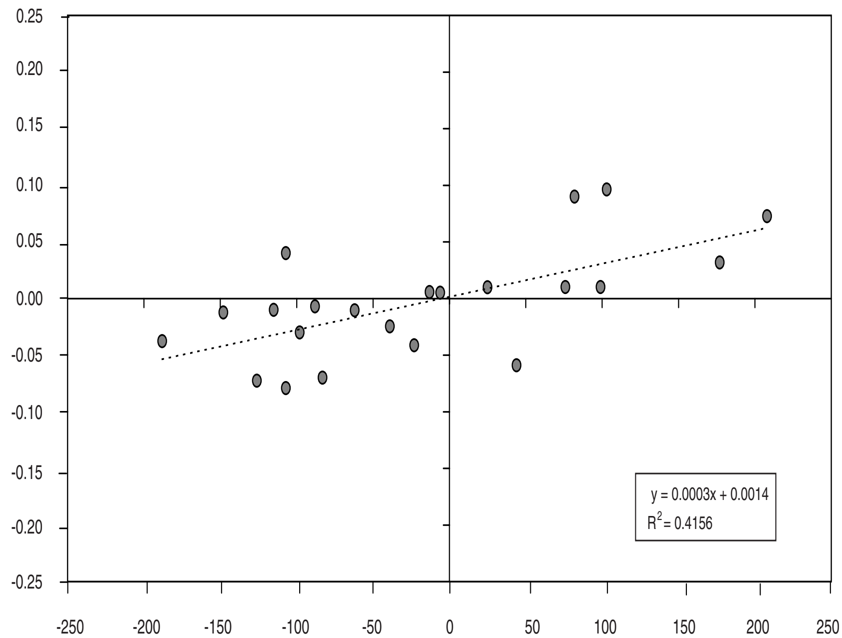
Notes: Observations on employment (horizontal axis) are for civilian nonfarm payrolls from the BLS. The surprise is the difference between the actual number released and the median expectation of surveyed business economists reported by the Federal Reserve Bank of St. Louis on the cover sheet of its release, *U.S. Financial Data*. The change in the interest rate (vertical axis) on the generic six-month Fed funds futures contract is from close of business on the day before the release to the close of business on the day of the release, as reported by the Bloomberg (Code: FF6 <index> HP).

Figure 8 Daily Change in TIPS (Five-Year) in Response to Employment Surprise



Notes: Observations on employment (horizontal axis) are for civilian nonfarm payrolls from the BLS. The surprise is the difference between the actual number released and the median expectation of surveyed business economists reported by the Federal Reserve Bank of St. Louis on the cover sheet of its release, *U.S. Financial Data*. The change in the five-year TIPS yield (vertical axis) is from the close of business on the day before the release to the close of business on the day of the release, as reported by Bloomberg.

Figure 9 Daily Change in Inflation Compensation (Five-Year, Five Years Ahead) in Response to Employment Surprise



Notes: Observations on employment (horizontal axis) are for civilian nonfarm payrolls from the BLS. The surprise is the difference between the actual number released and the median expectation of surveyed business economists reported by the Federal Reserve Bank of St. Louis on the cover sheet of its release, *U.S. Financial Data*. The change in the five-year, five-year-ahead inflation compensation (vertical axis) is from the close of business on the day before the release to the close of business on the day of the release. Data are from the Division of Monetary Affairs of the Board of Governors of the Federal Reserve System.

REFERENCES

Barro, Robert J., and David B. Gordon. 1983. "A Positive Theory of Monetary Policy in a Natural Rate Model." *Journal of Political Economy* 91 (August): 589–610.

Broaddus, J. Alfred, Jr. 2004. "Macroeconomic Principles and Monetary Policy." Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Winter): 1–9.

______________, and Marvin Goodfriend. 2004. "Sustaining Price Stability." Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Summer): 3–20.

Ferguson, Roger W., Jr. 2006. "Economic Outlook for the United States." Remarks at the Howard University Economics Forum, Washington D.C., March 3, 2006. quoted in " Factbox-Fed Views on U.S. Inflation Targeting."

Financial Times. 2000. "Risks as Bank Offers Greater Transparency." October 3: 27.

Friedman, Milton. 1974. "A Theoretical Framework for Monetary Analysis." In *Milton Friedman's Monetary Framework: A Debate with His Critics*, ed. Robert J. Gordon. Chicago: University of Chicago Press.

Goodfriend, Marvin. 1993. "Interest Rate Policy and the Inflation Scare Problem." Federal Reserve Bank of Richmond *Economic Quarterly* 79 (Winter): 1–24.

______________. 2004. "Monetary Policy in the New Neoclassical Synthesis: A Primer." Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Summer): 3–20.

______________, and Robert G. King. 1997. "The New Neoclassical Synthesis." NBER Macroeconomics *Annual* 12.

______________. 2004. "The Incredible Volcker Disinflation." Carnegie-Rochester Conference on Public Policy.

Greenspan, Alan. 1993. Remarks before the Economic Club of New York, April 19.

______________. 2004. "Risk and Uncertainty in Monetary Policy." AEA Papers and Proceedings *American Economic Review* 94 (May): 33–48.

Gurkaynak, Refet, Brian Sack, and Eric Swanson. 2003. " The Excess Sensitivity of Long-Term Interest Rates: Evidence and Implications for

Macroeconomic Models." Federal Reserve Board Finance and Economics Discussion Series 2003-50.

Hetzel, Robert. 2000 "The Taylor Rule: Is It a Useful Guide to Understanding Monetary Policy?" Federal Reserve Bank of Richmond *Economic Quarterly* 86 (Spring): 1–33.

______________. 2004. "How Do Central Banks Control Inflation?" Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Summer): 47–63.

______________. 2005. "What Difference Would an Inflation Target Make?" Federal Reserve Bank of Richmond *Economic Quarterly* 90 (Spring): 45–72.

______________. 2006. *The Monetary Policy of the Federal Reserve System: An Analytical History*.

King, Robert G., and Alexander L. Wolman. 1999. "What Should the Monetary Authority Do When Prices Are Sticky?" In *Monetary Policy Rules*, ed. John B. Taylor. Chicago: The University of Chicago Press: 349–98.

Kwan, Simon. 2005. "Inflation Expectations: How the Market Speaks." Federal Reserve Bank of San Francisco *Economic Letter 25*.

Kydland, Finn E., and Edward C. Prescott. 1977. "Rules Rather than Discretion: The Inconsistency of Optimal Plans." *Journal of Political Economy* 85 (June): 473–91.

Lindsey, David E., Athanasios Orphanides, and Robert H. Rasche. 2005. "The Reform of October 1979: How It Happened and Why." Reflections on Monetary Policy 25 Years After October 1979. Federal Reserve Bank of St. Louis *Review*, (March/April): 187–235.

Lucas, Robert E., Jr. 1981. "Rules, Discretion, and the Role of the Economic Advisor (1980)." In *Studies in Business-Cycle Theory*. Cambridge, Mass: The MIT Press.

Meyer, Laurence H. 2004. *A Term at the Fed: An Insider's View*. New York: Harper Collins.

Orphanides, Athanasios. 2001. "Monetary Policy Rules Based on Real-Time Data." The *American Economic Review* 91 (September): 964–85.

______________. 2003a. "Monetary Policy Evaluation with Noisy Information." *Journal of Monetary Economics* 50 (April): 605–31.

______________. 2003b. "The Quest for Prosperity without Inflation." *Journal of Monetary Economics* 50 (April): 633–63.

______________. 2003c. "Historical Monetary Policy Analysis and the Taylor Rule." *Journal of Monetary Economics* 50 (July): 983–1022.

______________. 2004. "Monetary Policy Rules, Macroeconomic Stability and Inflation: A View from the Trenches." *Journal of Money, Credit, and Banking* 36 (April): 151–75.

______________, and Simon van Norden. 2002. "The Unreliability of Output Gap Estimates in Real Time." *Review of Economics and Statistics* 84 (November): 569–83.

______________. 2004. "The Reliability of Inflation Forecasts Based on Output Gap Measures in Real Time." Working Paper. Finance and Economics Discussion Series, Federal Reserve Board.

U. S. Congress. 1993. "Federal Reserve's First Monetary Policy Report for 1993." Hearing before the Senate Committee on Banking, Housing, and Urban Affairs. February 19, 1993, 103 Cong. Washington: Government Printing Office.

______________.1994. "Conduct of Monetary Policy." Hearing before the Subcommittee on Economic Growth and Credit Formation of the House Committee on Banking, Finance and Urban Affairs. February 22, 1994, 103 Cong. Washington: Government Printing Office.

______________. 1994. "Interest Rates, Wages, Employment, and Inflation." Hearing before the House Committee on the Budget. June 22, 1994, 103 Cong. Washington: Government Printing Office.

______________. 1995. "The Economic Outlook for the Nation." Hearing before the Senate Committee on Finance. January 25, 1995, 104 Cong. Washington: Government Printing Office.

______________. 1995. "Federal Reserve's First Monetary Policy Report for 1995." Hearing before the Senate Committee on Banking, Housing, and Urban Affairs. February 22, 1995, 104 Cong. Washington: Government Printing Office.

______________. 1998. "Federal Reserve's First Monetary Policy Report for 1998." Statement before the Subcommittee on Domestic and International Monetary Policy, House Committee on Banking and Financial Services. February 24, 1998, 105 Cong. Washington: Government Printing Office.

______________. 1999. "Conduct of Monetary Policy." Hearing before the House Committee on Banking and Financial Services. February 24, 1999, 106 Cong. Washington: Government Printing Office.

______________. 1999. "The Economic Outlook and Monetary Policy." Hearing before the Joint Economic Committee. June 17, 1999, 106 Cong. Washington: Government Printing Office.

———. 1999. "Conduct of Monetary Policy." Hearing before the House Committee on Banking and Financial Services. July 22, 1999, 106 Cong. Washington: Government Printing Office.

———. 2000. "Federal Reserve's First Monetary Policy Report for 2000." Hearing before the Senate Committee on Banking, Housing, and Urban Affairs. 2nd sess. February 23, 2000, 106 Cong. Washington: Government Printing Office.

Volcker, Paul A. 1980. "A Rare Opportunity." Remarks before the 43rd Annual Dinner of the Tax Foundation, New York City, December 3, 1980.

———. Statement before the U.S. Congress Joint Economic Committee, November 24, 1982.

Wolman, Alexander L. 1997. "Zero Inflation and the Friedman Rule: A Welfare Comparison." Federal Reserve Bank of Richmond *Economic Quarterly* 83 (Fall): 1–21.

———. 1998. "Staggered Price Setting and the Zero Bound on Nominal Interest Rates." Federal Reserve Bank of Richmond *Economic Quarterly* 84 (Fall): 1–24.

———. 1999. "Sticky Prices, Marginal Cost, and the Behavior of Inflation." Federal Reserve Bank of Richmond *Economic Quarterly* 85 (Fall): 29–48.

———. 2001. "A Primer on Optimal Monetary Policy with Staggered Price-Setting." Federal Reserve Bank of Richmond *Economic Quarterly* 87 (Fall): 27–52.

Woodford, Michael. 2005. "Central-Bank Communication and Policy Effectiveness." Prepared for the Federal Reserve Bank of Kansas City Conference "To Greenspan Era: Lessons for the Future," Jackson Hole, Wyoming, August 25-27, 2005.