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Recent Trends in Homeownership

Carlos Garriga, William T. Gavin, and Don Schlagenhauf

The homeownership rate began to trend upward in 1995 after years of being relatively constant, near 64 percent. This article describes recent changes in the share of U.S. housing that is owner-occupied and explores the reasons for the surprising rise over the past decade. Explanations that have been offered include demographics, low mortgage rates, changes in housing policy, and innovations in the mortgage financial market. Of all these explanations, the most plausible one is that innovations in the financial markets increased access to mortgage finance, mainly by reducing downpayment constraints and allowing younger people to buy homes. (JEL D10, R21, R31)

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The United States has a relatively high rate of homeownership; only a few countries—Ireland, Spain, and Italy—have much higher rates.[1] This article describes recent changes in the share of U.S. housing that is owner-occupied, with an explanation for its surprising rise over the past decade.

Figure 1 shows the homeownership rate in the United States during the period from 1930 to the present. During the Great Depression, when the homeownership rate fell, the government began to adopt policies to promote homeownership. Toward the end of World War II, the homeownership rate began to rise. In fact, the rate rose steadily until reaching 64 percent in 1965. For the next 30 years, despite a wide variety of policies at all levels of government aimed at stimulating homeownership, this rate seemed stuck permanently near the 64 percent level. However, in 1995, the trend turned upward and reached 69 percent in 2004.

In 2003, there were 120.8 million housing units in the United States; 14.9 million of these were vacant or seasonal, while 105.9 million were occupied as primary residences. Of the occupied units, 72.2 million were owner-occupied. (The homeownership rate is computed by dividing the number of owner-occupied housing units by the number of units occupied as primary residences.) To get some idea of the magnitude of a 5-percentage-point increase in the homeownership rate over the past decade, note that each year, on net, a half million renters would have had to become homeowners.

This article investigates various explanations for the turnaround that began in 1995. We examine changes in tax policy and other government programs in the economy (including mortgage interest rates, relative home prices, and household income) and innovations in the mortgage market that may account for the steady rise in homeownership over the past decade.

HOMEOWNERSHIP RATE BY DEMOGRAPHIC CHARACTERISTICS

To try to understand why the homeownership rate has increased, we examine its change from

[1] See *The Economist* (2002) for a cross-country comparison of homeownership rates.

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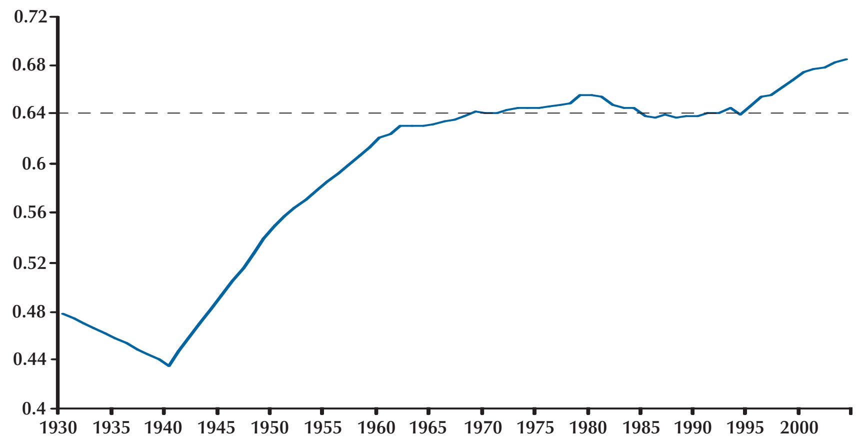
Figure 1

U.S. Homeownership Rate, 1930 to 2004



SOURCE: Colton (2003) for the early years, which include interpolated data, and Housing Vacancy Survey, Table 12, U.S. Census Bureau, 2005, for data after 1960.

Table 1

Homeownership Rates by Age

Age group	Rate in 1985	Percent change in homeownership rate: 1985 to 1994	Percent change in homeownership rate: 1994 to 2004	Rate in 2004
U.S. total	63.9	0.2	7.8	69.0
Less than 35 years	39.9	–6.5	15.5	43.1
35 to 44 years	68.1	–5.3	7.3	69.2
45 to 54 years	75.9	–0.9	2.7	77.2
55 to 64 years	79.5	–0.3	3.0	81.7
65 years and over	74.8	3.5	4.8	81.1

SOURCE: Data come from the Housing Vacancy Survey, Table 15, U.S. Census Bureau, 2005.

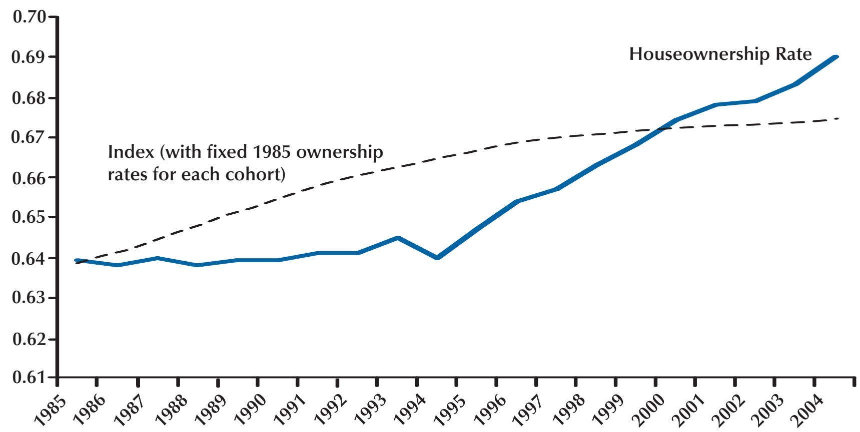
various demographic perspectives. Table 1 includes information about homeownership rates by age. The top row shows that the U.S. homeownership rate in 1985 was 63.9 percent. It rose a mere 0.2 percent during the decade ending in 1994. This relatively flat trend masked considerable divergence among age groups. For most groups in the period 1985 to 1994, homeownership rates fell. The younger the group, the greater was the decline. Only for the oldest group, aged 65 years and older, did homeownership rise—to 77.4 percent by 1994.

The rate of homeownership among the oldest group continued to rise—up 4.8 percent to 81.1 by 2004. The homeownership rates for all the younger groups, after 1994, stopped falling and began to rise as well. The turnaround was greatest for the two youngest groups, which are dominated by first-time buyers.

An obvious question is whether changes in

Figure 2

The Effect of Demographics on the Homeownership Rate, 1985 Weights



SOURCE: Housing Vacancy Survey, Table 15, U.S. Census Bureau, 2005.

Table 2

Homeownership Rates by Family Status

	Rate in 1985	Percent change in homeownership rate 1985 to 1994	Percent change in homeownership rate 1994 to 2004	Rate in 2004
United States	63.9	0.2	7.8	69.0
Married-couple families	78.2	0.8	6.6	84.0
Other families				
Male	57.8	–8.7	12.9	59.6
Female	45.8	–3.5	15.2	50.9
Nonfamily households				
Male	38.8	11.1	17.2	50.5
Female	51.3	6.2	9.9	59.9

SOURCE: Data come from the Housing Vacancy Survey, Table 15, U.S. Census Bureau, 2005.

the U.S. age distribution, such as the baby boom effect, could account for the increase in participation in the housing market. We construct a fixed-weight index holding ownership rates for each age cohort constant at the 1985 rate. The relative shares of each cohort in the population of residents are changing over time.[2] Figure 2 shows that this index, based on changing shares of the age cohorts, predicts that the average homeownership rate would have grown more rapidly before 1995 than what is actually observed. The fixed weight index grew from 63.9 in 1985 to 66.5 in 1994 and then more slowly to 67.4 in 2004. Figure 2 clearly

[2] The 1985 index in Figure 2 was created by taking the ownership rates for each age group in 1985 as fixed weights and then calculating a fixed-weight index of homeownership that changes because the relative share of each age group changes over time.

Table 3

Homeownership Rates by Ethnic Group

	Rate in 1994	Percent change in homeownership rate 1994 to 2004	Rate in 2004
United States	64.0	7.8	69.0
Non-Hispanic white	70.0	8.6	76.0
Black	42.3	16.1	49.1
American Indian	51.7	7.5	55.6
Asian or Pacific Islander	51.3	16.6	59.8
Hispanic or Latino	41.2	16.7	48.1

SOURCE: Data come from the Housing Vacancy Survey, Table 20, U.S. Census Bureau, 2005.

demonstrates that age demographics cannot be the primary explanation for the rise in the homeownership rate that began in 1995.

Table 2 decomposes homeownership trends by family status. The top row repeats the information for U.S. total households. The second row includes households with families headed by a married couple. This group has the highest levels of homeownership. All other groups are much lower. For families headed by a single parent, male-led families had higher homeownership than did female-led families. However, female-led families have purchased homes at a higher rate over the past two decades, so the two rates have tended to converge. It is also interesting to note that the opposite pattern exists for non-family households; that is, female-led households started at a higher rate than male-led households, but the homeownership rate for male-led households rose faster and closed some of the gap.[3]

Table 3 reports results by ethnic group using data that begin in 1994. The top row reports statistics for the total U.S. population. Since 1994, the average U.S. homeownership rate has risen 7.8 percent. The second row shows the rate for the non-Hispanic white population. Here the rates are highest. The lowest rates are for black and Hispanic (or Latino) households. However, these two groups had much faster growth in homeownership rates, almost double those of white households. American Indian homeownership rates are between those of white and black households. However, the increase was slightly below total U.S. growth.

Not surprisingly, homeownership rates are lowest for young, minority, and low-income households, and hence they offer the greatest scope for increasing the overall average. This point is important for public policymakers because, to achieve significant progress in promoting homeownership rates, it makes sense to focus policies on groups with the lowest participation.

GOVERNMENT POLICIES TO PROMOTE HOMEOWNERSHIP

The government has long had a policy of promoting homeownership. The tax code is skewed to favor homeownership, the government sponsors agencies that promote homeownership among military veterans and low-income families, and both the Clinton and George W. Bush administrations have promoted programs designed to help young and low-income homebuyers.

Tax Law

One of the programs supporting homeownership is the home mortgage interest deduction.

[3] Households are classified as family households if two or more of the occupants are related and as non-family if none of the occupants are related.

Homeowners who itemize their tax returns have been able to deduct interest payments on home mortgage loans from their taxable income since the passage of the 16th amendment in 1913. All interest payments on consumer loans were deductible until the 1986 tax reform, which eliminated the deduction for all interest payments except those to service home mortgage debt. This reform has actually increased the value of the home mortgage interest deduction, as homeowners can substitute mortgage debt for other types of debt.

The government has never taxed imputed in-kind service flows from homeownership. Landlords must pay taxes on the rental income net of maintenance and depreciation costs. If the same house is owner-occupied, there is no tax on the imputed rental income.

In 1951, Congress enacted legislation that allowed homeowners to exclude capital gains from the sale of a principal residence if they purchased another residence costing at least as much within two years. Beginning in 1964, taxpayers could take a one-time exclusion of a capital gain of $125,000 if they were at least 55 years old. The purpose was to protect elderly taxpayers from a heavy burden associated with becoming a renter or moving into a smaller residence. In 1997, the Clinton administration sponsored legislation that allows homeowners to take a tax-free capital gain up to $250,000 on the sale of a principal residence every other year. This feature of the tax code is not likely to help young, low-income, and first-time homebuyers.

The TAXSIM program at the National Bureau of Economic Research constructs average marginal tax rates for U.S. taxpayers in different categories. One of the calculations is the average marginal subsidy rate for the mortgage interest payment deduction. Since 1986, the average marginal subsidy has been relatively constant, around 23 percent: That is, the average taxpayer deducts 23 cents from his tax bill for the last dollar of mortgage interest that is paid.[4] By itself, this subsidy cannot explain the recent change in the homeownership trend, as there has not been a change in this policy over this time horizon. Glaeser and Shapiro (2003) have argued that the home interest rate mortgage deduction does not increase homeownership. Rather, they find that the deductibility of the mortgage interest and property tax payments encourage those who are already homeowners to buy larger and more expensive homes.

The federal government also supports homeownership by authorizing state and local governments to issue tax-exempt mortgage revenue bonds. The National Council of State Housing Authorities reports that funds from such bond issues have supported an average of 100,000 home purchases for low-income buyers over the past two decades. In principle, the programs are large enough to be important for homeownership rates. There is, however, no evidence of a rise in the use of these bonds since 1995 and, although there have been few empirical studies on this issue, Benjamin and Sirmans (1987) and Government Accounting Office (1988) suggest that the subsidy is capitalized in the home price so that there is no measurable benefit to the homebuyer.

The Secondary Mortgage Market

During the Great Depression, the federal government created two agencies to increase funds available to finance mortgages.[5] First, in 1934, the government created the Federal Housing Administration (FHA), which insured long-term fixed-rate mortgages. In 1938, it created the Federal National Mortgage Association (Fannie Mae) to purchase FHA-insured mortgages, the beginning of a secondary market for home mortgages. The development of such a market enhances liquidity, thus lowering the liquidity premium paid by borrowers. In addition, the government created the Veterans Administration (VA) program at the end of World War II to help veterans purchase homes. Fannie Mae began purchasing VA-insured loans in 1948. There was a rapid rise in homeownership following World War II, with the homeownership rate rising from around 40 percent before the war to 64 percent by 1965. Colton (2003) argues that both the VA and FHA programs contributed to this large rise and that

4 See Table 9 in Feenberg and Poterba (2004).

5 For a detailed history of housing finance, see Ryding (1990).

their success was largely due to guarantee provisions that allowed new households and veterans to buy homes without a downpayment.

In 1968, Congress restructured Fannie Mae as a government-sponsored enterprise (GSE) and created the Government National Mortgage Association (Ginnie Mae) to assume some of Fannie Mae's functions. Ginnie Mae was authorized to guarantee principal and interest payments on its securities that were backed by VA and FHA loans. Ginnie Mae began to offer guaranteed mortgage-backed securities in 1970. It was in this year that the federal government chartered the Federal Home Loan Mortgage Corporation (Freddie Mac) to develop a secondary market for conventional mortgages. Freddie Mac began issuing mortgage-backed securities in 1971, and Fannie Mae followed a decade later with its first issue of mortgage-backed securities in 1981. The securitization of mortgage debt increased its marketability and should have reduced the wedge between mortgage interest rates and other interest rates. Through the 1960s to the end of the 1980s, the 5-year moving average of the difference between the contract interest rate on new homes and the 10-year constant maturity yield on Treasury bonds fell from 1.5 percentage points in 1965 to half a percentage point at the end of the 1980s. Since then, however, it has risen steadily and has averaged 1.5 percent in the past five years.

Of course, there are many reasons why the spread between mortgage rates and Treasury yields will vary. Analysts looking for the interest rate–lowering effects of the GSEs look at the spread between interest rates on conforming and jumbo loans from comparable mortgage contracts. Conforming loans are those that meet the standards set by the GSEs. Jumbo loans are those that exceed the maximum size of loans that the GSEs will purchase. This spread depends on many factors surrounding the particular terms of a loan and the market forces affecting the non-GSE lenders. In a definitive study, Passmore, Sherlund, and Burgess (2005) estimate that the average interest rate benefit of the GSEs is between 15 and 18 basis points. Sanders (2005) compares these results with other recent studies. He concludes that, although the results of Passmore, Sherlund, and Burgess are on the low side in the literature, other comprehensive studies also find small effects. But, more importantly, for the trend in homeownership rates, Sanders shows that the unadjusted spread between jumbo and conforming loans has fluctuated between 10 and 50 basis points since 1990, with no apparent trend.[6]

Affordable Housing Programs

The Department of Housing and Urban Development (HUD) has three affordable housing programs: HOZ, HOME, and SHOP. The Homeownership Zone (HOZ) program has helped communities reclaim vacant and blighted properties, increase homeownership, and promote economic revitalization by creating entire neighborhoods of new, single-family homes, called Homeownership Zones. There have been two competitive funding rounds. The first was in federal fiscal year 1996 and authorized $30 million in subsidies for about 2,000 new and rehabbed units in six cities. The other, in federal fiscal year 1997, authorized about $12.7 million in subsidies in five cities for just under 1,400 new and rehabbed units. No further funding has been authorized under this program.

The Home Investment Partnerships Program (HOME) was created under Title II of the National Affordable Housing Act of 1990. It has become a key funding source for supporting HUD's homeownership goals. HOME provides grants to state and local governments to increase the homeownership rate among lower-income and minority households, as well as to revitalize and stabilize communities. HOME funds may be used to support the following eligible activities: homebuyer programs, rehabilitation of owner-occupied units, rental housing development, and tenant-based rental assistance. According to a study commissioned by HUD, between 1992 and 2002, $3.1 billion in HOME funds helped 270,000 low-income households buy homes.[7] During the first few years, most of the funds were used to assist renters and

[6] We do not address issues involving the costs and benefits of having the GSEs in the market. See Poole (2005) for a discussion of risks that have grown with the size of the GSEs.

[7] See Turnham et al. (2004).

owners of rental units. In 1992, only 7 percent of the funds and 3 percent of the housing units assisted were owner-occupied. By 2002, the percentages rose to 31 percent of the funds and 39 percent of the housing units.

In December 2003, President Bush signed into law a new initiative under HOME—the American Dream Downpayment Initiative Act (ADDI)—that authorizes up to $200 million in formula grants to help first-time homebuyers with the biggest hurdle to homeownership: downpayment, closing costs, and rehabilitation costs.[8] To be eligible for ADDI assistance, individuals must be first-time homebuyers interested in purchasing single-family housing. Individuals who qualify for ADDI assistance must have incomes not exceeding 80 percent of the median area income. The maximum downpayment grant is $10,000 or 6 percent of the purchase price of a house, whichever is greater. HUD analysts expect the subsidy to be around $7,500 on average for each homebuyer that participates in the program. The Bush administration expects ADDI to fund approximately 40,000 households annually.

The Self-Help Homeownership Opportunity Program (SHOP) provides funds for nonprofit organizations to purchase home sites and develop or improve the infrastructure needed to set the stage for "sweat equity" and volunteer-based homeownership programs for low-income families. This program targets families who are willing to contribute their own time and effort into home improvement. Grants are provided by the federal government to nonprofit organizations, enabling them to acquire land and improve infrastructure to build new homes. An example is Habitat for Humanity. For fiscal year 2003 funding was $25 million.

Overall, these programs are too small to have had a measurable effect on homeownership rates. Even if all these programs together succeeded helping 50,000 renters become homeowners each year, that number would be an order of magnitude smaller than the number of households that became homeowners during each year of the past decade. With only 50,000 a year, it would take approximately 25 years to increase the homeownership rate by just 1 percentage point.

HOMEOWNERSHIP AND ECONOMIC CONDITIONS

The decision of buying or renting is an important one that depends on the costs and benefits of owning versus renting a home. Housing affordability indices attempt to account for the main financial factors that influence the decision: mortgage interest rates, housing prices, and family income.

Housing Costs

The mortgage interest rate is an important factor in the cost of a home. Figure 3 plots the average mortgage rate on loans used to buy existing homes and the 10-year-ahead inflation forecast. At 15 percent in 1981, the mortgage rate has fallen rather steadily to around 6 percent in 2005. The expected inflation rate also fell over this period, and so the real mortgage rate did not fall as quickly as did the nominal rate; but the real rate also fell from about 8 percent in 1981 to 3.5 percent in 2005. Two percentage points of that decline have occurred since 2000.

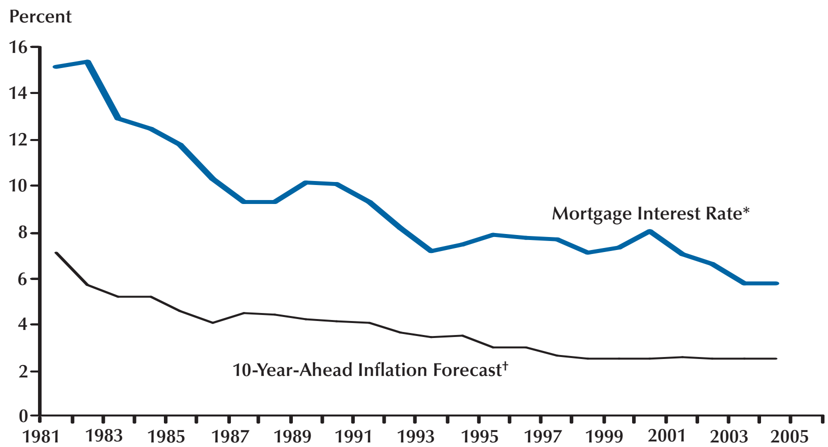
We look at the partial effect of house prices and interest rates on housing affordability by constructing two counterfactual historical indices: The indices shown in Figure 4 are quarterly payments on interest and principal for a conventional loan with a 20 percent downpayment. The first index is based on the actual time series of house prices with the mortgage rate fixed at 10 percent—the rate observed in 1990:Q1. The second index is similar to the first, but the house price is fixed at the 1990:Q1 level and the payments are based on the actual time series of mortgage interest rates. The third index uses actual time series for both the house price and the mortgage interest rate. It shows that the cost effect of the falling interest rate has been more than offset by the rising house price.

The Office of Federal Housing Enterprise Oversight publishes a house price index (HPI)

8 In 2003, the ADDI appropriation was $74.5 million. In 2004, HUD announced $161.5 million in funding for the ADDI.

Figure 3

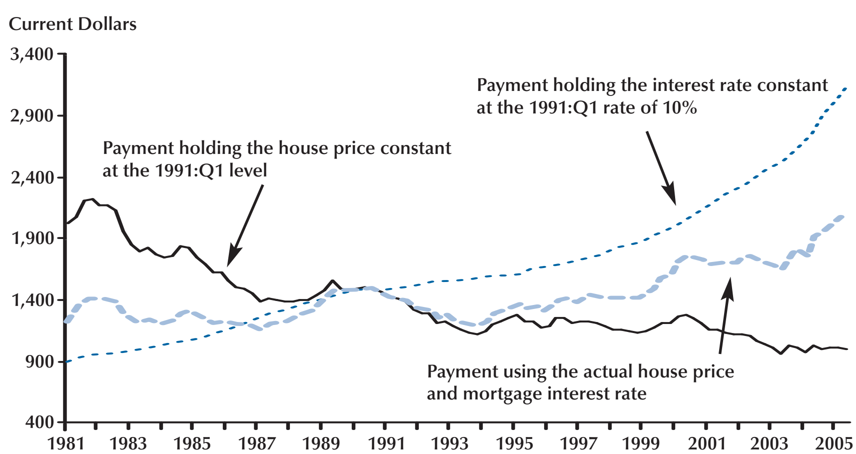
The Mortgage Interest Rate and Expected Inflation



SOURCE: *Effective rate on loans closed on existing homes: Federal Home Loan Bank Board. †Inflation forecast from the survey of professional forecasters: Federal Reserve Bank of Philadelphia.

Figure 4

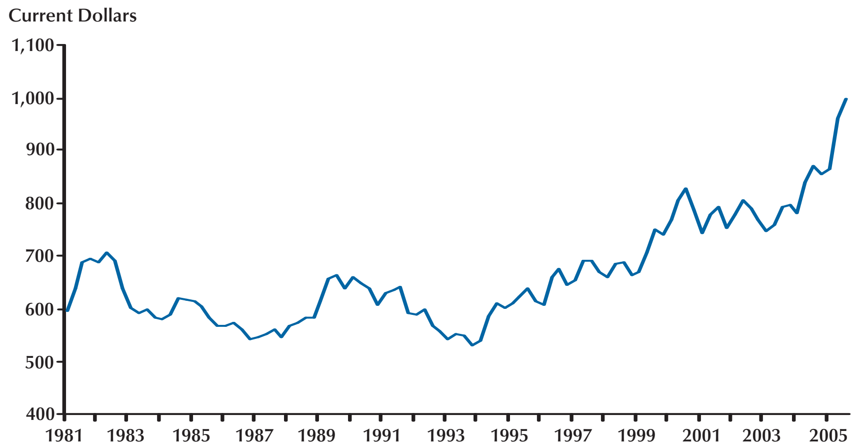
Hypothetical Payments for Principal and Interest



SOURCE: The House Price Index (HPI) is published by the Office of Federal Housing Enterprise Oversight (OFHEO) using data provided by the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac). The mortgage rate is the effective rate on loans closed on existing homes, compiled by the Federal Home Loan Bank Board.

Figure 5

Actual Monthly Payment for Principal and Interest of Median First-Time Buyer



SOURCE: National Association of Realtors.

using data provided by Fannie Mae and Freddie Mac. It is a broad measure of the movement of single-family house prices. The HPI is a weighted repeat sales index, meaning that it measures average price changes in repeat sales or refinancings on the same properties. It is based on transactions involving conforming, conventional mortgages purchased or securitized by Fannie Mae or Freddie Mac. Only mortgage transactions on single-family properties are included. The mortgage rate is the effective rate on loans closed on existing homes compiled by the Federal Home Loan Bank Board.

Figure 4's dotted line (fixed mortgage rate) shows that rising house prices contributed to a dramatic rise in the payment. The solid line shows the effect of declining interest rates. The next effect is the dashed line, which lies between the two. The rising house price only offset the effect of lower interest rates through 1999. Since then, the rising price dominates and payments have risen rather sharply. This finding is consistent with Painter and Redfearn (2002), who examine the role of interest rates in influencing long-run ownership rates and find that interest rates play little direct role in changing ownership rates.

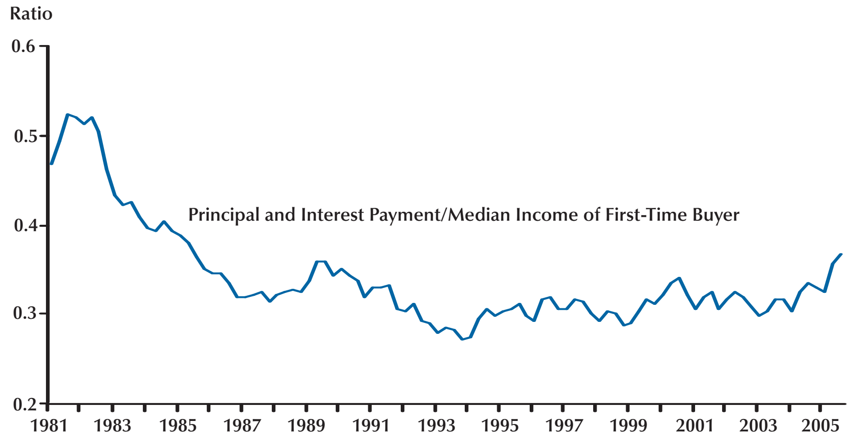
Affordability for First-Time Buyers

Using data on first-time homebuyers from the American Housing Survey (AHS), we plot the actual monthly payment for principal and interest of the median first-time buyer in Figure 5. Here the payments were relatively flat until 1995, when they began to trend upward. We use these data in Figure 6, with the median income of first-time homebuyers, to show the principal and interest payments as a share of income.

Perhaps we should not be surprised to see that the income of the first-time buyers rose almost as fast as did the size of the payment. The question is whether the median income of first-time homebuyers was representative of the population. In Figure 7, we plot the AHS affordability index. This index is equal to 100 when median family income qualifies for an 80 percent mortgage on a median-priced existing single-family home. A rising index indicates that more buyers can afford to enter the market. As the figure shows, there was an erratic decline in the affordability index from 92 percent at the end of 1993 to 63 percent in 2005.

Figure 6

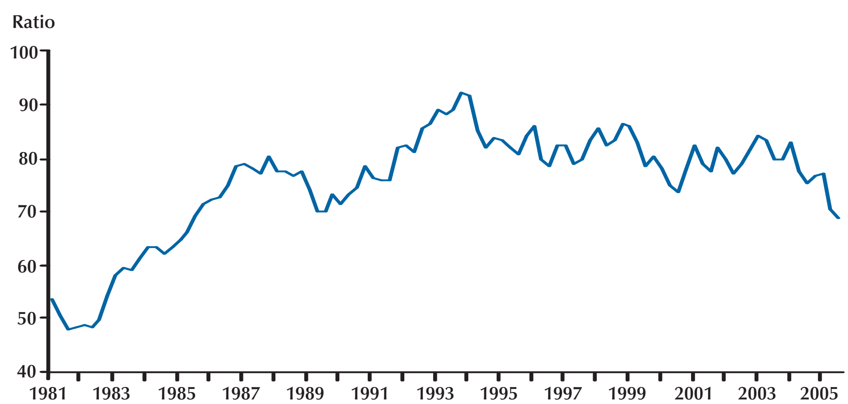
First-Time Housing Cost as a Share of Income



SOURCE: National Association of Realtors.

Figure 7

Affordability Index

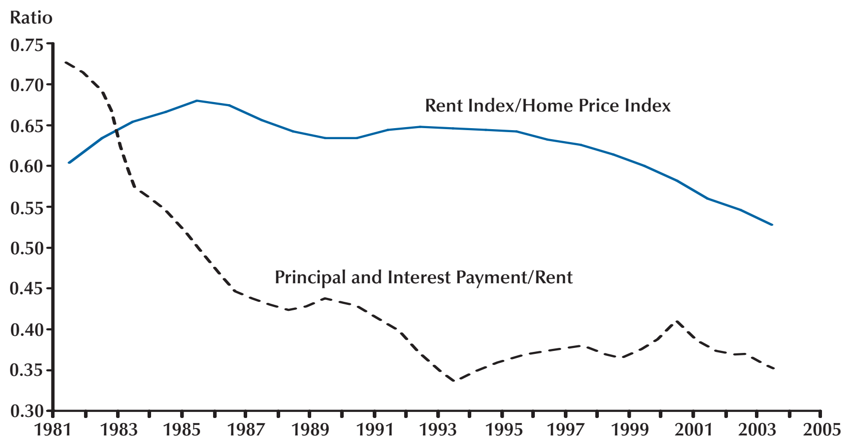


NOTE: Index = 100 when median family income qualifies for an 80 percent mortgage on a median-priced existing single-family home. Rising index indicates more buyers can afford to enter the market.

SOURCE: National Association of Realtors.

Figure 8

Relative Cost of Renting vs. Buying



SOURCE: The rent index is from Supplemental Table 2.4.5U of the NIPA. The home price index is Freddie Mac's Conventional Mortgage Home Price Index. The rent/payment and interest cost data come from the American Housing Survey.

Rent or Buy?

Another important factor in deciding whether to rent or buy is the monthly rental payment relative to the monthly principal and interest payment.[9] Figure 8 presents two alternative measures of the relative cost of renting versus owning. The ratio of rental index to home price index, shown in the solid line, is the ratio of the rental index from the National Income and Product Accounts (NIPA) to Freddie Mac's conventional mortgage home price index. This relative price of renting rose to a peak in 1985 and has been on a generally downward trend since 1995. The message from this index is that we cannot look to the relative cost of renting as an explanation for the post-1995 rise in homeownership rates. That message is mixed when we look at the ratio of the median payment of principal and interest to the median rent payment. Here the relative size of the house payment fell by half, from 0.73 in 1981 to 0.35 in 1994. After 1994, however, it was relatively flat, fluctuating at or below 0.40. None of these macroeconomic factors explains the rising trend in the homeownership rate in an obvious way. On this point, one of the surprising aspects of the 2001 recession was the ongoing strength in consumption growth and, in particular, housing demand.

FINANCIAL INNOVATIONS

Historically, the U.S. mortgage market was shaped by the FHA's introduction of mortgage insurance that promoted the use of 30-year fixed-rate mortgages and low downpayments.[10] More recently, a series of financial innovations have also contributed to the ability of younger households to buy homes with little or no downpayment. Using a quantitative general equilibrium model of the housing tenure choice (whether to buy or rent), Chambers, Garriga, and Schlagenhauf (2005) find that innovations affecting the size of the downpayment are the most important factor explaining the rise in homeownership, especially for young and first-time buyers.

9 There is an extensive literature (see Rosen, 1979) demonstrating that households are more likely to own their residence as the user cost decreases.

10 For a survey of the FHA contribution to innovations in the U.S. mortgage market, see Pennington-Cross and Yezer (2000).

Table 4

Trends in Downpayment Percentages

		Type of loan	
Year	Type of buyer	FHA (%)	Other loans (%)
1995	First-time	21.6	29.8
	Repeat	22.0	33.3
	Total	23.2	33.5
1999	First-time	13.8	22.1
	Repeat	16.7	24.3
	Total	16.0	25.7
2001	First-time	16.3	24.1
	Repeat	26.5	28.5
	Total	22.6	27.0

SOURCE: Data were constructed using micro data from the American Housing Surveys: 1995, 1999, and 2001.

Table 5

Private Mortgage Insurance Premia

	Mortgage length in years			
Downpayment percentage	30	25	20	15
3-4.99	0.90	0.81	0.81	0.79
5-9.99	0.78	0.56	0.28	0.21
10-14.99	0.52	0.56	0.23	0.19
15-19.99	0.32	0.56	0.23	0.19

SOURCE: Data were downloaded in September 2004 from Jack Guttentag's interesting website at the University of Pennsylvania: www.mtgprofessor.com.

Mortgage Contracts

A lower downpayment constraint should affect the distribution of homeownership as well as the overall homeownership rate. The American Housing Survey collects information on the size of downpayments, and Table 4 shows the median downpayment as a percentage of the loan size for first-time and repeat buyers. Data categorized as FHA or non-FHA loans are shown for three years, 1995, 1999, and 2001. Between 1995 and 1999, we see a drop in the downpayment percentage. The average repeat homebuyer has a larger downpayment because capital gains from the prior home are usually used in the downpayment for the new home.

Why did the downpayment percentage fall? One explanation is the increased use of private mortgage insurance (PMI). Fannie Mae and Freddie Mac require mortgage insurance when the loan-to-value ratio exceeds 80 percent. As a result, borrowers are able to purchase a more expensive home than they might otherwise be able to afford.

To illustrate how PMI works, Table 5 shows an example of 2004 insurance premiums for alternative downpayment percentages and mortgage

Table 6

A Loan with Mortgage Insurance vs. a Combo Loan

Mortgage rate (%)	Combination loan annual payment ($)	Loan with mortgage insurance annual payment ($)
5	6,412	6,929
7	7,906	8,405
11	11,203	11,677

NOTE: This table is taken from Chambers, Garriga, and Schlagenhauf (2005). The values in this table are calculated for a 30-year "80-15-5" $100,000 combo mortgage and a 30-year $100,000 loan with a loan-to-value ratio of 95 percent and PMI. The insurance premia are from Table 5.

terms. For Fannie Mae and Freddie Mac loans, the premium rate is applied to the original balance and holds for ten years, after which it falls uniformly to 0.20 percent of the original loan balance unless it is already less than 0.20 percent, in which case the premium remains unchanged. Premiums are annual rates paid monthly. To obtain the monthly premium in dollars, multiply the premium rate in Table 5 by the loan balance and divide by 1,200. According to the table, if a homebuyer purchases a home with less than 5 percent down, then the premium rate is 0.90. For a $100,000 loan, the monthly insurance premium is $90,000/1,200 = $75. Under federal law, premiums are automatically terminated when the loan balance falls to 78 percent of the original property value and may terminate earlier, at the borrower's initiative, when the balance reaches 80 percent of the appreciated value.

Another explanation for the rising trend in homeownership may be the development of the "80-20"—also known as the no downpayment loan—or the "80-15-5" combo loan. In both of these mortgage products, the buyer takes out two loans. The "80-20" loan corresponds to the traditional loan-to-value rate of 80 percent, while the second loan is for the 20 percent downpayment. The loan on the additional 20 percent has an interest rate that is approximately 2 percent higher than the primary mortgage rate. The "80-15-5" program has a 5 percent downpayment along with a second mortgage for the remaining 15 percent.

In Table 6, we examine the annual cost of a $100,000 30-year fixed-rate "80-15-5" combo mortgage and a $100,000 fixed-rate mortgage where the loan-to-value ratio is 95 percent and PMI is purchased. These two mortgage products have the same loan-to-value ratio and hence are comparable. The first loan product does not require PMI. As can be seen, the annual payment associated with a combo loan is lower than the annual payment associated with a loan with mortgage insurance for the three mortgage rates we considered.[11] The reason the loan with PMI is more expensive is that the insurance premium is figured on the entire loan value.

Private Programs to Lower Downpayment Requirements

A number of private programs exist to reduce closing costs, which can range up to 6 percent of the selling price of the home. The primary programs are the Nehemiah Program, the AmeriDream Downpayment Assistance Program, HART Action Resource Trust, Consumer Debt Solutions, Inc., and Partners in Charity. Since all of these programs are similar, we will focus on the Nehemiah Program. This program provides gift funds for downpayment and closing costs to qualified homebuyers using an eligible loan program such

[11] We also consider the tax benefits associated with each mortgage product to see if tax considerations from the mortgage deduction play a role. We found that the mortgage interest rate deduction did not change the conclusion that the annual payment associated with the combo mortgage product is lower.

as an FHA or conventional loan that allows gifts from charitable organizations. Gift funds range from 1 percent to 6 percent of the final contract sales price, depending on the particular needs of the homebuyer. The home purchaser's monthly payment for principal, interest, taxes, and insurance cannot exceed 29 percent of income. Any home on the market can be a Nehemiah participating home as long as the seller agrees to the Nehemiah participation requirements. The seller must contribute 3 percent of the sales price of the house to the Nehemiah Corporation and pay a processing fee of $499. The benefits to the seller include access to a wider market of homebuyers and less need to negotiate the selling price. The contribution by the seller to Nehemiah may be tax deductible as a cost of the sale.

The Subprime Market

Another innovation in the mortgage market is the use of risk-based pricing to serve homebuyers who have poor credit ratings. Chomsisengphet and Pennington-Cross (2006) describe the evolution of the subprime mortgage market in which lenders make loans to households with poor credit histories. Lenders are compensated with higher mortgage interest rates—about 2 percentage points higher during the period from 1995 to 2003—higher origination fees, larger downpayments, and prepayment penalties. The use of subprime mortgages has grown rapidly since 1995 and may account for some of the increase in the homeownership rates since then.

Transaction Costs

Another possible explanation for rising homeownership rates is declining transaction costs, especially for low-income households. In early 1990 the initial fees and charges for a 30-year conventional loan were 2 percent of the loan amount. Financing this expense raised the effective mortgage rate by about 0.3 percentage points. By the summer of 2001, these charges had fallen to half a percent of the loan amount and added only about 0.06 percentage points to the effective mortgage rate. Since then, the initial fees and charges have fluctuated between 0.3 and 0.6 percent of the loan amount. The data show that these costs declined rather steadily between 1990 and 2001, so this explanation does not seem likely.[12]

CONCLUSION

In this paper, we examined the behavior of the homeownership rate—a statistic that has been a target of public policymakers. It is interesting that the previous large increase in the homeownership rate occurred after World War II and the Korean War. Then, the government guaranteed the payments of principal and interest so that returning war veterans did not have to make a downpayment. Relaxing this constraint was the only channel through which the VA program helped veterans become homeowners. After years of being relatively constant, near 64 percent, the homeownership rate began to increase again. We examine a number of explanations of this change that have been offered, including demographics, low mortgage rates, changes in housing policy, and innovations in the mortgage financial market. Of all these explanations, we find that the most plausible explanation is that innovations in the financial markets increased access to mortgage finance, mainly by reducing downpayment constraints and allowing younger people to buy homes.

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What Happens to Banks When House Prices Fall? U.S. Regional Housing Busts of the 1980s and 1990s

David C. Wheelock

The recent rapid appreciation of house prices in many U.S. markets has prompted concern over the possible effects of a sharp decline in prices, especially for commercial banks and other real estate lenders. This article examines regional real estate booms and busts in the 1980s and 1990s: Only about half of state house price booms were followed by a severe decline in prices, but large declines occurred in several states that did not have a prior boom. Banks in states that had large house price declines experienced high loan default rates and, thus, low profit and high failure rates. Although U.S. banks may have become more exposed to residential real estate recently, they appear less vulnerable to a decline in house prices than banks in states with large price declines in the earlier period. (JEL G210, R110, R310)

Federal Reserve Bank of St. Louis *Review*, September/October 2006, *88*(5), pp. 413-29.

House prices in the United States have soared over the past five years. A common measure of the trend in house prices is the repeat sales index produced by the Office of Federal Housing Enterprise Oversight (OFHEO). According to this measure, between 2001:Q1 and 2005:Q3, U.S. house prices increased by an average of 40 percent in nominal terms and 29 percent relative to the consumer price index (excluding the shelter component of the CPI). This rapid appreciation has led some analysts to forecast a correction in real house prices—possibly even a decline in nominal prices.

A decline in nominal house prices would reduce household wealth, which could restrain the growth of consumer expenditures and overall economic activity. Mortgage default rates could increase sharply if a decline in house prices were accompanied by slower growth of household income or rising interest rates. Furthermore, a decline in house prices would reduce the value of collateral behind the $8 trillion residential mortgage debt market and thereby increase the losses lenders experience on loan defaults. The popularity of nontraditional mortgage loans, such as interest-only loans and adjustable-rate loans that permit negative amortization ("option ARMS"), raises additional concern about default risk because such loans expose borrowers to more interest-rate and house-price risk than traditional fixed-rate, amortizing loans.

This article explores the implications of a substantial decline in nominal house prices by revisiting episodes of large decline in house prices that occurred in several U.S. states during the 1980s and 1990s. States that experienced large declines in residential real estate prices tended to suffer more bank distress, and longer and deeper declines in economic activity, than did other states. Several states have recently experienced increases in house prices that rival rates of appreciation experienced by states that subsequently saw marked house price declines in the 1980s and 1990s. In the aggregate, however, U.S. banks

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appear less vulnerable to a decline in house prices today than did banks located in states that experienced large declines in house prices in those earlier decades. Further, state-level data from the 1980s and 1990s show that periods of rapid house price appreciation were not frequently followed by large declines in house prices (and, by the same token, that large declines were not always preceded by large house price increases).

The next section reviews the recent rapid appreciation of U.S. house prices. Subsequent sections present information about state housing booms and busts during the 1980s and 1990s, compare the exposure of U.S. commercial banks to residential real estate during 2005 with exposure levels at the height of state housing booms in the 1980s and 1990s, and offer conclusions.

THE RECENT BOOM

Since 2000, U.S. house prices have risen rapidly relative to conventional measures of fundamentals, such as rents and household income. Rental rates, or a measure of the rental-equivalent for owner-occupied housing, represent the flow of income (or services) derived from ownership of a house. Rent is thus analogous to the dividends one receives from ownership of corporate stock. Many analysts argue that house prices and rents should grow at similar rates over the long term. Similarly, house prices are often measured against personal or household income under the presumption that the growth rates of house prices and income cannot diverge for long periods.

Three common relative measures of the growth of U.S. house prices are plotted in Figure 1: (i) the OFHEO repeat sales house price index (HPI) divided by the consumer price index (excluding the shelter component of the CPI); (ii) the HPI divided by an index of property rental rates; (iii) the HPI divided by median household income. By these measures, house prices broke above their long-run averages in 2000, rose during the 2001 recession, and continued to rise through 2005.[1]

U.S. averages fail to convey the considerable variation across markets in the extent to which house prices have risen. In general, prices have risen the most rapidly on the coasts, especially in California and southern Florida markets. Figure 2 illustrates the variation in HPI to income across selected states. Between 2000 and 2004, the standard deviation of HPI to median household income across all states nearly doubled.

Economists disagree about whether house prices have become "too high" relative to fundamentals, even in markets that have seen exceptional price appreciation. Although conventional measures suggest that U.S. house prices are overvalued in many markets, carrying costs have fallen, mainly because of a decline in long-term real interest rates.[2] Still, historically, price/income and price/rent ratios have exhibited long-run mean reversion (Gallin, 2004; Malpezzi, 1999). In this environment, many observers believe that an increase in long-term interest rates would exert considerable downward pressure on house prices, which could have substantial negative impacts on lenders and economic activity in general.[3]

HOUSING BUSTS OF THE PAST

The United States has not experienced a large, nationwide decline in nominal house prices since the Great Depression of the 1930s. Several cities and a few states have experienced large declines in recent memory, however, as have some countries.[4]

1 Because data on median household income for 2005 are not yet available, Figure 1 shows data on the ratio of HPI to household income through 2004.

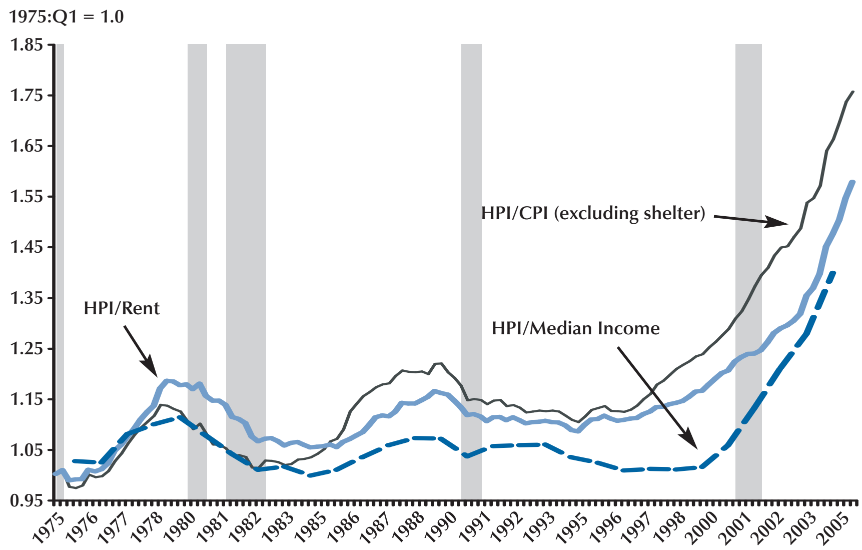
2 See Himmelberg, Mayer, and Sinai (2005) for more on the deficiencies of conventional measures and an attempt at a more accurate measurement of the fundamentals. In addition, the HPI has various shortcomings (as do alternative measures), and some alternative aggregate measures of house prices show less appreciation.

3 Case, Quigley, and Shiller (2001) estimate the effects of changes in housing market and financial market wealth on household consumption using data for U.S. states and for 14 developed countries. They find that changes in housing wealth have a much larger impact on consumption than do changes in stock market wealth. Similarly, Helbling and Terrones (2004) find that large declines in house prices have typically led to larger declines in economic activity than have large declines in equity prices.

4 Girouard et al. (2006) and the International Monetary Fund (2003) examine the recent rapid appreciation of house prices in many countries and house price cycles that have occurred since 1970.

Figure 1

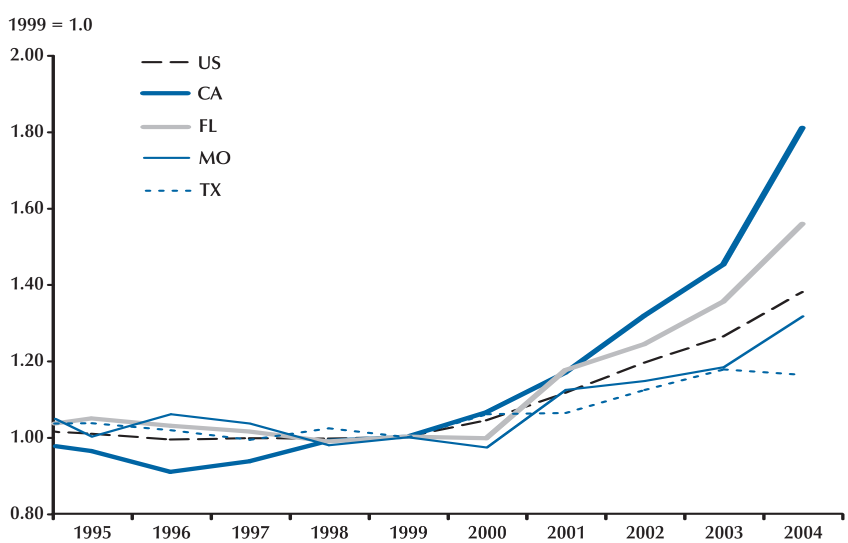
Real Price of Housing, Price/Rent, Price/Median Income, 1975:Q1-2005:Q3



NOTE: National Bureau of Economic Research–dated recessions are shaded in gray.

Figure 2

HPI/Median Household Income: U.S. and Selected States: 1995-2004



A historical perspective is necessarily restricted to the fairly recent past because comprehensive data on house prices are not available before the 1970s. Nevertheless, the past 30 years contains a rich history of housing booms and busts among U.S. states and cities. Here, I focus on large movements in house prices—measured using the state-level, repeat-sales HPI produced by the OFHEO—that occurred between 1980 and 1999.[5]

First, I sought to determine whether episodes of rapid house price appreciation ("booms") are typically followed by large declines in nominal house prices ("busts") and whether large declines are typically preceded by large appreciations. Empirically, I define a "boom" as an increase in the ratio of HPI to state per capita income (HPI/PCY) of at least 7 percent (annual rate) for three or more consecutive quarters. For the United States as a whole, HPI/PCY increased at a 6.2 percent rate during the year ending 2005:Q1 and at an average 5.4 percent annual rate during 2001:Q1–2005:Q1. Seventeen states experienced annualized HPI/PCY growth rates of at least 7 percent for three or more quarters between 2001 and 2005.[6]

U.S. states experienced 20 house price booms (i.e., annualized HPI/PCY growth of at least 7 percent for three or more quarters) between 1980 and 1999. Table 1 lists these episodes and the average annualized growth rate of HPI/PCY during each episode. For booms that were followed by a fall in nominal house prices, the table also identifies the quarter in which the HPI reached its peak and the subsequent percentage decline in the index.[7] Some booms were not followed by a decline in nominal HPI, but simply by a slowing of the rate of growth of HPI/PCY to under 7 percent. In these cases, the columns labeled "HPI Peak" and "Subsequent Decline in HPI" are not applicable ("N/A").

Of the 20 booms listed in Table 1, ten were followed within a few quarters by a decline in the nominal HPI of at least 5 percent and nine were followed by declines of more than 10 percent. The other ten booms were followed by periods of either slowly rising or flat house prices. Apparently, the adage that "what goes up, must come down," does not always apply to the housing market.

I define a "bust" as a decline in *nominal* HPI of at least 10 percent over a period of four or more quarters from an HPI peak to an HPI trough.[8] I define housing busts in terms of nominal HPI, rather than HPI/PCY or some other relative measure, because mortgage loans are contracted for nominal amounts. Thus, a decline in nominal house prices necessarily produces a decline in household wealth, which will more likely increase loan default rates than a decline in relative house prices that occurs without a decline in nominal prices.

To identify HPI peaks and troughs, I first identified all index observations that equaled the maximum or minimum values of the index within a rolling, nine-quarter window. I then eliminated all but the highest of any consecutive maximums and lowest of any consecutive minimums, to ensure that peaks and troughs alternate, and computed the percentage decline in the HPI between the remaining peaks and troughs.

Between 1980 and 1999, there were 17 instances in which a state experienced a nominal HPI decline of at least 10 percent over four or more quarters. Table 2 presents information about each bust, which I list in four groups. For each episode, the table lists the date of the HPI peak (which I define as the start of the bust) and the percentage decline in the HPI to its subsequent minimum point (which I define as the end of the bust). The table also indicates whether a bust was preceded by a boom, defined, as above, as three or more consecutive quarters of HPI/PCY growth of at least 7 percent. I also report the total number of quarters (not necessarily consecutive) in which

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5 The HPI begins in 1975, but data before about 1980 are very noisy, especially for smaller states.

6 Arguably, it would be preferable to measure house prices against household income. However, annual, state-level household income data are not available prior to 1984.

7 The nominal HPI peak usually occurred in the same quarter as the HPI/PCY peak. The percentage decline in nominal HPI is from the HPI peak quarter to the quarter in which the HPI reached its low point before a subsequent peak.

8 I impose the requirement that busts occur over at least four quarters because the HPI's for a few small states exhibit considerable volatility, especially in early years, with large declines in the index in some quarters followed immediately by large increases in the next quarter. By focusing on HPI declines lasting at least four quarters, I avoid defining such volatility as booms or busts.

Table 1

State House Price Booms, 1980-99

State	Boom period*	Average growth in HPI/PCY† (%)	HPI peak	Subsequent decline in HPI‡ (%)
AK	1981:Q2–1982:Q3, 1984:Q1	8.7	1984:Q3	43.7
AK	1990:Q3–1991:Q2, 1991:Q4	11.3	N/A§	N/A
CA	1988:Q2–1990:Q1	11.9	1990:Q3	14.4
CO	1994:Q1–1994:Q3	7.7	N/A	N/A
CT	1985:Q2–1987:Q4	12.5	1988:Q2	20.7
DE	1986:Q4–1987:Q2	7.8	1993:Q2	3.1
HI	1988:Q3–1992:Q2	11.3	1994:Q3	17.8
MA	1984:Q1–1987:Q2	11.7	1989:Q4	12.2
ME	1985:Q4–1987:Q4	7.9	1989:Q4	11.6
MI	1987:Q1–1987:Q3	8.1	N/A	N/A
MT	1983:Q4–1984:Q2	9.4	1984:Q1	13.1
MT	1994:Q1–1994:Q4	9.7	N/A	N/A
NH	1985:Q2–1987:Q2	12.0	1989:Q4	22.1
NJ	1985:Q3–1987:Q4	12.2	1988:Q3	7.8
NY	1985:Q1–1987:Q3	10.3	1989:Q4	4.7
OR	1990:Q2–1991:Q1	8.5	N/A	N/A
PA	1987:Q1–1988:Q2	8.1	N/A	N/A
RI	1985:Q4–1988:Q1	15.7	1989:Q4	14.1
UT	1993:Q3–1994:Q4	9.9	N/A	N/A
WA	1989:Q4–1990:Q4	12.5	N/A	N/A

NOTE: *Quarters in which year-over-year percentage increase in HPI/PCY exceeded 7 percent. †Average year-over-year percentage increase in HPI/PCY from first quarter in which growth exceeded 7 percent to the last quarter of HPI/PCY growth in excess of 7 percent, including any intervening quarters in which growth was below 7 percent. ‡Percentage decline in nominal HPI from the quarter in which the nominal HPI reached its peak to the quarter in which HPI reached its low value before a subsequent peak; the quarter of the nominal HPI peak was frequently the same quarter that HPI/PCY peaked. §Not applicable; these booms were not followed by a decline in nominal HPI, but simply a decline in the growth rate of HPI/PCY to less than 7 percent.

HPI/PCY grew at an annual rate of at least 7 percent during the 24 quarters before each bust.[9] Ten busts were preceded by a boom.[10] Finally, I also report data on HPI/PCY and the ratio of HPI to median household income (HPI/HY) in the quarter of the HPI peak preceding each bust.[11] For comparison, I also present recent levels of HPI/PCY and HPI/HY (2005:Q1 for HPI/PCY and 2004 for HPI/HY).

The house price busts of Iowa, Michigan, West Virginia, and Wisconsin (and to a lesser extent of other Midwestern states) occurred during the recessions of 1980 and 1981-82.[12] Both farm

[9] Most busts occurred after several quarters of stagnant house prices, rather than immediately after a period of rapidly rising prices.

[10] The case of Montana was unusual among the ten busts in that the state's nominal HPI peak occurred in the second of the three consecutive quarters of HPI/PCY growth in excess of 7 percent (1983:Q4–1984:Q2). In all other cases, the HPI peak came after the period of rapid HPI/PCY growth.

[11] State-level data on median household income are not available before 1984.

[12] Other states that experienced declines in nominal house prices at this time include Missouri (–7.9 percent), Nebraska (–5.0 percent), and Ohio (–5.4 percent). North Dakota and South Dakota also appear to have experienced large house price declines, but the HPIs for both states exhibit too much volatility to measure the size of their declines.

Table 2

State House Price Busts, 1980-99

A. Early-1980s farm and Rust Belt collapse

State	IA	MI	WI	WV
HPI peak quarter	1980:Q3	1981:Q3	1980:Q3	1981:Q2
HPI % decline	14.4	11.2	18.4	29.5
Boom before bust?	No	Yes	No	No
Quarters before bust that HPI/PCY growth exceeded 7 percent	0	4	0	0
Peak HPI/PCY	1.121	1.017	1.077	1.605
HPI/PCY 2005:Q1	0.726	0.977	0.917	0.814
Peak HPI/HY	N/A	N/A	N/A	N/A
HPI/HY 2004	0.53	0.74	0.65	0.64

B. Mid-1980s drop in energy prices

State	AK	LA	MT	OK	TX	WY
HPI peak quarter	1984:Q3	1983:Q2	1984:Q1	1983:Q4	1986:Q2	1982:Q4
HPI % decline	43.7	16.4	13.1	26.3	15.7	38.1
Boom before bust?	Yes	No	Yes	No	No	No
Quarters before bust that HPI/PCY growth exceeded 7 percent	7	2	3	1	0	3
Peak HPI/PCY	0.777	1.216	1.060	1.085	1.093	0.926
HPI/PCY 2005:Q1	0.656	0.721	1.041	0.627	0.613	0.606
Peak HPI/HY	0.46	0.61	0.59	0.56	0.56	N/A
HPI/HY 2004	0.41	0.56	0.87	0.45	0.47	0.47

and so-called "Rust Belt" states, whose incomes derive relatively heavily from older manufacturing industries, such as automobiles and steel, suffered large income declines during these two recessions. During 1980-82, Iowa, Wisconsin, West Virginia, and Michigan ranked 42nd, 44th, 45th, and 50th, respectively, among all states in real personal income growth, and 45th, 40th, 48th, and 50th in employment growth. None of the states experienced a particularly large increase in house prices before its bust. Among them, only Michigan experienced any quarters of HPI/PCY growth above 7 percent before house prices started to fall.

The second wave of state house price busts was associated with a sharp decline in energy prices. After rising rapidly during the 1970s, the price of oil peaked in mid-1980 at almost $40 per barrel. The price of oil then declined to about $30 per barrel in 1982-84, before plunging to a low of under $12 in 1986. Although real personal income grew at an average annual rate of 0.97 percent during 1985-87 for the United States as a whole, Alaska, Louisiana, Montana, Oklahoma, Texas, and Wyoming experienced far slower growth rates of –0.29 percent, –0.19 percent, 0.10 percent, –0.19 percent, 0.43 percent, and –0.61 percent.

Among the six energy-producing states that had large declines in nominal house prices, only Alaska and Montana experienced house price booms before their busts. Several of the states witnessed rapid rates of both residential and nonresidential construction, however, which some analysts argue contributed to the subsequent collapse of real estate values (Hanc, 1998).

Table 2, cont'd

State House Price Busts, 1980-99

C. New England real estate crash

State	CT	MA	ME	NH	RI
HPI peak quarter	1988:Q2	1989:Q4	1989:Q4	1989:Q4	1989:Q4
HPI % decline	20.7	12.2	11.6	22.1	14.1
Boom before bust?	Yes	Yes	Yes	Yes	Yes
Quarters before bust that HPI/PCY growth exceeded 7 percent	11	14	7	9	10
Peak HPI/PCY	1.140	1.534	1.477	1.298	1.421
HPI/PCY 2005:Q1	0.895	1.590	1.498	1.219	1.550
Peak HPI/HY	0.78	0.95	0.94	0.74	0.88
HPI/HY 2004	0.75	1.26	1.08	0.79	1.11

D. Early-to-mid 1990s defense cutbacks and Japanese financial crisis

State	CA	HI
HPI peak quarter	1990:Q3	1994:Q3
HPI % decline	14.4	17.8
Boom before bust?	Yes	Yes
Quarters before bust that HPI/PCY growth exceeded 7 percent	8	12
Peak HPI/PCY	1.072	1.155
HPI/PCY 2005:Q1	1.450	1.245
Peak HPI/HY	0.69	0.72
HPI/HY 2004	1.03	0.72

In contrast with the house price busts of the first two groups of states, which for the most part did not follow booms, all of the busts among the states in the third and fourth groups did follow booms. States that had busts in the late 1980s and early 1990s have higher population densities and generally less land available for new construction around their principal cities than states that experienced busts in the early-to-mid 1980s. These differences might explain why the states in the third and fourth groups experienced rapid house price appreciation before their declines when states in the first and second groups did not. Interestingly, most of the states in the third and fourth groups have experienced rapid growth in HPI-to-income measures since 2000; and, as of 2005:Q1, several had price-to-income ratios that equaled or exceeded the levels reached before their earlier house price busts.

New England experienced rapid growth of income and employment, and a real estate boom, during the national recovery from the 1981-82 recession and subsequent expansion. The New England economy slowed toward the end of the decade, however, when cuts in federal defense spending and increased competition in the computer industry had a disproportionately large impact on the region.[13] Among U.S. census regions, New England experienced the largest decline in real personal income during the recession of 1990-91, with an average annual growth rate of –1.02 percent, compared with an average

[13] Federal Deposit Insurance Corporation (FDIC, 1997, p. 340).

of –0.40 percent for the United States as a whole. Although forces external to New England triggered the region's real estate downturn, many analysts concluded that real estate prices had risen faster than could be justified by fundamentals during the boom, which exacerbated the subsequent collapse.[14]

California's experience was similar to that of New England. The state's economy expanded rapidly in the 1980s, but began to slow when federal defense expenditures were cut toward the end of the decade. Continued strong demand for civilian aircraft and increased NASA expenditures offset the impact of defense spending cuts for a time, as did the greater diversity of the northern California economy. Commercial and residential real estate prices plunged, however, when the recession finally took hold.[15] California experienced a larger decline in economic activity during the 1990-91 recession than did the United States as a whole, with an average real personal income growth rate of –0.67 percent, compared with the U.S. average rate of –0.40 percent.

Hawaii was the last state to experience a house price bust in the 1990s. A strong state economy and heavy buying by Japanese investors contributed to a rapid appreciation of Hawaii's real estate from the late 1980s through 1991. HPI/PCY rose at a rate in excess of 7 percent over 12 consecutive quarters between 1988 and 1991. Hawaii's boom ended when Japan's stock and real estate markets collapsed and the U.S. economy was struggling to recover from the 1990-91 recession (Ablan, 2004).

House Price Busts, Income Growth, and Banking Conditions

A systematic examination of real economic activity and banking conditions during each of the 17 large declines in nominal HPI listed in Table 2 reveals common characteristics of these events, especially about the timing of changes in economic activity and banking conditions during bust episodes. The following are some general observations:

- House price declines typically followed an economic shock, such as a decline in commodity prices, a cutback in government expenditures, etc., and frequently came after a period of rising interest rates. HPI peaks usually coincided with or followed declines in state personal income growth and other measures of general economic activity.
- House prices often continued to fall after economic activity had begun to recover.
- Banks experienced loan losses and falling net income after house prices started to decline. Bank holdings of nonperforming loans and "other real estate owned" (a measure of foreclosed property) typically rose sharply about eight quarters after an HPI peak. Most states also experienced an increase in bank and thrift failures at this time.[16]

Figures 3 through 6 illustrate these patterns for the case of Massachusetts, which is somewhat representative. Massachusetts and other New England states experienced a classic real estate boom/bust cycle and banking crisis. After increasing rapidly over the preceding six years, Massachusetts house (and other real estate) prices reached a plateau in early 1989 and peaked in the fourth quarter of that year. State personal income growth declined a few quarters before house prices peaked and became negative in the first quarter of 1989 (Figures 3 and 4). Massachusetts experienced a deeper and slightly longer decline in real personal income during the 1990-91 recession than did the United States as a whole. After falling some 12 percent, nominal house prices reached a low point in 1992:Q2, two quarters after real personal income had begun to rise.

Massachusetts banks experienced heavy losses and numerous failures as a result of real estate loan defaults, and the aggregate return on equity (ROE) of the state's banks was below the national average for six quarters beginning in 1989:Q4

[14] See FDIC (1997, Chap. 10) and references therein.

[15] California's experience is described in FDIC (1997, Chap. 11).

[16] Thrift institutions include savings and loan associations, savings banks, and similar depository institutions. Data on bank and thrift failures are available on the website of the Federal Deposit Insurance Corporation: www.fdic.gov.

Figure 3

Massachusetts Housing Bust and Real Personal Income Growth (year-over-year)

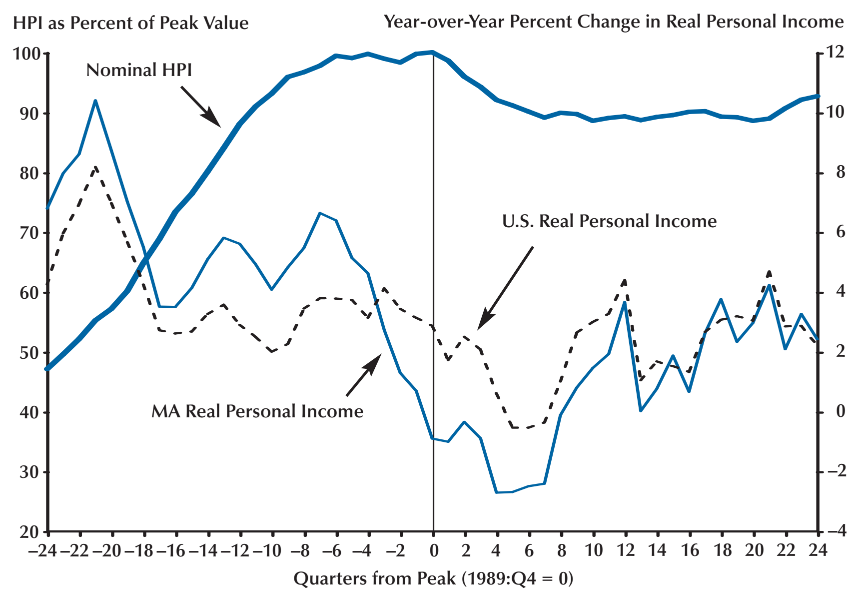


Figure 4

Massachusetts Housing Bust and Real Personal Income Growth (annualized percent change)

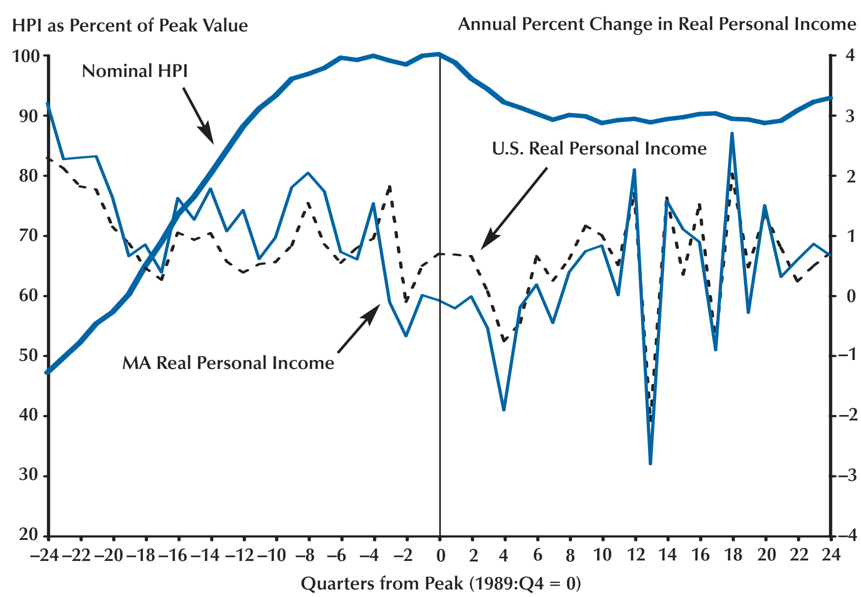


Figure 5

Massachusetts Housing Bust and Bank Return on Equity

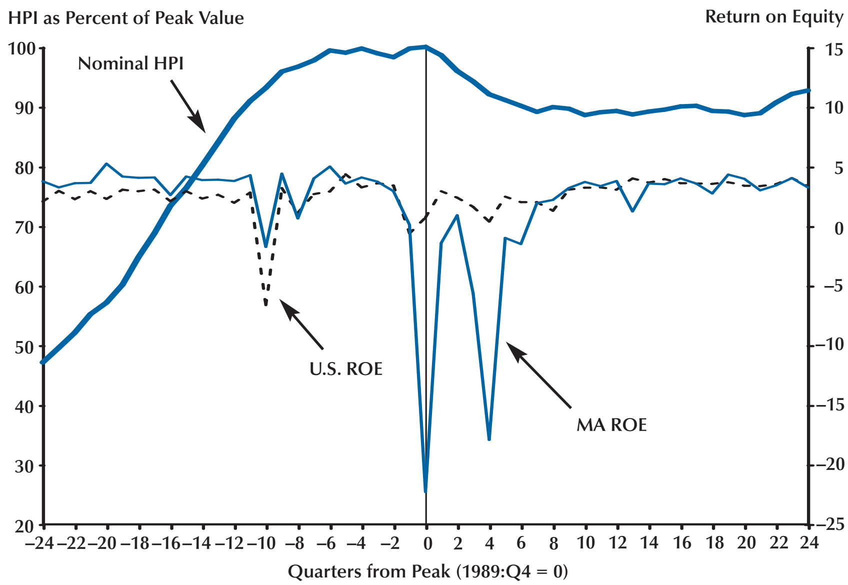
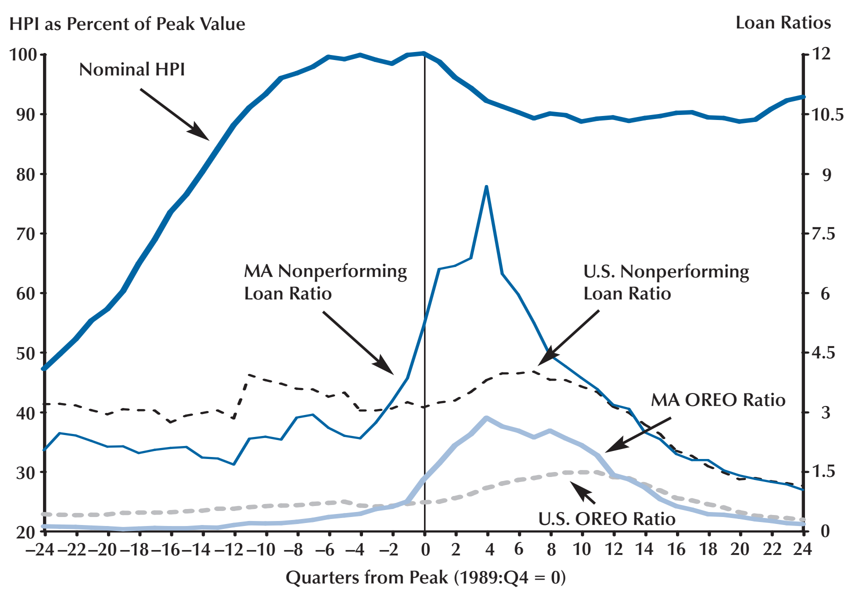


Figure 6

Massachusetts Housing Bust and Bank Loan Performance



(Figure 5). Typical of banks in other states with sharp declines in real estate prices, Massachusetts banks experienced a large increase in nonperforming loans and other real estate owned (OREO, which reflects foreclosures) as a percentage of total assets, peaking four quarters after house prices had begun to decline (Figure 6). Massachusetts experienced a surge in bank failures. Although just one Massachusetts bank failed in 1989, seven failed in 1990, 14 failed in 1991, and 16 failed in 1992. These 38 failures represented 37 percent of the total number of Massachusetts banks in operation at the end of 1988.[17]

The patterns illustrated in Figures 3 through 6 do not, of course, indicate whether the decline in house prices contributed to the decline in real personal income. Loan losses eroded bank capital and impaired the ability of financial institutions to extend credit, however, suggesting that a "capital crunch" may have contributed to the decline in economic activity.[18] Indeed, then-Federal Reserve Chairman Alan Greenspan (2004) blamed "financial headwinds" associated with the weak capital positions of U.S. banks for the unusually slow recovery of the U.S. economy from the recession of 1990-91.

ARE FINANCIAL INSTITUTIONS CURRENTLY VULNERABLE TO A HOUSE PRICE COLLAPSE?

Various measures suggest that U.S. banks have become increasingly exposed to residential real estate since 2000.[19] Two measures are plotted in Figures 7 and 8. The first plots quarterly observations on the stock of bank loans on 1- to 4-family residential property plus the market value of bank holdings of mortgage-backed securities (excluding those issued or guaranteed by a U.S. government agency or enterprise), all divided by total U.S. commercial bank assets. The second plots the stock of untapped home equity lines at banks divided by total bank assets. Both figures show that as a percentage of total assets, banks' exposure to residential real estate increased substantially over the five years ending in 2005:Q1.[20]

These simple exposure measures indicate little, however, about whether banks have become more vulnerable to a decline in house prices. Without information about the risks of specific assets held by banks, one cannot determine definitively how vulnerable banks are to a decline in house prices. However, alongside the large increase in the size of bank residential real estate portfolios has been a substantial increase in bank equity-capital relative to total bank assets. The greater a bank's capital, the larger the amount of loan defaults and other declines in asset value it can withstand before becoming insolvent. Because capital serves as a cushion against loan and security losses, the increase in real estate loans and securities as a share of bank assets is probably less worrisome than it otherwise would have been.

Of course, banks might have increased their capital in recent years to compensate for increased risks in their real estate loan portfolios or other assets. Still, banks in general have a larger cushion against possible losses now than they did at the end of the 1990s. Between 1999:Q1 and 2005:Q1, capital increased from 8.5 percent of total bank assets to 9.9 percent of total assets, as illustrated in Figure 9. Hence, banks' exposure to residential real estate as a fraction of total capital, which is illustrated in Figure 10, increased much less dramatically than did exposure as a fraction

[17] Massachusetts also had 28 unassisted bank mergers between 1989 and 1992, and the number of banks in the state declined from 103 at the end of 1988 to 61 at the end of 1992 (FDIC web site: www2.fdic.gov/hsob/hsobRpt.asp).

[18] Peek and Rosengren (1992) present evidence of a capital crunch (i.e., a reduction in the supply of loans associated with impaired capital) among New England banks.

[19] Of course, many other financial intermediaries are involved in the mortgage market, including thrifts, private mortgage insurers, and government-sponsored enterprises, such as Fannie Mae and Freddie Mac. I focus here on commercial banks because they are more central to the monetary transmission mechanism and payments system and because comparable historical data on other intermediaries are less complete.

[20] Broader measures that include all residential real estate bank loans show similar trends. The stock of bank loans on 1- to 4-family residential property plus the market value of bank holdings of mortgage-backed securities (excluding those issued or guaranteed by a U.S. government agency or enterprise) is computed as the sum of the following items from the reports of income and condition (call reports) that banks file quarterly with federal banking authorities: RCON1430, RCFD0409, RCFD1710, RCFD1713, RCFD1734, and RCFD1736. Total bank assets is call report item number RCFD1710. Untapped home equity lines of credit is item number RCFD3814.

Figure 7

Residential Real Estate Exposure/Assets, U.S. Bank Average, 1994:Q1-2005:Q1

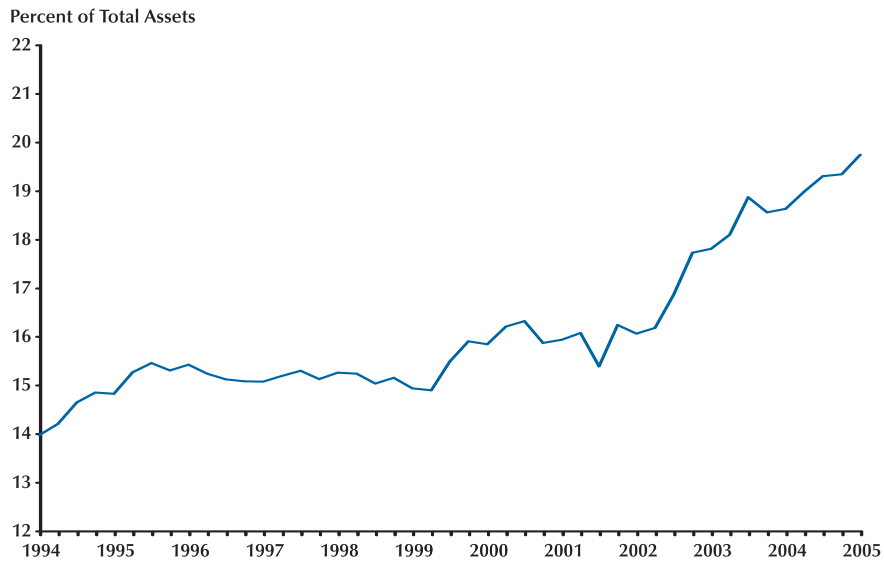


Figure 8

Home Equity Lines Not Drawn, U.S. Bank Average, 1994:Q1-2005:Q1

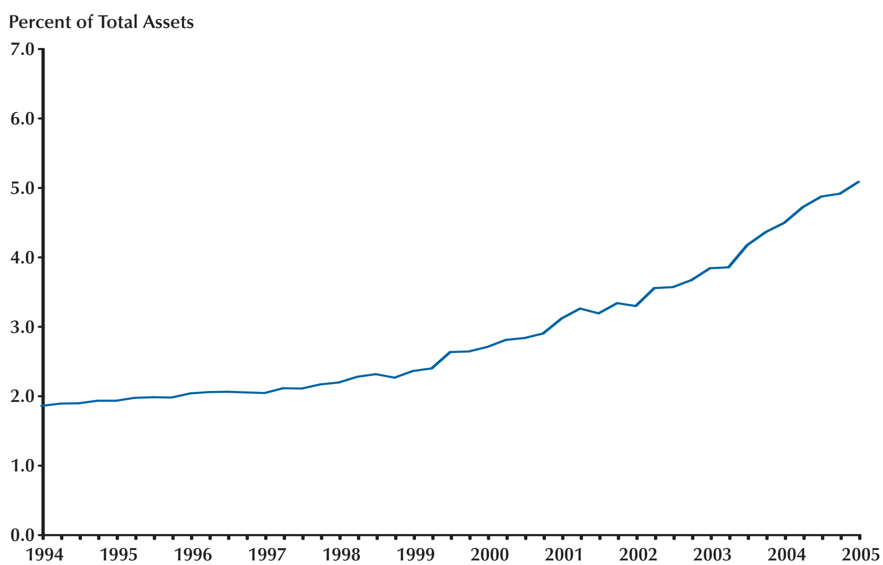


Figure 9

Capital/Assets, U.S. Bank Average, 1980:Q1-2005:Q1

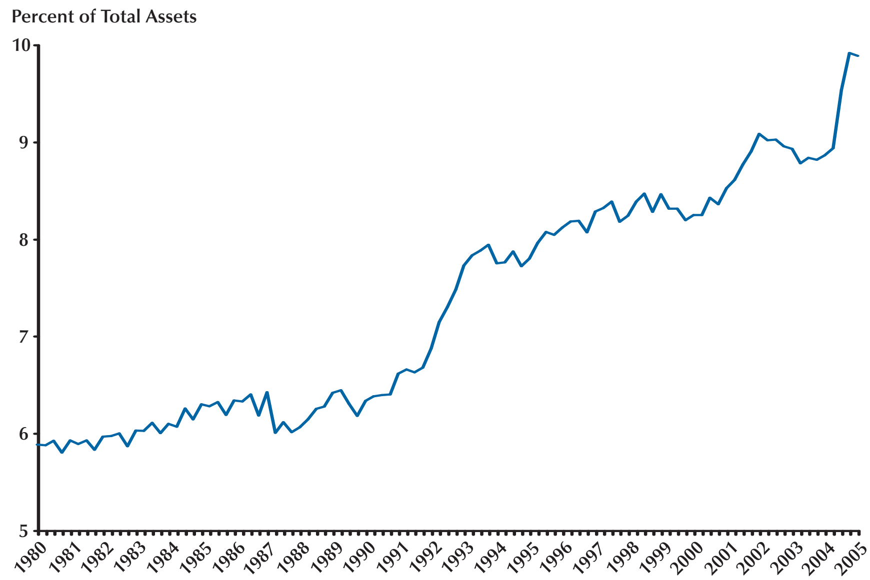


Figure 10

Residential Real Estate Exposure/Capital, U.S. Bank Average, 1994:Q1-2005:Q1

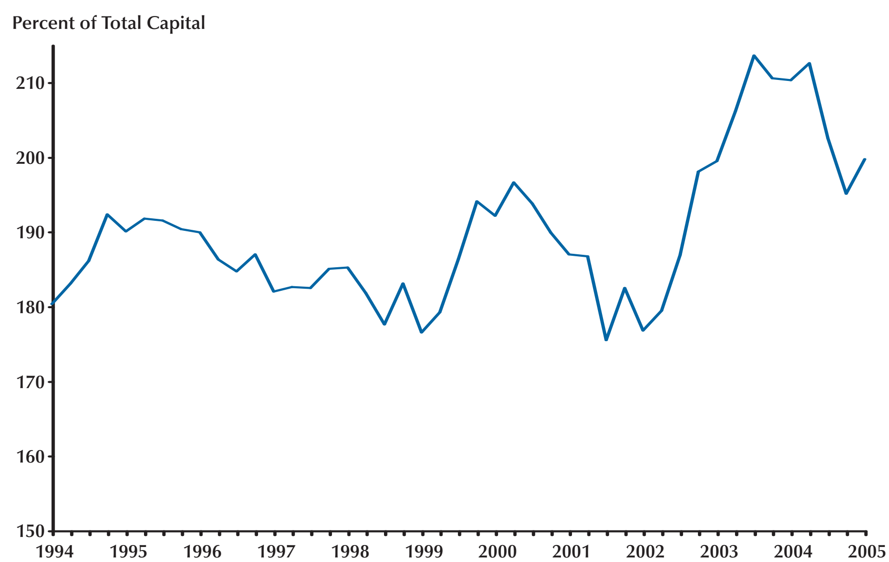
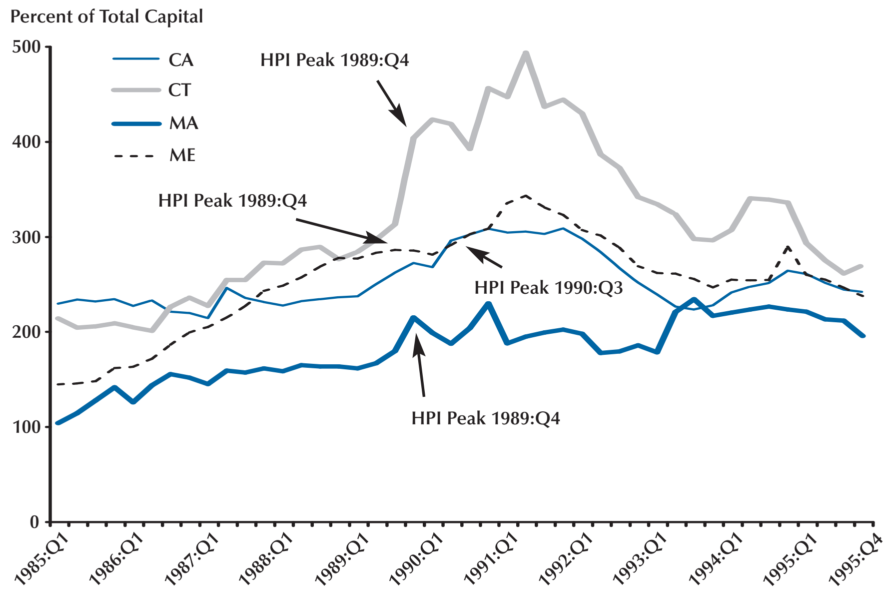


Figure 11

Residential Real Estate Exposure/Capital, Selected States, 1985:Q1-1995:Q4



of total bank assets. As of 2005:Q1, U.S. banks held about $2 of 1- to 4-family residential real estate loans and non-government-issued or non-government-guaranteed mortgage-backed securities for every $1 of capital, roughly 8 percent more than in the late 1990s.

The U.S. banking industry today is considerably better capitalized than it was in the 1980s and early 1990s. Interstate branching, which has been permitted only since 1997, makes cross-state comparisons of bank exposure to real estate (as well as other measures of bank condition) less meaningful today than in the late 1980s and early 1990s.[21] As a whole, however, U.S. banks currently are less exposed to residential real estate than were banks located in most states that had large house price declines in the late 1980s and early 1990s.

Figure 11 plots residential real estate exposure as a percentage of bank capital from 1985:Q1 to 1995:Q4 for banks located in four states that suffered a large decline in house prices in the early 1990s. The quarter in which the HPI attained its peak in each state is marked on the figure. In 2005:Q1, U.S. commercial bank holdings of 1- to 4-family residential real estate loans and non-government-issued or non-government-guaranteed mortgage-backed securities totaled 200 percent of aggregate bank capital. Massachusetts banks had a comparable level of residential real estate exposure, at 214 percent of capital, when the state HPI peak was reached in 1989:Q4. Massachusetts banks were, however, considerably more exposed to nonresidential real estate in 1989 than U.S. banks were in 2005. For example, the total real estate loans of Massachusetts banks in 1989:Q4 equaled 551 percent of bank capital, whereas the total real estate loans of U.S. banks as a whole in 2005:Q1 equaled 308 percent of bank capital.

The other three states for which data are shown in Figure 11 all had considerably greater exposure to residential real estate at their HPI peaks than did U.S. banks in 2005:Q1. Banks of most other northeastern states that experienced

[21] The Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994 permitted interstate branch banking as of 1997.

Table 3

Commercial Bank Residential Real Estate Exposure by Asset Quartile, 2005:Q1

Quartile*	Exposure/assets†	HELC/assets‡	Capital/assets§	Exposure/capital¶
1	0.15	0.01	0.13	1.14
2	0.17	0.01	0.11	1.62
3	0.18	0.02	0.10	1.82
4	0.20	0.05	0.10	2.02

NOTE: *Quartiles 1 through 4 consist, respectively, of banks with less than $53 million, $53 to $106 million, $106 to $238 million, and more than $238 million of assets. †The stock of loans on 1- to 4-family residential property plus the market value of bank holdings of mortgage-backed securities (excluding those issued or guaranteed by a U.S. government agency or enterprise), all divided by total assets for all banks in the given quartile. ‡The stock of untapped home equity lines of credit divided by total assets for all banks in the given quartile. §The ratio of tier-1 equity-capital to assets for all banks in the given quartile. ¶The stock of loans on 1- to 4-family residential property plus the market value of bank holdings of mortgage-backed securities (excluding those issued or guaranteed by a U.S. government agency or enterprise), all divided by total equity-capital for all banks in the given quartile.

large declines in house prices in the early 1990s had similarly high exposure levels.[22] Thus, U.S. banks today are, on the whole, less exposed to residential real estate than were banks located in states that experienced large declines in residential real estate prices in the early 1990s. This suggests that a decline in house prices today of a size comparable to those experienced by New England states or California in the early 1990s would have less impact on the U.S. banking system than it did on New England banks in the early 1990s.

Aggregate exposure measures do not, of course, reveal the extent of variation across banks. In general, large banks tend to have more exposure to residential real estate, and also hold less capital as a percentage of total assets, than small banks. Table 3 presents data for 2005:Q1 on residential real estate exposure and capital-to-asset ratios for banks in each asset-size quartile. Residential real estate exposure is lowest and the aggregate capital-to-asset ratio is highest for banks in quartile 1, which comprises the smallest 25 percent of U.S. banks in terms of total assets. Across successive quartiles, exposure rises and capital-to-assets ratios fall.[23]

On the surface, the negative association between residential real estate exposure and capital-to-assets ratios across quartiles might suggest that larger banks are generally more vulnerable to a decline in residential real estate prices than small banks. Without information about the specific loans and securities that comprise a bank's portfolio, however, one cannot judge how vulnerable a given bank is to a decline in house prices. For example, a bank with a geographically diversified real estate loan portfolio would be less vulnerable to a localized decline in real estate prices than a bank with a less diversified portfolio. Thus, if larger banks are better able to diversify their portfolios than small banks, they could maintain higher ratios of real estate loans to capital without necessarily being more vulnerable to a decline in real estate prices. Similarly, if larger banks are more adept at hedging portfolio risk through the use of derivative securities or other means, they could operate with lower capital-to-asset ratios than smaller banks without being any more vulnerable to a decline in real estate markets.

22 Among states that had large house price declines, ratios of 1- to 4-family residential property loans plus non-government-issued or non-government-guaranteed mortgage-backed securities to total bank capital were as follows (HPI peak quarter): CA, 3.01 (1990:Q3), CT, 4.03 (1989:Q4), MA, 2.14 (1989:Q4), ME, 3.07 (1989:Q4), NH, 3.18 (1989:Q4), NJ, 2.68 (1988:Q3), RI, 1.71 (1989:Q4). As of 2005:Q1, the ratio for U.S. banks was 2.00.

23 Quartiles 1 through 4 consist, respectively, of banks with total assets of less than $53 million, between $53 million and $106 million, between $106 million and $238 million, and more than $238 million.

CONCLUSION

The rapid increase in U.S. house prices since 2000 has prompted concerns about the possible effects of a sharp decline in house prices on financial institutions and macroeconomic activity. Evidence from other countries suggests that declining house prices, especially when preceded by a period of rapid house price appreciation, can have a marked contractionary impact on macroeconomic activity. This article looks to the experiences of U.S. states for evidence about house price booms and busts. This review finds that house price booms have not always led to busts and that busts do not always follow booms. Sharp declines in nominal house prices in farm and manufacturing states in the early 1980s, and in energy-producing states in the mid-1980s, were not generally preceded by periods of rapid house price appreciation. The large declines in house prices experienced in New England states, California, and Hawaii in the late 1980s and early 1990s, however, were preceded by extended periods of rapid growth in house prices relative to personal income.

Banking conditions deteriorated markedly in all states that experienced a large decline in nominal house prices during the 1980s or 1990s. Within a few quarters of the start of a decline, banks experienced increased loan defaults and falling income. Several states that had large declines in real estate prices also witnessed increases in bank failures, as well as more severe declines in economic activity than did the United States as a whole. Additional research is required, however, to determine whether either the decline in real estate prices or the deterioration of banking conditions caused state income growth to lag the national average.

U.S. banks, as a whole, have become increasingly exposed to residential real estate since 2000, as reflected in increases in their holding of real estate loans and securities and in the amount of available home equity lines of credit as a percentage of total bank assets. Bank capital has also increased, however, which makes the increase in residential real estate exposure less worrisome than it would otherwise be. Further, a portion of the residential real estate loans and securities held by banks are guaranteed by third parties, and many banks purchase only highly rated securities that have little credit risk.[24]

Although they have become more exposed to residential real estate since 2000, U.S. banks as a whole appear considerably less vulnerable to a decline in residential real estate prices than were banks located in states that experienced large house price declines in the late 1980s and early 1990s. Further, the proliferation of interstate branching that has occurred since 1997 suggests that, today, banks in general are probably less vulnerable to local real estate shocks than in the late 1980s and early 1990s.

In sum, U.S. banks seem well positioned to withstand a modest decline in house prices, especially a localized decline. Still, empirical evidence from the United States and other countries indicates that declines in housing wealth can have severe macroeconomic repercussions, especially if banking system capital does become impaired.

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[24] Lenders typically purchase insurance against default for mortgages that exceed 80 percent of a home's value from the Federal Housing Administration (FHA), Department of Veterans Affairs (VA), or one of several private mortgage insurance companies. Private mortgage insurance companies as a whole are profitable and have experienced an increase in capital per dollar of assets insured since the mid-1990s, suggesting that they could withstand an increase in claims associated with some decline in the housing market and increase in defaults. See Mortgage Insurance Companies of America (2005).

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Do Inflation Targeters Outperform Non-targeters?

Michael J. Dueker and Andreas M. Fischer

Ten years of empirical studies of inflation targeting have not uncovered clear evidence that monetary policy that incorporates formal targets imparts better inflation performance. The authors survey the literature and find that the "no difference" verdict concerning inflation targeting has been robust to a wide range of countries and methods of analysis, starting with a study by Dueker and Fischer (1996a). The authors present updated Markov-switching estimates from the original Dueker and Fischer (1996a) article and show that their early conclusions about inflation targeting among early adopters have not been overturned with an additional decade of data. These findings to date do not rule out the possibility, however, that formal inflation targets could prove pivotal if the global environment of disinflation were to reverse course. (JEL E52, E42, E61)

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Since its inception in the early 1990s, inflation targeting has unleashed considerable debate on the merits of the new policy framework. Its introduction has raised numerous issues: the difficulty of evaluating central bank performance in achieving the target, the effect of inflation targeting on inflation expectations, the choice of inflation indicators, links with exchange rate policy, and the interaction between the central bank and the central government. Analysis of these issues was valuable not only to decisionmakers and analysts in the countries where inflation targets were already in use, but also to those countries contemplating such a policy. Revisiting the perceived merits of inflation targeting is especially timely now that Ben Bernanke, who has a clear academic record in favor of a quantitative inflation objective, is the Chairman of the Board of Governors of the Federal Reserve System.

Contributions to the policy debate concerning inflation targeting have come in the form of theoretical analysis and empirical evidence. This note updates the empirical evidence from an early study on inflation targeting by Dueker and Fischer (1996a) (denoted as D-F hereafter) that sought to provide an answer to the question: Do inflation targets impart an aversion to inflation and inflation variability among inflation-targeting countries above and beyond that displayed by non-inflation-targeting countries? D-F examined this question by matching three early adopters of inflation targets—New Zealand (which adopted an inflation target in 1990), Canada (1991), and the United Kingdom (1992)—with three neighboring countries that did not have formal inflation targets in the early 1990s—Australia, the United States, and Germany, respectively. All three inflation targeters achieved their announced targets ahead of schedule, perhaps in part because the 1990s saw a marked disinflation throughout the industrialized world.

Numerous studies have re-examined the empirical effects of inflation targeting. Many subsequent studies have followed the formula laid out in D-F: Match each inflation-targeting

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country with a neighboring non-inflation-targeting country and look for differences in their respective inflation outcomes. Despite permutations of the empirical technique, the introduction of real factors, longer historical time series, and a greater number of countries to study, the initial finding has not been overturned. In fact, we show that the basic findings from D-F regarding the timing of the downward shifts in the policy-implied baseline rate of inflation are quite robust to an extension of the sample from 1995 to 2005. For this reason, we argue that, although inflation targeting enjoys considerable academic sympathy and the endorsement of many international organizations, there remains little empirical evidence that an inflation-targeting regime performs better than a non-inflation-targeting regime in the same circumstances.

SOME PROBLEMS WITH COMPARING TARGETERS WITH NON-TARGETERS

Before reviewing the subsequent literature, it is important to understand some of the limitations of the empirical literature that tries to document the macroeconomic effects of inflation targeting. One issue is that, even if a central bank is recognized as an inflation targeter, the dating of the new policy regime is often contentious. The fact that the adoption date is arguable says something indirectly about the clarity of a central bank's program. For example, Bernanke et al. (1999) and Ball and Sheridan (2004) set Australia's adoption date at 1994:Q1, whereas Rasche and Williams (2005) document an earlier Reserve Bank of Australia announcement from June 1993.[1] Similarly, Sweden and South Africa have presumptive adoption dates that differ from the date of the first announced inflation target. Does this mean that some inflation targeters were targeting inflation up to two years before the announcement of official targets? Getting the date right is important because many studies are interested in the effect that the announcement of inflation targeting has on financial markets and inflation expectations. If an announcement of an inflation program is credible, the strongest evidence of its effect on expectations and financial market variables will be in the first months after the declaration. Apart from Vega and Winkelried (2005), there is little work on the robustness of findings to alternative adoption dates. Some studies, such as Ball and Sheridan (2004), Hyvonen (2004), Batini and Laxton (2005), and Levin, Natalucci, and Piger (2004), assume a uniform adoption date across countries.

An issue that the D-F study raises that still has not been resolved in the discussion of central bank preferences and inflation targets is endogeneity. Numerous studies argue that inflation targets are a commitment device and the establishment of a target accounts for the observed change in the central bank's policy rule. An alternative interpretation is that central bankers, regardless of whether they are inflation targeters or not, have grown to take inflation much more seriously today than in the past and that the announcement of an inflation target simply affirms this evolution. The endogeneity criticism was first mentioned by Alders et al. (1996) and repeated later by Uhlig (2004) and Gertler (2005) in published commentaries.

An inherent weakness of the side-by-side comparisons of inflation targeters and non-inflation targeters is that conclusions are based on point estimates. No study provides confidence bands to test whether one central bank moved significantly sooner or reduced inflation significantly more than another. Against this background, quantifying the success of inflation targeting using a scorecard approach based on low mean inflation, low inflation variability, and low inflation persistence becomes more difficult when the empirical sample coincides with a global disinflation. Attempts to remove common trends and common cycles between targeters and non-targeters are not undertaken.[2] What arises is a beauty contest,

[1] Siklos (1999) sets the date at January 1993 and Johnson (2003) at March 1993. See also footnote 9 of Almeida and Goodhart (1998).

[2] An exception is Lee (1999). He uses a data decomposition procedure, which involves cointegration and canonical correlation analysis, to remove common trend and cyclical components from the data used in D-F.

where the performance measures are interpreted subjectively. One issue concerns the use of a control group of non-inflation targeters. Studies by D-F and Groeneveld, Koedijk, and Kool (1998) use neighboring countries in their bilateral framework to control for regional shocks. Almeida and Goodhart (1998), Nadal-DeSimone (2001), Siklos (1999), and Rasche and Williams (2005) instead focus on successful non-inflation targeters (i.e., the Federal Reserve, Bundesbank, or the Swiss National Bank) in their comparisons. More recent studies by Cecchetti and Ehrmann (2002) and Vega and Winkelried (2005) expand the set of non-inflation targeters but at the expense of lowering the performance requirement of the non-inflation targeters.

A further problem in interpreting the results lies in the classifications of the inflation targeters. There is little dispute that the initial targeters such as New Zealand, Canada, Sweden, and the United Kingdom qualify as inflation targeters. The inclusion, however, of de facto and not only de jure inflation targeters raises questions. Finland, Greece, and Spain are cases in point. It is unclear how the Exchange Rate Mechanism and other considerations related to their entry to the European Monetary Union allowed their central banks to act as independent inflation targeters. In some cases, it is not clear whether a country, such as Switzerland, is a de facto inflation targeter. The Swiss National Bank—a self-declared non-targeter—appears in many studies as a de facto inflation targeter after 2000, yet the European Central Bank (ECB) does not. Although both of these central banks produce inflation forecasts and operate with the same definition of price stability, the ECB is not classified as an inflation targeter because of its twin-pillar strategy, which targets the stock of money and the inflation rate.[3]

The comparative literature on inflation targeting has been extended to emerging markets. This evidence tends to be more favorable than for industrialized countries. The merits of inflation targeting in emerging countries are not easily compared with those in industrialized countries. Mishkin (2004) highlights issues of preconditions, a later adoption date, and the frequent use of a declared exchange rate objective. For these reasons the studies focusing on emerging markets are not discussed here. Contributions in this area include Batini and Laxton (2005), Fraga, Goldfajn, and Minella (2004), the International Monetary Fund (2005), Dueker and Fischer (2001), and Jonas and Mishkin (2005).

TARGETERS VERSUS NON-TARGETERS: THE EMPIRICAL EVIDENCE

Empirical studies on the merits of inflation targeting document evidence from survey data, output volatility, inflation persistence, and changes in central bank reaction functions. We summarize this evidence below. What emerges is a mixed picture at best. Although different measures register an improvement in inflation performance in the targeting countries, it is difficult to find evidence that shows inflation-targeting regimes perform better than neighboring non-inflation-targeting regimes.

Survey Expectations

In evaluating inflation targeters, a highly relevant consideration is whether the expectations of market participants concerning inflation rates have fallen together with recent actual rates. Survey expectations have been used frequently as a proxy for inflation expectations.[4] Laidler and Robson (1993) and three different studies in a volume edited by Leiderman and Svensson (1995)—Fischer (1995), Svensson (1995), and Bowen (1995)—found that survey measures of expected inflation still lagged actual inflation in Canada, New Zealand, Sweden, and the United Kingdom after the introduction of inflation targets. Bernanke et al. (1999) compare actual inflation with average survey predictions of inflation made

[3] See Batini and Laxton (2005) and the International Monetary Fund (2005) for a discussion on this issue.

[4] Other studies such as Groenevald et al. (1998) focus on interest rate and inflation forecasts before and after the introduction of inflation targets. Their results for the same six countries used in D-F suggest that inflation targets have not enhanced the credibility of the targeters.

6 months, 12 months, and 18 months earlier. They find for New Zealand, Canada, the United Kingdom, and Sweden that the adjustment was for the most part gradual. Johnson (2003) extends the analysis to include Australia and conditions on the announcement of inflation targets. He finds that in Australia and Canada inflation targets reduced expected inflation slowly; in New Zealand and Sweden there was an immediate drop; in the United Kingdom no effect is seen.

Survey evidence has been criticized by McCallum (1998) and others in that they exhibit various weaknesses including non-homogeneity across countries and time as well as the inherently dubious nature of unofficial survey data. Johnson (2002) addresses these concerns by pooling a panel of five targeting countries with six non-targeting countries. His unified framework works with a homogenous survey, is able to control for measurement problems, and offers a direct test between targeters and non-targeters. He finds that neither the variability of expected inflation nor the average absolute forecast error falls after the announcement of targets when one controls for the level and variability of past inflation.

Output Volatility

Cecchetti and Ehrmann (2002) ask whether inflation targeting increases output volatility; they seek to measure the impact of inflation targeting on output and inflation for a set of 23 countries, including 9 that target inflation explicitly. The hypothesis is that aggregate shocks that move output and inflation in opposite directions create a trade-off between output and inflation variability.[5] Assuming that the central bank's objective can be written as a simple quadratic loss function, Cecchetti and Ehrmann (2002) estimate the realized output and inflation patterns of 23 industrial and developing economies to infer the degree of policymakers' inflation variability aversion. Their evidence allows them to conclude that both inflation-targeting and non-inflation-targeting European countries increased their revealed aversions to inflation variability during the pre-European Monetary Union period and experienced accompanying increases in output variability.

Inflation Persistence

It is well known that inflation dynamics are heavily influenced by regime changes in monetary policy. A frequently noted example is that the level of inflation persistence was lower during the gold standard. When considering whether inflation targeting represents a fundamental change in monetary policy, a question arises: Did inflation targeting reduce the level of persistence in inflation? The evidence finds that there is a significant drop in inflation persistence across countries in the 1990s. Once again, however, the importance of inflation targets as a determinant of inflation persistence is mixed when one compares the records of targeters and non-targeters.

Although D-F do not focus explicitly on inflation persistence in their study, the estimates of the transition probabilities of the two-state Markov process for the baseline inflation path (i.e., implicit inflation target) allow one to make inferences about inflation's persistence. Their results show that for both targeters and non-targeters there is a high level of persistence in the low- and high-inflation state. The estimates of the transition probabilities are above 0.95 in most countries, and no evidence of a difference in behavior between the two sets of countries is apparent. This evidence from the transition probabilities lends further support to the claim in D-F that there is no substantive difference between targeters and non-targeters.

Univariate regressions of inflation are another way to test for the impact of inflation targeting on inflation persistence. Siklos (1999) provides point estimates from an AR(1) model for samples that roll at two-year intervals since 1968. His evidence shows that persistence has been lowest for the United States and that the drop in persistence in the targeting countries follows that of the United States. Pétursson (2004) and Vega and Winkelried (2005) use an expanded set of targeters and confirm Siklos's (1999) inconclusive findings based on persistence measures.

5 Several studies focus on sacrifice ratios. Again the record is mixed. Almeida and Goodhart (1998) show that the sacrifice ratios increased in the 1990s for the inflation targeters, whereas Corbo et al. (2002) find that the average sacrifice ratio for targeters was lower than for non-targeters in the 1990s.

An alternative approach to measure whether inflation persistence has fallen is to compute impulse responses. Ball and Sheridan (2004) compute impulse responses showing the effects of inflation shocks on future inflation. The results for CPI inflation show that inflation persistence has decreased over time. The estimates by Ball and Sheridan (2004) find that in the pre-targeting periods, a unit inflation shock in quarter t raises inflation at $t+1$ by more than 0.4 percentage points and this effect dissipates slowly. For the targeting period, the effect is around 0.2 at $t+1$ and disappears in three quarters. Because this pattern holds for both control groups, this result is interpreted as evidence that targeting does not much affect inflation behavior.

"NO DIFFERENCE" THROUGH A DECADE OF STUDIES

A common explanation for the "no difference" result is that inflation targeting represents a convergence to best practices in the conduct of monetary policy. Bernanke et al. (1999) and Mishkin (2002) suggest that the successful non-inflation targeters' strategies for conducting monetary policy have many of the same characteristics as those pursued by inflation targeters.[6] Both groups focus on the long-run goal of price stability and stress transparency, accountability, and flexibility—the key elements of inflation-targeting regimes. In a nutshell, inflation targeting is best regarded as a framework for the conduct of monetary policy and not as a monetary policy rule. Such an interpretation allays the criticism that econometric estimates ought to find something unique about the policy rules of inflation targeters.

The "no difference" verdict also needs to be qualified in two ways. First, no empirical study provides an argument against inflation targeting or shows that it is harmful. Ball and Sheridan (2004) suggest that inflation targeting may be desirable for political rather than economic reasons.[7] These benefits are not easily measured. Second, inflation targeting may improve economic performance in the future. The economic environment has been quiet during the past decade, and thus the true test awaits. No one really knows what would happen to small inflation-targeting countries if inflation were to reawaken in one of the big three (i.e., the United States, the euro area, or Japan).

UPDATED RESULTS FOR THREE COUNTRY PAIRS FROM DUEKER AND FISCHER

D-F[8] looked for evidence of a significant change in a central bank's reaction function after the introduction of inflation targeting as evidence of an increase in the bank's aversion to inflation. Here we present updated estimates from their empirical model to check whether the conclusions, which were based on short spans of inflation targeting, would have differed from a retrospective vantage point. D-F used a monetary policy reaction function that targets inflation in an open economy while allowing for occasional feedback from the gap between the exchange rate and its implicit target. (See McCallum, 1987.) Note that this is a model of inflation targeting and not exchange rate pegging, however. The feedback from the exchange rate is analogous to a monetary response to an output gap. Like the output gap, the exchange rate gap is specified such that it will close eventually regardless of monetary policy. Any monetary policy response to the exchange rate is intended only to attenuate the gap and its consequences. The true nominal target is the inflation rate. We also present results for the case where

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6 Bernanke et al. (1999) emphasize the role of transparency and its consistency with the principles of a democratic society.

7 Ball and Sheridan (2004) argue that it is an open question whether the improvement in the inflation performance of inflation targeting countries in the 1990s is largely a function of monetary policy or of "regression to the mean," but lean toward the latter view. Hyvonen (2004) shows historical and regional evidence that is inconsistent with the "regression to the mean" view.

8 The original paper by Dueker and Fischer (1996a) was first presented in a CEPR workshop titled "Inflation Targets" held in Milan in November 1994 and later at a conference titled "Monetary Policy in a Converging Europe" organized by the De Nederlandsche Bank NV and the Limburg Institute of Financial Economics of the University of Limburg in February 1995. The papers and proceedings of the latter conference were published the following year by Kluwer Academic Publishers.

monetary policy is assumed not to respond to the exchange rate at all, and the conclusions about the shifts in trend inflation are quite robust to this alternative specification.

Neumann and von Hagen (2002) and Corbo, Landerretche, and Schmidt-Hebbel (2002) perform a similar cross-country comparison using a Taylor rule. Both studies show that the weight on the inflation gap increases after inflation targeting was introduced. As mentioned in Mishkin (2002), however, the evidence also says that the central banks are not doing their job because the long-run inflation coefficient remains less than unity. Mishkin (2002) concludes that the Taylor rule estimates do not allow one to conclude that inflation-targeting countries have improved monetary policy enough to achieve price stability. We choose to use an inflation-targeting model where, if the forecasted relation between the interest rate instrument and inflation holds, then inflation will be at its target level every period. In a Taylor rule, in contrast, the inflation target is only a long-run target. To show that the target is not binding in the short run, we note that in his original study Taylor (1993) fit the interest rate well between 1987 and 1993 using a 2 percent long-run inflation target, even though the average rate of consumer price inflation was actually twice as high—4.0 percent—during the same period. Thus, a Taylor rule lacks a timetable for reaching the target, a feature that is important to inflation targeting in practice.

DESCRIPTION OF THE EMPIRICAL MODEL

The central bank reaction function we estimate is closely related to a Taylor rule, but it has a concrete objective to achieve a (time-varying) target rate of inflation in the next period. The time-varying inflation target recognizes that it is not realistic to expect that the inflation rate will jump to a long-run desired level below 2 percent next period if it recently has been running at more than 4 percent. Our reaction function is an instrument-target relationship (ITR) rule that takes a near-term target or "baseline" inflation rate and uses a minimum-mean-squared-error (MMSE) forecast of the relationship between the policy instrument and inflation to derive an implied quarterly change in the 3-month T-bill interest rate instrument, i. The MMSE forecast trades off bias and forecast error variance and takes into account covariances between components. Thus, unlike the mathematical expectation, the MMSE forecast is not a linear operator and cannot be passed across linear components of the function being forecast. If the near-term target or "baseline" inflation rate is denoted π_{0t} where π is inflation and α is given, then a stripped-down version of our policy rule is

$$(1)\qquad \Delta i_t = [\Delta i + \alpha\pi]_{MMSE(t|t-1)} - \alpha\pi_{0t},$$

where $[\Delta i + \alpha\pi]_{MMSE(t|t-1)}$ is the MMSE one-step-ahead forecast. This forecast links the change in the interest rate to the desired near-term inflation rate. We can show that our rule is closely related to the following inflation forecast Taylor rule with interest rate smoothing:

$$(2)\qquad i_t = \rho i_{t-1} + (1-\rho)i^e + \alpha(\pi_{t|t-1} - \pi_{0t}),$$

where i^e is the long-run equilibrium short-term nominal interest rate, equal to the inflation target plus the equilibrium real rate of interest, and $\pi_{t|t-1}$ is the forecasted rate of inflation. Equation (2) satisfies the Taylor principle provided that $\rho + \alpha \geq 1$. Note that we have omitted feedback from the output gap from the Taylor rule in equation (2) in order to focus on the core relation between equations (1) and (2) as models of inflation targeting.

The forecast-based rule of equation (1) and the Taylor rule of equation (2) are equivalent up to an approximation:

$$(3)\quad [\Delta i + \alpha\pi]_{MMSE(t\,t-1)} \approx (1-\rho)(i^e - i_{t-1}) + \alpha\pi_{t\,t-1}.$$

Examination of equation (3) shows that the correspondence between the two rules is quite close: When inflation is near the target level, $(1-\rho)(i^e - i_{t-1})$ is a reasonable "forecast" of next period's change in the interest rate whereby the interest rate is expected to return gradually to its long-run mean.

Despite the similarities, the inflation-targeting rule has some advantages relative to the Taylor rule. First, it does not assume that policymakers know the long-run equilibrium real rate of interest. Second, it does not depend on a stand-alone inflation forecast. Indeed, a controversial feature of the inflation forecast Taylor rule is the interest rate assumption that goes into the inflation forecast. The Bank of England, for example, assumes in its inflation report that the interest rate instrument will remain constant at its current level, although critics of this approach note that often the need for further interest rate hikes or cuts is obvious. Equation (1), in contrast, is based on a forecast of the relation between inflation and the interest rate instrument, so no stand-alone inflation forecast appears. The ITR rule's forecast allows policy to aim at a specific near-term inflation target in the next period, as inflation-targeting countries might do in practice.

The full empirical model from D-F does not attribute all fluctuations in period-by-period intended inflation to changes in the baseline inflation target because the inflation target is assumed to be subject to Markov switching such that π_{0t} is a probability-weighted average of a high and low rate. A second source of fluctuation in intended inflation comes from a desire to push next period's inflation above or below the trend rate to respond to exchange rate considerations. D-F specifically made a modeling choice to leave out a policy response to the output gap. This avoids the use of variables that are subject to data revisions. This way, filtered quantities from the model represent pieces of information that would have been available to policymakers in real time. The data included in the analysis were interest rates, exchange rates, and consumer prices. Real-time data sets for output and monetary aggregates for all six countries are not available as far back as the 1970s. Moreover, recent results on optimal policy rules have shown that the response to output has very small or zero weight in optimal rules; see Svensson and Woodford (2004) and Woodford (2004).

The following equations incorporate these two potential motives for modifying short-run intended inflation. Several parameters are assumed to be subject to discrete changes because, for example, the central bank chooses to respond only episodically, if at all, to the exchange rate. We know that some of the central banks in our sample, such as Canada and New Zealand, have published monetary conditions indices that weigh interest rate and exchange rate movements in tandem to gauge the stance of monetary policy. In this case, it is natural to conclude that exchange rate movements at times have influenced the central bank's judgment regarding the appropriate interest rate. Even though the Reserve Bank of Australia declines to publish a monetary conditions index, the Deputy Governor, Glenn Stevens, has said, "I am certainly not saying that we ignore the exchange rate, far from it….Policy makers must, and do, form views of the exchange rate as part of the policy process" (Stevens, 1998). For Germany, on the other hand, there was concern in 1978 about a sharp appreciation of the Deutsche mark and in the opposite direction in 1984-85. Great Britain pegged its exchange rate during its relatively brief entry in the European Monetary System from 1990 to 1992. Even before that, however, Britain pursued a managed float in the late 1980s that shadowed the Deutsche mark (Zurlinden, 1993). Nevertheless, we leave the importance of the exchange rate as an empirical issue, and we also present results where this channel of policy response is shut down, which yields similar conclusions about the similarity of inflation behavior across targeters and non-targeters. The exception is the United States. We never use a specification that allows for exchange rate feedback for the United States. Instead, we allow for feedback from the term spread between the 3-month T-bill rate and the 10-year Treasury bond rate because of the term spread's record as a forward-looking cyclical indicator.

In the D-F model, the trend rate of inflation can vary across time, especially between the pre-target era and the post-target era. In equations (4) through (8), $\hat{e}$ is the baseline exchange rate conditional on the values of the Markov state variables and $\tilde{e}$ is the baseline rate not conditional on the values of the state variables. We allow for three state variables subject to Markov switching: $S1$ for parameters related to the implicit inflation objective, $S2$ for parameters related to exchange-rate responses (the term spread for the United

States), and $S3$ for switching in the variance. In equations (7) and (8), Y_t denotes available information through time t. To implement equation (1) as a model of policy, we set $\alpha = 0.25$ and π_{0t} is allowed to depend on an unobserved two-state Markov process. This value of α makes sense if a 25-basis-point drop is the response of inflation next period to an interest rate hike of 100 basis points. Other values of α might lead to a better policy rule, but we needed to make a choice to calculate MMSE forecasts for equation (1).

Interest rate changes:

$$\begin{aligned}\Delta i_t &= [\Delta i + 0.25\pi]_{t|t-1} - 0.25\pi_0(S1_t)\\ &\quad + \lambda(S2_t)[\ln\tilde{e} - \ln e]_{t-1} + u_t\\ &\quad \mathrm{var}[u_t] = \sigma^2(S3_t).\end{aligned} \tag{4}$$

Time-varying parameter forecast equation:

$$\begin{aligned}&[\Delta i + 0.25\pi]_t =\\ &\beta_{0t} + \beta_{1t}\Delta\ln e_{t-1} + \beta_{2t}\pi_{t-1} + \beta_{3t}\Delta i_{t-1} + v_t,\\ &\beta_t = \beta_{t-1} + \upsilon_t\\ &\upsilon_t \sim \mathrm{Normal}(0, Q).\end{aligned} \tag{5}$$

Baseline exchange rate:

$$\ln\hat{e}(S2_t) = \delta(S2_t)\ln\tilde{e}_{t-1} + (1 - \delta(S2_t))\ln e_{t-1}. \tag{6}$$

Expected baseline:

$$\ln\tilde{e}_t = \sum_{j=0}^{1}\mathrm{Prob}(S2_t = j|Y_t)\ln\hat{e}(S2_t = j) \tag{7}$$

$$\begin{aligned}&\mathrm{Prob}(S1_t = i,\ S2_t = j,\ S3_t = k|Y_{t-1}) =\\ &\mathrm{Prob}(S1_t = i|Y_{t-1})\mathrm{Prob}(S2_t = j|Y_{t-1})\mathrm{Prob}(S3_t = k|Y_{t-1})\\ &P(S1_t = 1|S1_{t-1} = 1) = p_1\\ &P(S1_t = 0|S1_{t-1} = 0) = q_1\\ &P(S2_t = 1|S2_{t-1} = 1) = p_2\\ &P(S2_t = 0|S2_{t-1} = 0) = q_2\\ &P(S3_t = 1|S3_{t-1} = 1) = p_3\\ &P(S1_t = 0|S_{t-1} = 0) = q_3.\end{aligned}$$

An important feature of the indicator model is the forecast for $[\Delta i + 0.25\pi]_{t|t-1}$. The forecasts are generated from a time-varying parameter model that is estimated by means of the Kalman filter, as in Dueker and Fischer (1996b). The Kalman filter generates MMSE forecasts. The random-walk assumption regarding the β coefficients suggests that agents need new information (other than the passage of time) to change their views about the relationships between variables. Equation (4) implies that *intended* inflation (interest rate changes minus the forecasted change in $[\Delta i + 0.25\pi]_{t|t-1}$) in any given quarter equals the baseline inflation path

$$\begin{aligned}&\pi_{0t}\mathrm{Prob}(S1_t = 0|Y_{t-1})\pi_0(S1_t = 0)\\ &+\mathrm{Prob}(S1_t = 1|Y_{t-1})\pi_0(S1_t = 1)\end{aligned}$$

plus possible adjustments prompted by the gap between the actual and baseline exchange rates.

The size of the feedback coefficient, $\lambda(S2_t)$, determines the rate at which one tries to close the exchange rate gap through policy actions. A low feedback coefficient implies that the central bank prefers gradualism as opposed to rapid adjustment and return to the target path. Such rebasing of the targets occurs for values of $\delta < 1$. Consequently, shifts in the implicit model-implied target exchange rate are gradually accommodated. As δ decreases from 1, the rate of accommodation increases. McCallum (1993) has used a similar weighting scheme; however, in his model δ remains constant.

Because of the autoregressive nature of equation (6), inferences of the state at time t would depend on the entire history of past realizations of the state variables if it were not for the collapsing procedure of equation (7). An independence assumption in equation (8) for the three state variables reduces the number of parameters needed for the transition probabilities. Maximum-likelihood estimates of the parameters are obtained by maximizing the log of the expected likelihood, as in Hamilton (1988):

$$\sum_{t=1}^{T}\ln\left(\sum_{i=0}^{1}\sum_{j=0}^{1}\sum_{k=0}^{1}\mathrm{Prob}(S1_t = i,\ S2_t = j,\ S3_t = k|Y_{t-1})L_t^{i,j,k}\right), \tag{8}$$

Table 1

Parameter Estimates with Occasional Exchange Rate Feedback

Parameter	New Zealand	Australia	Canada	United States	United Kingdom	Germany
$\pi_0(S1 = 0)$	15.653 (0.311)	6.628 (0.605)	7.729 (0.648)	5.202 (0.311)	15.170 (1.245)	4.786 (0.256)
$\pi_0(S1 = 1)$	2.994 (0.116)	1.389 (0.313)	2.589 (0.341)	2.220 (0.154)	2.838 (0.195)	1.697 (0.212)
$\lambda(S2 = 0)$	0.000	0.000	0.000	0.059 (0.035)	0.016 (0.013)	0.011 (0.003)
$\lambda(S2 = 1)$	0.079 (0.008)	0.168 (0.039)	0.000	0.930 (0.133)	0.016 (0.212)	0.043 (0.009)
$\delta(S2 = 0)$	0.507	0.748 (0.105)	0.376	3.508 (1.087)	0.000 (0.011)	0.999
$\delta(S2 = 1)$	0.000 (0.002)	0.414 (0.184)	0.002 (0.073)	0.065 (0.014)	0.002 (0.473)	0.000 (0.013)
$\sigma(S3 = 0)$	2.042 (0.342)	2.746 (0.561)	3.737 (1.098)	0.000	2.127 (0.389)	3.206 (0.990)
$\sigma(S3 = 1)$	0.012 (0.004)	0.208 (0.043)	0.287 (0.063)	0.000	0.115 (0.023)	0.102 (0.022)
p_1	0.978 (0.016)	0.990 (0.012)	0.830 (0.095)	0.920	0.987 (0.012)	0.930 (0.054)
q_1	0.875 (0.078)	0.991 (0.011)	0.935 (0.038)	0.970 (0.019)	0.998	0.982 (0.016)
p_2	0.934 (0.067)	0.963 (0.030)	0.995 (0.321)	0.990 (0.011)	0.996	0.967 (0.018)
q_2	0.564 (0.247)	0.857 (0.109)	0.391 (0.404)	0.975 (0.030)	0.277	0.655 (0.160)
p_3	0.874 (0.064)	0.974 (0.020)	0.942 (0.039)	0.664 (0.132)	0.906 (0.062)	0.955 (0.036)
q_3	0.962 (0.023)	0.966 (0.027)	0.975 (0.019)	0.867 (0.049)	0.957 (0.024)	0.943 (0.041)
Log-likelihood	–197.515	–173.672	–196.360	–128.232	–186.562	–104.386
Sample	1975:Q1–2005:Q2	1976:Q1–2005:Q3	1970:Q1–2005:Q4	1972:Q1–2005:Q2	1972:Q1–2005:Q3	1972:Q1–1998:Q4

NOTE: Standard errors are given in parentheses. If no standard error appears for a coefficient, this implies that the coefficient was set at a boundary value and not estimated. For the United States, the interest rate spread was used in place of the exchange rate.

where the densities are

$$
\begin{aligned}
\ln L_t^{i,j,k} &= -0.5\ln(2\pi\sigma^2(S3_t = k)) \\
&\quad -0.5\exp(\hat{e}(S1_t = i,\, S2_t = j)_t^2 / \sigma^2(S3_t = k)).
\end{aligned} \tag{9}
$$

ESTIMATION RESULTS AND INTERPRETATION

The central bank reaction function of equations (3) through (7) is used to find estimates for policy-implied baseline inflation rates for six countries: the United States, Australia, Canada, Germany, New Zealand, and the United Kingdom. Three countries that did not have formal inflation targets before 1994—the United States, Germany, and Australia—were included for purposes of comparison. The sample frequency is quarterly for all countries. The interest rate is a 3-month rate, prices are measured by the consumer price index, and the exchange rate is the domestic/U.S. dollar rate except for the United Kingdom, where the pound/mark rate (pound/euro after 1999 in the updated data) is used. For the United States the exchange rate is replaced with an interest rate spread that represents the slope of the yield curve.

Table 1 presents the updated parameter estimates, with each country's date range at the bottom. (For Germany, the updated results run only through 1998:Q4, after which policymaking by the ECB began.) Parameter estimates *without* exchange rate feedback are in Table 2. For two of the three inflation targeters, the probability of being in the high-inflation regime when inflation targets were implemented was very low, as seen in Table 3. The exception is Canada, which experienced a period of elevated inflation at the same time the United States did (around 1990). Our principal focus is on the graphs of the regime-switching baseline inflation rates, which are plotted alongside a one-year moving average of each country's inflation rate. Gaps between the actual inflation rate and the model-implied trend rate

Table 2

Parameter Estimates without Exchange Rate Feedback

Parameter	New Zealand	Australia	Canada	United States	United Kingdom	Germany
$\pi_0(S1 = 0)$	15.156 (0.947)	6.665 (0.622)	7.729 (0.648)	6.004 (0.441)	15.569 (1.854)	4.251 (0.435)
$\pi_0(S1 = 1)$	2.616 (0.467)	1.478 (0.352)	2.589 (0.341)	2.463 (0.199)	2.818 (0.199)	1.449 (0.331)
$\sigma^2(S3 = 0)$	7.639 (3.738)	3.203 (0.644)	3.737 (1.098)	8.125 (2.419)	2.148 (0.379)	3.051 (0.901)
$\sigma^2(S3 = 1)$	0.905 (0.158)	0.240 (0.056)	0.287 (0.063)	0.139 (0.026)	0.117 (0.024)	0.156 (0.032)
p_1	0.968 (0.043)	0.990 (0.013)	0.830 (0.095)	0.872 (0.072)	0.987 (0.012)	0.934 (0.051)
q_1	0.980 (0.017)	0.992 (0.011)	0.935 (0.038)	0.966 (0.021)	0.999	0.980 (0.018)
p_3	0.919 (0.060)	0.956 (0.027)	0.942 (0.039)	0.846 (0.089)	0.922 (0.061)	0.946 (0.045)
q_3	0.976 (0.022)	0.931 (0.041)	0.975 (0.019)	0.936 (0.038)	0.964 (0.025)	0.935 (0.050)
Log-likelihood	–206.770	–178.052	–196.360	–158.249	–187.316	–113.191
Sample	1975:Q1–2005:Q2	1976:Q1–2005:Q3	1970:Q1–2005:Q4	1972:Q1–2005:Q2	1972:Q1–2005:Q3	1972:Q1–1998:Q4

NOTE: Standard errors are given in parentheses. If no standard error appears for a coefficient, this implies that the coefficient was set at a boundary value and not estimated.

Table 3

Summary of Main Results

	Annual inflation when $S1$ = low state	Annual inflation when $S1$ = high state	Probability of being in high-inflation state when inflation targets were announced	Feedback significant for exchange rate ($S2 = 0$)
United States	2.22	5.20	—	—
Australia	1.39	6.63	—	Yes
Germany	1.70	4.79	—	Yes
Canada	2.59	7.73	0.90	No
New Zealand	2.99	15.65	0.01	Yes
United Kingdom	2.84	15.17	0.21	No

can occur for two reasons: (i) a shock has caused actual inflation to deviate from its trend or (ii) inflation has moved to a new trend level so recently that the model's parameter estimates have not yet inferred the new trend level. It was especially important to distinguish between actual inflation and the model-implied trend rate in the early 1990s after an oil price shock in 1990.

In Figures 1 through 6,[9] panel A is based on the original estimates from D-F, panel B is based on updated estimates that allow for exchange rate feedback, and panel C is based on updated estimates that do not allow for exchange rate feedback.

New Zealand versus Australia

In 1991, the Reserve Bank of New Zealand adopted a pioneering inflation-targeting mandate, whereas the Reserve Bank of Australia had a more nebulous charge to keep inflation at levels

[9] We thank Kluwer Academic Publishers for granting permission to reproduce Figures 1a through 6a from the original article in this updated version.

comparable with those of its major trading partners. The Policy Targets Agreement between the Governor of the Reserve Bank of New Zealand and the Minister of Finance defined a precise target framework for inflation. A time frame, escape clauses, policy report, and sanctions within the Reserve Bank Act were clearly specified.

Based on Figures 1A and 2A, D-F concludes that, in a global environment of low inflation, it was difficult to say that formal inflation targets were instrumental in spurring disinflation in New Zealand and Australia, given that both countries experienced inflation regime shifts prior to adopting formal inflation targets. The indicator model suggests that New Zealand moved to a regime with a 4 percent inflation trend in about 1988, as seen in Figure 2A. Similarly, Figure 2A suggests that Australia shifted to a 3 percent inflation trend in 1992. With another decade of data, Figure 1B modifies the timing and magnitude of New Zealand's inflation regime shift to 1989 and a trend rate of about 3 percent. The updated inference for Australia in Figure 2B still identifies 1992 as the shift date but finds a trend rate of inflation of about 2 percent. Figures 2C and 3C do not alter the inferences regarding the timing and magnitude of the reductions in trend inflation, in the absence of exchange rate feedback. None of these updates runs counter to the interpretation that formal inflation targets served more as an ex post official stamp than a cause of disinflation.

Canada versus the United States

D-F note that, although the United States and Canada have undergone similar disinflationary cycles, Canadian inflation had usually remained above that of the United States between the collapse of the Bretton Woods system and 1992. After the Bank of Canada's announcement of explicit inflation targets in February 1991, however, Canadian inflation dipped below that of the United States for the first time since 1970 and remained low.

A key reason for the Bank of Canada to oppose an exchange rate peg was that U.S. monetary policy was viewed to be too growth oriented and the implicit inflation objective in the United States of 3 percent was regarded as too high.[10] Hence, one intention of the announcement of a 1 to 3 percent inflation target by 1995 was to signal that the Bank of Canada had become serious about its objective of price stability. Indirectly, the Bank of Canada was also signaling that it wanted to do better than the United States in terms of inflation performance.

Figure 3A from D-F suggests that Canada's nascent policy regime was too new to allow the model to infer a trend inflation rate below 4 percent, although Figure 3A does show a widening gap between actual inflation and the model-implied trend after 1992. The updated chart in Figure 3B, in contrast, highlights how much more stringently Canada has aimed at 3 percent inflation since 1992 than before. Figures 4A and 4B give a consistent picture of trend inflation in the United States: The trend rate went down to about 3 percent circa 1984 and has remained there, with the possible exception of a short period around 1990. Figures 3C and 4C show that neither exchange rate feedback (Canada) nor feedback from the term spread (United States) play an important role in shaping inferences regarding either country's disinflation. In sum, Canada's inflation targets appear to have helped match but not exceed the inflation performance of the United States, a country without formal inflation targets.

United Kingdom versus Germany

The actual and trend inflation paths for the United Kingdom and Germany, which are depicted in Figures 5A and 6A, show that British inflation, which has the higher historical average, has also been the more volatile. German inflation cycles tend to be more gradual. The different inflation records reflect the different targeting strategies of the two countries. The Bank of England pursued a policy of monetary targeting during the mid-1970s to early 1980s. The Bank of England shifted its emphasis to the exchange rate prior to its entry into the European Monetary System in 1990, which it left in 1992. Since then it has followed a strategy of inflation targeting. As of 1994, the

[10] See Friedman (1995) for a discussion of inflation targeting in Canada.

Figure 1

Baseline Inflation Rate for New Zealand

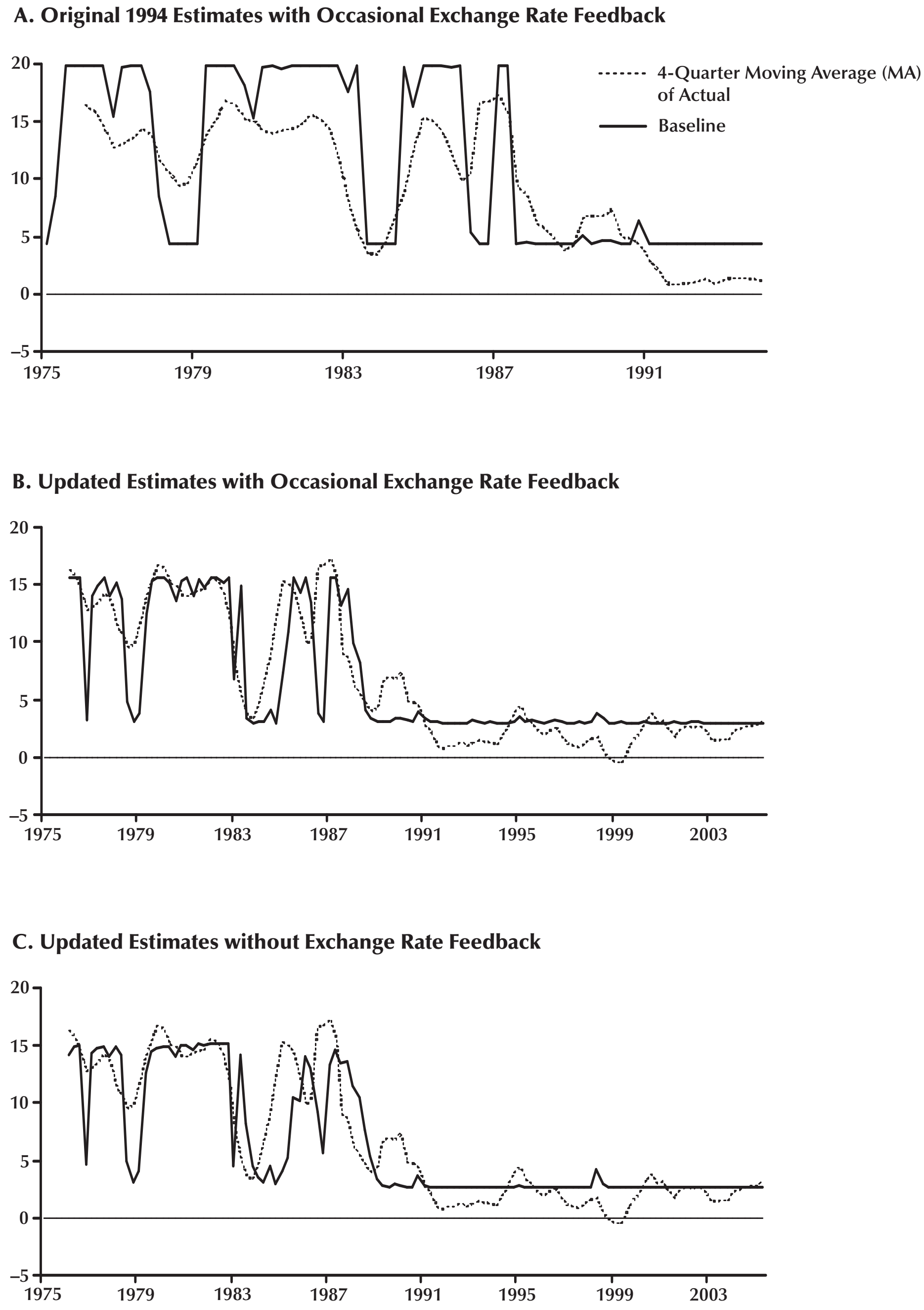


Figure 2

Baseline Inflation Rate for Australia

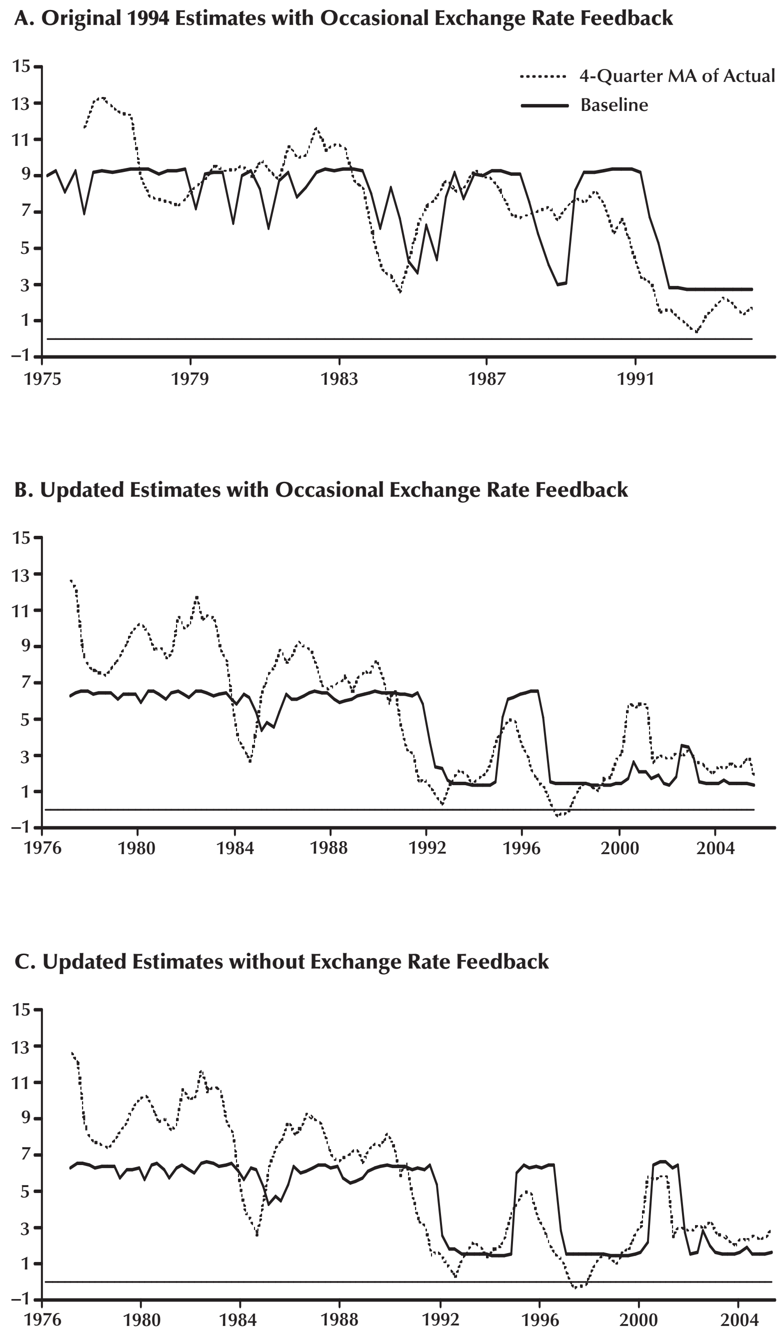
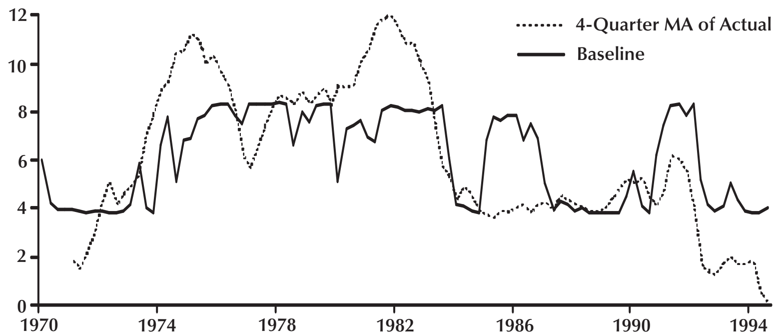


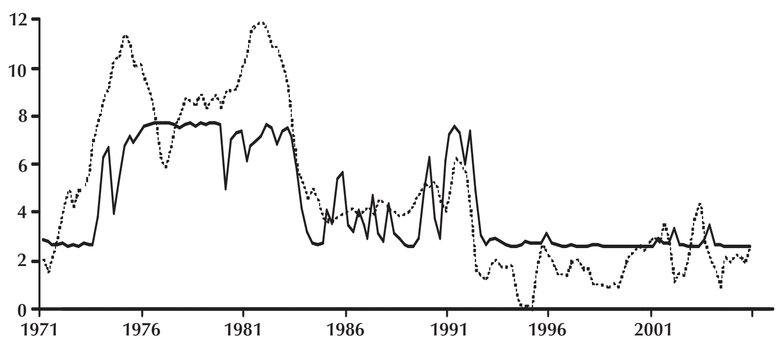
Figure 3

Baseline Inflation Rate for Canada

A. Original 1994 Estimates with Occasional Exchange Rate Feedback



B. Updated Estimates with Occasional Exchange Rate Feedback



C. Updated Estimates without Exchange Rate Feedback

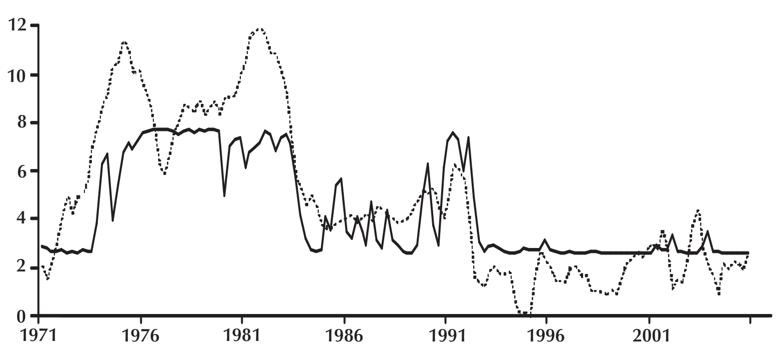
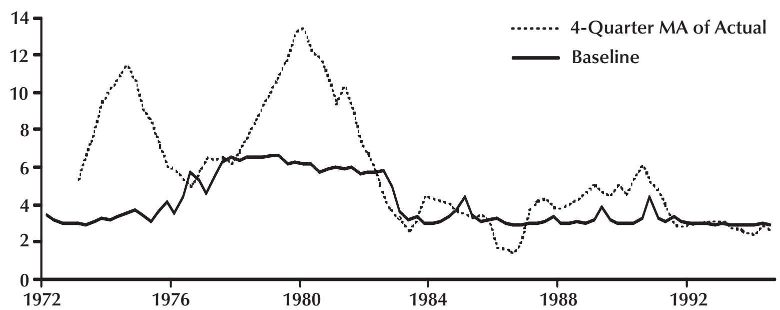


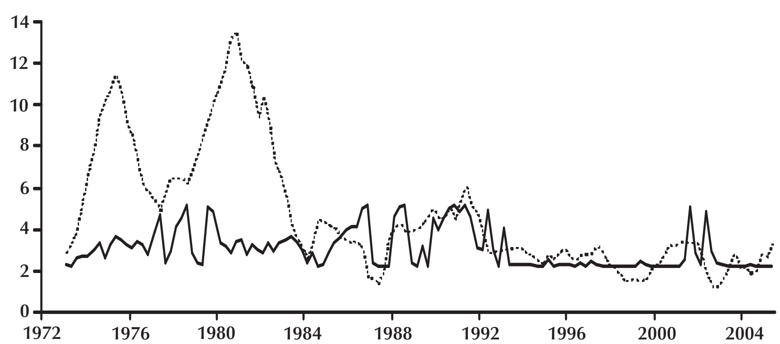
Figure 4

Baseline Inflation Rate for the United States

A. Original 1994 Estimates with Occasional Feedback from Term Spread



B. Updated Estimates with Occasional Feedback from Term Spread



C. Updated Estimates without Feedback from Term Spread

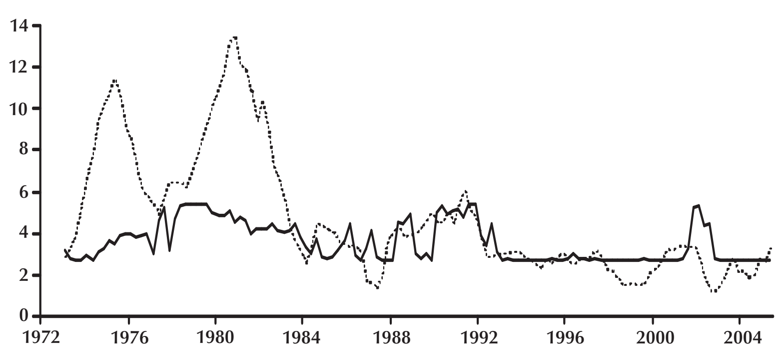
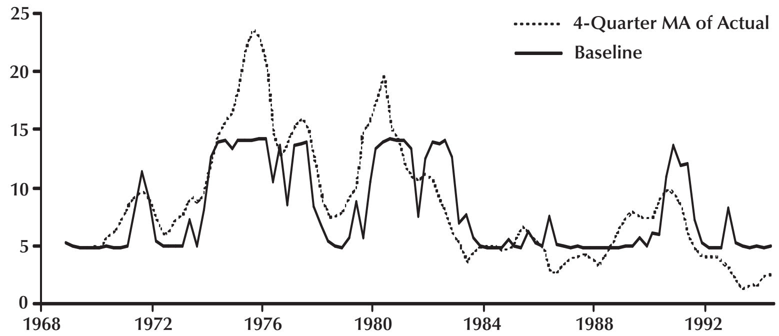


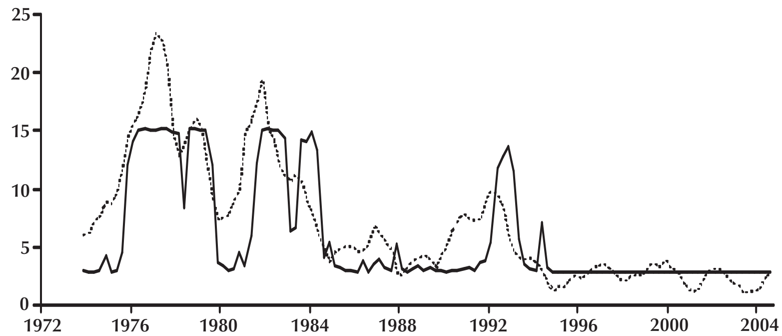
Figure 5

Baseline Inflation Rate for the United Kingdom

A. Original 1994 Estimates with Occasional Exchange Rate Feedback



B. Updated Estimates with Occasional Exchange Rate Feedback



C. Updated Estimates without Exchange Rate Feedback

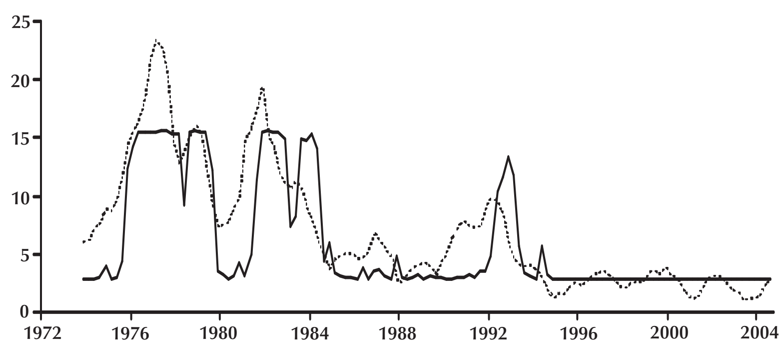
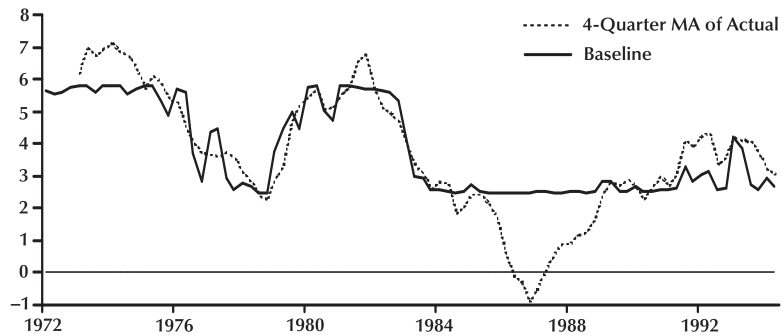


Figure 6

Baseline Inflation Rate for Germany

A. Original 1994 Estimates with Occasional Exchange Rate Feedback



B. Updated (1998) Estimates with Occasional Exchange Rate Feedback

C. Updated (1998) Estimates without Exchange Rate Feedback

Bundesbank, in contrast, had maintained a nominal anchor in the form of monetary targets since 1975.

As with Canada, it was premature in 1994 to claim that the United Kingdom's trend rate of inflation appeared decisively lower than 5 percent after the introduction of inflation targets in late 1992, as shown in Figure 5A. With another decade of data, however, Figure 5B shows that the trend rate of inflation is estimated to have remained closer to 3 percent since 1992. Nevertheless this same trend rate also pertained to most of the 1980s.

Through 1994, D-F note that the estimates of the trend rate of inflation in Germany closely matched the Bundesbank's informal inflation targets, which were documented in von Hagen (2005). From 1975 to 1985, the Bank referred to the informal target as unavoidable inflation and this varied from year to year. From 1986 through 1998, the Bundesbank pursued a fixed, unconditional inflation target of 0 to 2 percent. D-F found in Figure 6A that the trend rate of inflation in Germany had remained at a level just below 3 percent from 1985 onward, even through the German reunification. With the additional data, Figure 6B suggests that Germany's baseline rate of inflation was about 1.5 percent after 1985, with the exception of the period around German reunification. Moreover, we know that the ECB has followed in the Bundesbank's footsteps in terms of keeping inflation at or below 2 percent in Europe. Thus, a decade later the United Kingdom can still be viewed as a follower in terms of carving a path of low inflation in Europe. Figures 5C and 6C do not contradict this conclusion, either, when the effects of any exchange rate feedback are removed.

CONCLUSION

Dueker and Fischer (1996a) provided the first comparative empirical analysis between a set of inflation-targeting countries and neighboring countries without formal inflation targets. Both the original study and the updated estimates presented here suggest that inflation-targeting countries generally followed a non-inflation-targeting neighbor in reducing their baseline or trend inflation rates. We also survey numerous empirical studies of inflation-targeting countries from the past decade and find very similar conclusions. Thus, on the heels of a decade of low global inflation, it has been hard to argue that formal inflation targets have led to any divergence between targeters and non-targeters in terms of inflation performance.

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A Close Look at Model-Dependent Monetary Policy Design

Miguel Casares

This article first explores the implications of model specification on the design of targeting rules in a world of model certainty. As a general prescription, a targeting rule must counterbalance the private-sector dynamics: The more backward-looking behavior is observed in either the output gap or inflation, the more forward-looking monetary policy should be. Likewise, a more forward-looking economy would require stronger backward-looking reactions of the nominal interest rate to the output gap or inflation. The article also analyzes the effects of implementing monetary policy in an environment with uncertainty. Our results indicate that a simple model-invariant rule of the style proposed by Taylor (1993) performs better than a model-dependent targeting rule in the presence of moderate parameter uncertainty. (JEL E52)

Federal Reserve Bank of St. Louis *Review*, September/October 2006, *88*(5), pp. 451-69.

The introduction of the so-called targeting rules in articles such as Svensson (1999) and Clarida, Galí, and Gertler (1999) represented a keystone for monetary policy analysis. A targeting rule is obtained by solving a central-bank optimization program that includes both an objective (loss) function and a single model describing the economy. Therefore, targeting rules have two major characteristics for monetary policy: They represent first-order optimality conditions for the central bank, and they rely on the particular model used to describe macroeconomic fluctuations. Targeting rules have probably received so much attention because of their first characteristic: They entail an optimal behavior for the central bank. The optimality property brought about insightful discussions on the convenience of a commitment-type decision process (see Clarida, Galí, and Gertler, 1999; Woodford, 1999; and Svensson, 2002). This article focuses on the second characteristic of targeting rules—their dependence on a particular model specification.

Two building blocks are required to define a targeting rule: a macro model and an objective (loss) function for the central bank. The model of this article consists of two equations representing the aggregate demand and aggregate supply behavior. It is a semi-structural model that allows for both backward-looking and forward-looking dynamics on inflation and the output gap while retaining much of the flavor of the New Keynesian model.[1] As for the central-bank loss function, it implies that monetary policy targets the volatilities of inflation, the output gap, and the nominal interest rate. This loss function is not directly obtained from any welfare criterion and simply represents the task of macro stabilization frequently assigned to central banks. A fully fledged (New Keynesian) model should be introduced to calculate its

[1] See Christiano, Eichenbaum, and Evans (2005) for a New Keynesian large model that incorporates backward-looking features.

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welfare-theoretic targeting rule, which unfortunately goes beyond the scope of this article.[2]

The analysis will be executed in three steps. In the next section, the targeting rule is derived and, after some algebra, presented as an interest rate optimal reaction function. This optimized interest rate rule provides response coefficients of the nominal interest rate to its own lags or leads and to other key variables such as inflation or the output gap. In the second step, in the following section, a baseline calibration is proposed, borrowing estimates from the New Keynesian literature. In turn, the calibrated model is able to replicate many regularities observed in second-moment statistics from actual data. Finally, the third step consists of looking at how the optimal response coefficients change when the model parameters vary.

As one alternative to targeting rules, the famous Taylor rule (Taylor, 1993) is an example of model-invariant monetary policy design. The Taylor rule is a simple rule (also called instrument rule) characterized by general policy prescriptions: The nominal interest rate should be raised (lowered) when inflation is above (below) its target value, when output is above (below) its potential level, or when the previous nominal interest is above (below) its target value. Thus, it can be said that a Taylor rule is a model-invariant policy rule because its formulation is not based on any specific model. In spite of being suboptimal, model-invariant rules have one advantage over targeting rules: Their stabilizing performance is more robust to model changes than model-dependent targeting rules (Levin and Williams, 2003).

The final section of this article studies the convenience of using a model-independent rule when there is uncertainty surrounding the true value of the model parameters. The presence of uncertainty may discourage the implementation of a targeting rule in favor of a model-independent rule. Some examples of parameter misidentification will recommend that the central bank choose a model-invariant rule (a Taylor-type rule) for its better stabilizing performance.

TARGETING RULES

As mentioned in the introduction, a targeting rule is built on two blocks: the model that represents the economic behavior of the private sector and the central-bank loss function that incorporates the objectives (or targets) of monetary policy. Regarding the model, the following aggregate demand–aggregate supply, (AD)-(AS), pair of equations determine the dynamic behavior of the output gap (y_t) and inflation (π_t):

(AD)
$$y_t = \theta_0 y_{t-1} + (1-\theta_0)E_t y_{t+1} - \theta_1(R_t - E_t\pi_{t+1}) + \upsilon_t,$$

(AS)
$$\pi_t = \phi_0\pi_{t-1} + (1-\phi_0)E_t\pi_{t+1} + \phi_1 y_t + \varepsilon_t,$$

where $0.0 \leq \theta_0$; $\phi_0 \leq 1.0$; θ_1, $\phi_1 > 0.0$; R_t is the nominal interest rate; and both υ_t and ε_t are white-noise shocks with constant standard deviations, σ_υ and σ_ε. Note that E_t denotes the rational expectations operator conditional to information available in period t. The output gap, y_t, is defined by the fractional difference between current output and potential output.[3] This (AD)-(AS) model has been recently used in work such as Smets (2003), Moreno (2004), Lindé (2005), and Moessner (2005). The AD curve negatively relates fluctuations of the output gap to the real interest rate in a way that conveys both backward-looking and forward-looking behavior. External habit formation in households' utility function can explain the introduction of the backward-looking term y_{t-1} as first pointed out by Fuhrer (2000). Meanwhile, the rate of inflation evolves in accordance with the AS curve, which may represent the presence of staggered price contracts as in Fuhrer and Moore (1995). Alternatively, the AS curve is similar to the inflation equation obtained when extending the sticky-price model described by Calvo (1983) to allow price indexation of nonoptimal prices on the previous observation of inflation as in Christiano, Eichenbaum, and Evans (2005). The

[2] Woodford (2003a) shows the welfare-theoretic loss functions implied by various specifications of the New Keynesian model. Moreover, Levin et al. (2006) and Casares (2006), respectively, characterize a welfare-theoretic targeting rule using a New Keynesian model for the United States and the euro area.

[3] The model abstracts from the way potential output is calculated because it is not relevant for the purposes of this article.

selection of this model can be justified on the following basis:

- Simple model: Two dynamic equations representing AD and AS behavior. The simplicity of the model will permit us to write the targeting rule as an interest-rate reaction function.
- Semi-structural equations: The pair (AD)-(AS) shows a number of similarities to the behavioral equations obtained in a closed-economy New Keynesian model with consumption external habit formation, Calvo-style sticky prices, and price indexation on lagged inflation as pointed out by Smets (2003) and Moreno (2004). However, it must be recognized that it does not accurately represent any particular microfounded economy.[4]
- The pair (AD)-(AS) collects a broad variety of model specifications. The values for θ_0 and ϕ_0 ranging from 0.0 to 1.0 can reproduce from purely backward-looking to completely forward-looking dynamics for the output gap and inflation (and all the cases in between). Thus, the fully forward-looking New Keynesian economy is depicted by the case $\theta_0 = \phi_0 = 0.0$, which has been used in articles such as Clarida, Galí, and Gertler (1999), McCallum (2003), Woodford (2003b), and Preston (2006). The purely backward-looking model ($\theta_0 = \phi_0 = 1.0$) is less frequently found in the literature (e.g., see Söderström, 2002, and Svensson, 2003).[5]

Turning to the second building block for a targeting rule, let us suppose that the central bank pursues a monetary policy that aims at reducing variability of inflation, the output gap, and the nominal interest rate. This is a common assumption in the literature on monetary policy rules (Smets, 2003; Giannoni and Woodford, 2003; Woodford, 2003b; and Moessner, 2005) and may be considered a realistic ad hoc way of introducing the central bank's stabilizing preference. Neglecting constant terms (or setting them to zero), the loss function for the central bank in period t is therefore

$$\text{(L)} \qquad L_t = \pi_t^2 + \gamma_y y_t^2 + \gamma_R R_t^2,$$

with γ_y and γ_R being nonnegative values that define the relative weights on the central bank's stabilizing preference.

The targeting rule is going to be derived using the timeless perspective approach defined by Woodford (1999, p. 18) and, in a more formal manner, in Woodford (2003a, pp. 538-39). The timeless perspective implies that the first-order conditions of the central bank do not depend on the moment of time in which they are set. In other words, they do not change over time and the central bank's behavior is time consistent. Regarding its practical calculation, the timeless perspective commitment is obtained by considering that the macro relationships involved in the model hold in all the periods (past, current, and future). This makes the timing of the decision irrelevant.

Accordingly, the optimal monetary policy is then designed by minimizing

$$\sum_{j=0}^{\infty} \beta^j E_t L_{t+j},$$

where $\beta < 1.0$ is the discount factor, subject to (AD)-(AS) relationships in periods $t+j$ with $j \in (\ldots,-2,-1,0,1,2,\ldots)$. The first-order conditions that result from such a central-bank optimizing program are

(TR.1)
$$2\pi_t - \beta^{-1}\theta_1\lambda_{t-1} + \xi_t - \beta\phi_0 E_t\xi_{t+1} - (1-\phi_0)\beta^{-1}\xi_{t-1} = 0,$$

(TR.2)
$$2\gamma_y y_t + \lambda_t - \beta\theta_0 E_t\lambda_{t+1} - \beta^{-1}(1-\theta_0)\lambda_{t-1} - \phi_1\xi_t = 0,$$

$$\text{(TR.3)} \qquad 2\gamma_R R_t + \theta_1\lambda_t = 0,$$

where λ_t and ξ_t are the Lagrange multipliers associated with (AD) and (AS), respectively. Now we will make substitutions in (TR.1)-(TR.3)

[4] In addition, the stochastic terms appearing in (AD) and (AS) have no direct link to structural shocks.

[5] One notices that the backward-looking (AD)-(AS) case can also be interpreted as a vector autoregression (VAR)-type representation of the economy and therefore can relate it to the literature on structural VAR models. See, e.g., Galí (1992) and Christiano, Eichenbaum, and Evans (2005).

to eliminate the Lagrange multipliers. After the algebra,

$$\pi_t = \frac{\beta^{-2}\gamma_R(1-\phi_0)(1-\theta_0)}{\phi_1\theta_1}R_{t-2} - \frac{\beta^{-1}\gamma_R(\phi_1\theta_1+(1-\phi_0)+(1-\theta_0))}{\phi_1\theta_1}R_{t-1}$$
$$+\frac{\gamma_R(1+\phi_0(1-\theta_0))}{\phi_1\theta_1}R_t + \frac{\gamma_R\theta_0(1-\phi_0)}{\phi_1\theta_1}E_{t-1}R_t - \frac{\beta\gamma_R(\phi_0+\theta_0)}{\phi_1\theta_1}E_tR_{t+1}$$
$$+\frac{\beta^2\gamma_R\phi_0\theta_0}{\phi_1\theta_1}E_tR_{t+2} + \frac{\beta^{-1}\gamma_y(1-\phi_0)}{\phi_1}y_{t-1} - \frac{\gamma_y}{\phi_1}y_t + \frac{\beta\gamma_y\phi_0}{\phi_1}E_ty_{t+1}.$$

The above expression can be rearranged so as to reach the following optimal reaction function of the central bank in terms of the nominal interest rate:

(TR)
$$R_t = \mu_1 R_{t-2} + \mu_2 R_{t-1} + \mu_3 E_{t-1}R_t + \mu_4 E_t R_{t+1}$$
$$+\mu_5 E_t R_{t+2} + \mu_6 \pi_t + \mu_7 y_{t-1} + \mu_8 y_t + \mu_9 E_t y_{t+1},$$

where $\mu_1 = -\frac{\beta^{-2}(1-\phi_0)(1-\theta_0)}{1+\phi_0(1-\theta_0)}$,

$$\mu_2 = \frac{\beta^{-1}(\phi_1\theta_1+(1-\phi_0)+(1-\theta_0))}{1+\phi_0(1-\theta_0)},\ \mu_3 = -\frac{(1-\phi_0)\theta_0}{1+\phi_0(1-\theta_0)},$$
$$\mu_4 = \frac{\beta(\phi_0+\theta_0)}{1+\phi_0(1-\theta_0)},\ \mu_5 = -\frac{\beta^2\phi_0\theta_0}{1+\phi_0(1-\theta_0)},$$
$$\mu_6 = \frac{\phi_1\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)},\ \mu_7 = -\frac{\beta^{-1}\gamma_y(1-\phi_0)\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)},$$
$$\mu_8 = \frac{\gamma_y\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)},\ \text{and}\ \mu_9 = -\frac{\beta\gamma_y\phi_0\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)}.$$

The derivation of (TR) represents a bridge between targeting rules and instrument rules that could help to close the gap opened by Svensson (2003).[6] It is easy to notice that (TR) recalls the instrument-style of a Taylor rule with similar prescriptions: The nominal interest rate must respond positively to current deviations of inflation from target ($\mu_6 > 0.0$) and to the current output gap ($\mu_8 > 0.0$). In some sense, (TR) can also be considered an instrument rule because it provides an operational reaction function for the central bank as advocated by McCallum (1999).[7] Besides, (TR) does not include any direct reaction to shocks, which makes it robust to any assumption on their generating process.[8] Nevertheless, it looks much more complex than a Taylor-type rule with regard to the internal dynamic structure. There are two lags (R_{t-2} and R_{t-1}), two leads (E_tR_{t+1} and E_tR_{t+2}), and the expected value of the current interest rate computed in the past period ($E_{t-1}R_t$). Moreover, one lag and one lead of the output gap (y_{t-1} and E_ty_{t+1}) also appear in (TR).

Accordingly, (TR) implies that optimal monetary policy must combine backward-looking and forward-looking dynamics for the nominal interest rate. This represents a more general case than the optimal instrument-style rule derived by Giannoni and Woodford (2003) in a forward-looking model, which included only backward-looking terms. Note that the backward-looking parameters from the (AD)-(AS) equations, θ_0 and ϕ_0, take part in the determination of all the optimal μ's reaction coefficients for the targeting rule (TR). Therefore the degree of backward-looking behavior in the dynamics of either the output gap or inflation is key for the optimal design of monetary policy. This point will be further investigated here in future sections.

Finally, the influence of the central bank's policy parameters, γ_y and γ_R, in the design of (TR) is found only in the size of the responses of the nominal interest rate to the output gap terms (both parameters) and to inflation (only γ_R). In other words, the value of either γ_y or γ_R is irrelevant for the determination of the coefficients on the lags and leads of R_t in (TR). These coefficients (from μ_1 to μ_5) are completely determined by the parameters that appear in the (AD)-(AS) equations, plus β.

BASELINE CALIBRATION

A baseline calibration is required to establish a benchmark reference for the analysis conducted below. The calibration procedure taken is simple: Choose some arbitrary values borrowed from the underlying micro structure of the New Keynesian model and check their empirical fit. However, the calibration is not intended to match data from any

6 See McCallum and Nelson (2005) and Svensson (2005) for further insightful discussions on the use of targeting rules versus instrument rules.

7 Assuming that the output gap were observable.

8 Giannoni and Woodford (2002) support the use of targeting rules because they are independent from the nature of the model's shocks.

particular economy. We will show just that the empirical properties of the model may resemble second-moment statistics observed in actual data.

Table 1 displays the numerical values of the baseline calibration. Both the (AD) and (AS) curves evenly feature backward- and forward-looking dynamics ($\theta_0 = \phi_0 = 0.5$). The (AD) curve with $\theta_0 = 0.5$ corresponds to a New Keynesian economy featuring strong habit formation on households' consumption preferences as advocated by Fuhrer (2000).[9] Likewise, having $\phi_0 = 0.5$ in the (AS) equation implies that there is full indexation of non-optimal prices to lagged inflation as estimated in Woodford (2003a, Chap. 5) or Christiano, Eichenbaum, and Evans (2005). Remarkably, the equal-weight calibration used here is consistent with the numerical estimates reported by Smets (2003) using euro area data and by Moreno (2004) for the U.S. economy.[10]

Regarding the slope coefficients, we set $\theta_1 = 0.06$ in the (AD) curve while $\phi_1 = 0.01$ in the (AS) curve. The value for the (AD) slope is found in a New Keynesian model with a habit-formation coefficient equal to 0.8 and a relative risk aversion coefficient for consumption in the utility function equal to 2.0. The calibrated (AS) slope, $\phi_1 = 0.01$, is very close to the slope of the hybrid New Keynesian Phillips curve from a sticky-price model à la Calvo, where firms adjust prices optimally once per year on average and index them to lagged inflation in periods without optimal adjustment.[11]

The model was solved with two alternative monetary policy rules: the optimal (TR) derived above and the Taylor-type rule with interest-rate smoothing[12]:

Table 1

Baseline Calibration

AD curve	$\theta_0 = 0.5$	$\theta_1 = 0.06$	$\sigma_\upsilon = 0.6$
AS curve	$\phi_0 = 0.5$	$\phi_1 = 0.01$	$\sigma_\varepsilon = 0.2$
TayR	$\mu_\pi = 1.5$	$\mu_y = 0.5$	$\mu_R = 0.80$
TR	$\gamma_y = 0.04$	$\gamma_R = 0.30$	$\beta = 0.99$

$$\text{(TayR)} \quad R_t = (1-\mu_R)\left[\mu_\pi \pi_t + \frac{\mu_y}{4} y_t\right] + \mu_R R_{t-1},$$

with the original numbers proposed in Taylor (1993), $\mu_\pi = 1.5$ and $\mu_y = 0.5$ together with a significant degree of interest-rate smoothing, $\mu_R = 0.80$. Regarding the calibration of (TR), the μ's coefficients depend on the values already assigned to θ_0, θ_1, ϕ_0, and ϕ_1 plus on the central bank parameters, β, γ_y, and γ_R. The discount factor takes the standard value $\beta = 0.99$, which implies a 4 percent annualized rate of discount. For the parameters on the central-bank stabilizing preference, we set $\gamma_y = 0.04$ and $\gamma_R = 0.30$, which reflects a monetary policy that is more concerned with stabilizing inflation than the output gap or the nominal interest rate.[13]

The (percent) standard deviations of the stochastic disturbances are $\sigma_\upsilon = 0.6$ and $\sigma_\varepsilon = 0.2$ because they let the model have realistic volatilities in the output gap, inflation, and the nominal interest rate. Table 2 gives a comparison between some second-moment statistics obtained in our calibrated model under both (TR) and (TayR) and numbers obtained for the United States, the euro area, the United Kingdom, and Japan.[14] Four

[9] As the external habit-formation coefficient approaches 1.0, the New Keynesian model delivers an (AD) curve with $\theta_0 = 0.5$.

[10] Nevertheless, the degree of backward-lookingness of U.S. inflation has been subject to controversy. Galí and Gertler (1999) claim that inflation responds strongly to future developments ($\phi_0 < 0.5$), while Lindé (2005) finds the opposite result ($\phi_0 > 0.5$).

[11] Under the common assumption of constant capital, the slope of the Phillips curve also depends on the Dixit-Stiglitz elasticity and the elasticity of the real marginal costs with respect to output. Our choice of $\phi_1 = 0.01$ is obtained when the former is 6 and the latter is 0.56, as in Amato and Laubach (2003), Woodford (2003a, Chap. 5), and Christiano, Eichenbaum, and Evans (2005).

[12] The output gap coefficient must be divided by 4 to assimilate Taylor (1993) coefficients because they were proposed for a rule based on annual observations, whereas our model provides quarterly observations.

[13] These loss function weights are similar to those used by Giannoni and Woodford (2003).

[14] The data are quarterly observations for the United States, the euro area, the United Kingdom, and Japan during the period 1980:Q1–2004:Q4. The rate of inflation is the annualized growth rate of the GDP deflator from the previous quarter except for the case of the United Kingdom, which is the annualized growth rate of the retail price index. The output gap has been computed by taking off a linear trend from the logarithm of the real GDP except for the case of Japan, which was obtained from a quadratic detrending due to its structural break on long-run growth. The nominal interest rate is the annualized rate of return on a comparable short-run risk-free bond. (Source:

Table 2

Business Cycle Statistics: Baseline Calibrated Model vs. Data

	Model with (TayR)	Model with (TR)	United States	Euro area	United Kingdom	Japan
Standard deviations (annualized, %)						
π	2.88	2.36	1.98	2.78	3.63	2.58
y	2.21	1.92	2.05	1.75	2.28	2.88
R	3.29	3.12	3.07	3.62	3.38	3.15
Coefficients of correlation						
(y,π)	0.38	0.19	0.04	0.04	0.20	0.28
(y,R)	0.20	–0.04	0.11	0.24	0.28	0.31
(π,R)	0.80	0.35	0.78	0.88	0.84	0.77
Coefficients of autocorrelation						
π	0.86	0.83	0.93	0.95	0.94	0.54
y	0.86	0.80	0.92	0.95	0.94	0.95
R	0.97	0.97	0.97	0.98	0.98	0.97

business cycle regularities can be extracted from observing the columns of actual data:

- The variabilities of the rate of inflation, the output gap, and the nominal interest rate are not very different. Their annualized standard deviations mostly are between 2 percent and 3 percent. The nominal interest rate seems to have a higher standard deviation relative to the other two variables.
- There is a weakly positive correlation between the output gap and either inflation or the nominal interest rate.
- There is a strongly positive correlation between the rate of inflation and the nominal interest rate.
- The three variables have high coefficients of autocorrelation.

As documented in Table 2, the calibrated model with (TayR) provides second-moment statistics that never deviate significantly from the numbers obtained in the data. It could be said that it correctly replicates the data regularities that we just mentioned. The calibrated model with the optimal rule (TR) provides statistics of similar magnitude to the data in many cases, although it does not reproduce correctly two of the correlations found in the data. The nominal interest rate has a slightly negative coefficient of correlation with output (slightly positive in the data) and also quite a low positive correlation with the rate of inflation (strongly positive correlation in the data). Table 2 also shows that the performance of the calibrated (TayR) is not dramatically worse than the performance under the calibrated optimal policy (TR). The higher standard deviations of the target variables when applying (TayR) are between 5 and 22 percent higher than those obtained when using (TR).

International Financial Statistics, August 2005, International Monetary Fund, except for U.K. real GDP and inflation, which were obtained from the National Statistics Office of the U.K. government, available at www.statistics.gov.uk.)

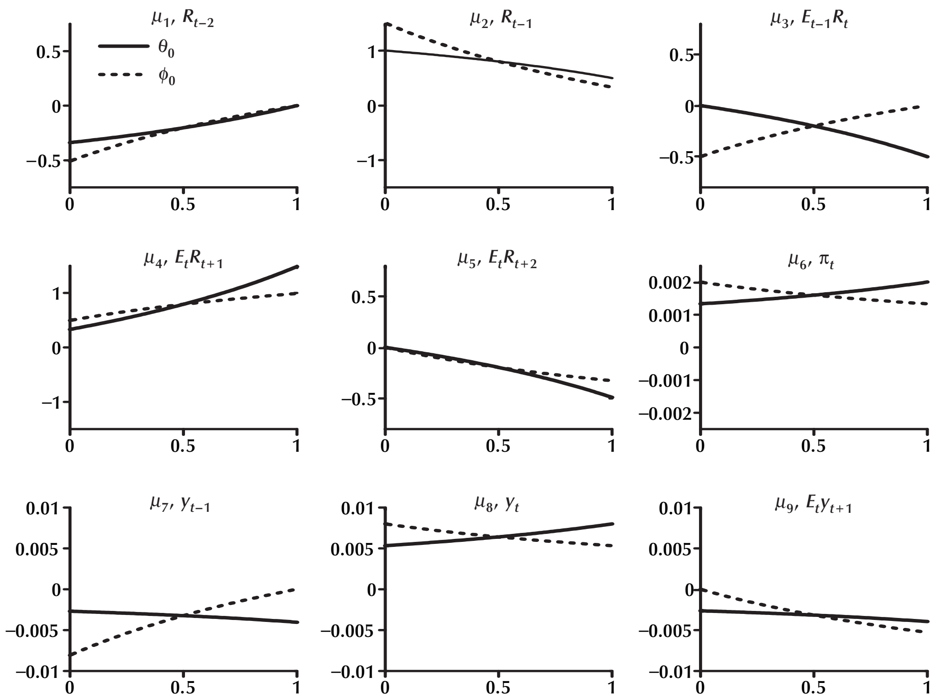
SENSITIVITY ANALYSIS IN A WELL-SPECIFIED MODEL...

This section addresses the implications of alternative specifications of the four (AD)-(AS) model parameters (θ_0, θ_1, ϕ_0, and ϕ_1) and the central-bank policy weights (γ_y and γ_R). In particular, we will examine how a change in each parameter from the baseline calibration reshapes the μ's coefficients on the optimal policy rule (TR).

Let us start by discussing the consequences

Figure 1

Coefficients of the Targeting Rule (TR) Depending on the Backward-Looking Parameters of the (AD) Equation, θ_0, and the (AS) Equation, ϕ_0



of altering the backward-looking coefficients, θ_0 and ϕ_0, from their lower bound (0.0) to their upper bound (1.0). Results are plotted in Figure 1. The solid lines of Figure 1 show the impact of changing the degree of backward-looking behavior on the output gap (θ_0), whereas the dotted lines represent the influence when increasing the backward-looking pattern of inflation (ϕ_0). The intersection of the two lines provides the optimal coefficients under the baseline calibration at $\theta_0 = \phi_0 = 0.5$.

As displayed in Figure 1, the degree of backward-lookingness of both the output gap and inflation plays a crucial role on the design of the targeting rule. Any change in either θ_0 or ϕ_0 affects all the nine μ's coefficients that enter (TR). Furthermore, both θ_0 and ϕ_0 shape the internal dynamics of (TR) in a similar way. Thus, an increase in either θ_0 or ϕ_0 would lead to a decrease in the coefficients on lagged nominal interest rates (μ_1 and μ_2) and, also, an increase in the coefficients on future nominal interest rates (μ_4 and μ_5). The latter assessment must be understood in terms of the absolute value of the coefficients because both μ_1 and μ_5 are negative coefficients.

Thus, there is a well-marked link between the model structure and optimal monetary policy: A more backward-looking economy requires a more forward-looking monetary policy rule. In a symmetric manner, an economy with deep forward-looking dynamics should have persistent inertia in the implementation of monetary policy. Remarkably, this "counterbalance assignment" is applicable to the internal structure of either the output gap or inflation. This finding represents a significant extension of a similar result reported by Leitemo (2006) restricted to the relationship between optimal policy and inflation dynamics.[15]

[15] As another difference from Leitemo (2006), our central bank loss function is also more general because it incorporates interest-rate targeting.

Table 3

Targeting Rule Coefficients under Alternative Model Specifications for θ_0 and ϕ_0

	μ_1	μ_2	μ_3	μ_4	μ_5	μ_6	μ_7	μ_8	μ_9
Baseline (θ_0 = 0.5, ϕ_0 = 0.5)	–0.20	0.81	–0.20	0.79	–0.20	0.0016	–0.0032	0.0064	–0.0032
Forward-looking output gap (θ_0 = 0.0, ϕ_0 = 0.5)	–0.34	1.01	0.0	0.33	0.0	0.0013	–0.0027	0.0053	–0.0026
Forward-looking inflation (θ_0 = 0.5, ϕ_0 = 0.0)	–0.51	1.52	–0.50	0.49	0.0	0.0020	–0.0081	0.0080	0.0
Purely forward-looking (θ_0 = 0.0, ϕ_0 = 0.0)	–1.02	2.02	0.0	0.0	0.0	0.0020	–0.0081	0.0080	0.0
Backward-looking output gap (θ_0 = 1.0, ϕ_0 = 0.5)	0.0	0.51	–0.50	1.49	–0.49	0.0020	–0.0040	0.0080	–0.0040
Backward-looking inflation (θ_0 = 0.5, ϕ_0 = 1.0)	0.0	0.34	0.0	0.99	–0.33	0.0013	0.0	0.0053	–0.0053
Purely backward-looking (θ_0 = 1.0, ϕ_0 = 1.0)	0.0	0.0006	0.0	1.98	–0.98	0.0020	0.0	0.0080	–0.0079

For illustrative purposes, Table 3 contains the values of the (TR) coefficients for alternative specifications of both θ_0 and ϕ_0. The purely forward-looking economy ($\theta_0 = \phi_0 = 0.0$) would have the highest lagged nominal interest rate coefficients ($\mu_1 = -1.02$ and $\mu_2 = 2.02$) and no reaction to the expected future nominal interest rates ($\mu_4 = \mu_5 = 0.0$). By contrast, a purely backward-looking economy ($\theta_0 = \phi_0 = 1.0$) would have an optimal policy with strong reactions to expected future developments ($\mu_4 = 1.98$ and $\mu_5 = -0.98$) and practically no dependence on past movements ($\mu_1 = 0.0$ and $\mu_2 \simeq 0.0$).

Figure 1 and Table 3 also inform about the impact of changing either θ_0 or ϕ_0 on the optimal coefficients that measure the reaction to changes in inflation or the output gap. Interestingly, the coefficient that gives the optimal reaction to inflation is quite robust to changes in either θ_0 or ϕ_0, because it always takes a rather low value ($\mu_6 = 0.0016$ at the baseline calibration). The reaction to the output gap is stronger than the reaction to inflation (contradicting the original Taylor prescription), with a value $\mu_8 = 0.0064$ under the baseline calibration.[16] The output gap coefficient is affected in a different way by changes in θ_0 and ϕ_0. If the output gap dynamics were more backward-looking (higher θ_0), the optimal policy would react more strongly to the output gap (higher μ_8). The reverse is observed (lower μ_8) when inflation has a greater backward-looking component (higher ϕ_0); the optimal policy will respond less aggressively to the output gap. Furthermore, the response coefficient to the lagged output gap (μ_7) will significantly decrease in absolute value.

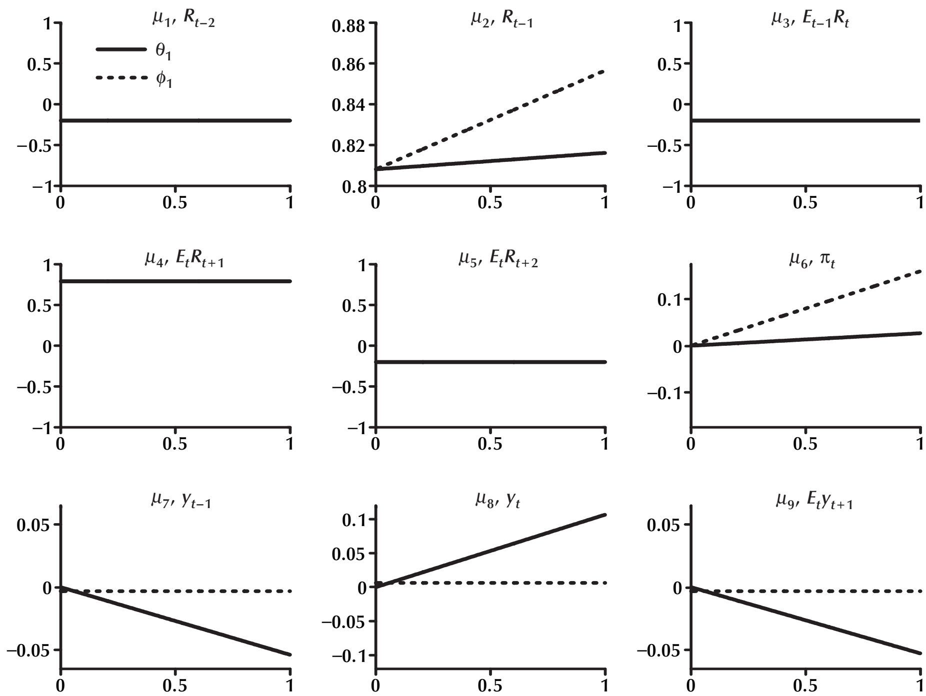
Let us turn to discuss the implications of changes in the slope parameters, θ_1 and ϕ_1 (Figure 2). As implied by the definition of the μ's in (TR), there is very little impact of either θ_1 or ϕ_1 on the structure of lags and leads.[17] The only coefficient of this type that is affected by the slope coefficients is μ_2, which is the one giving reactions to R_{t-1}. Nevertheless, the value of μ_2 is rather insensitive to changes in the slope coefficients

[16] Actually, it can be observed from (TR) that $(\mu_6/\mu_8) = (\phi_1/\gamma_y)$. The baseline calibration implies $\phi_1 < \gamma_y$, which gives rise to an optimal policy with larger reactions to the output gap than to inflation. To reverse this result, either the slope of the Phillips curve should increase (higher ϕ_1) or the central bank should have a weaker stabilizing preference for the output gap (lower γ_y).

[17] The reaction to changes in ϕ_1 is not visible in some of the cases plotted in Figure 2 because it overlaps the reaction to changes in θ_1. In turn, both reactions are null (flat lines) and indistinguishable.

Figure 2

Coefficients of the Targeting Rule (TR) Depending on the Slope Parameters of the (AD) Equation, θ_1, and the (AS) Equation, ϕ_1



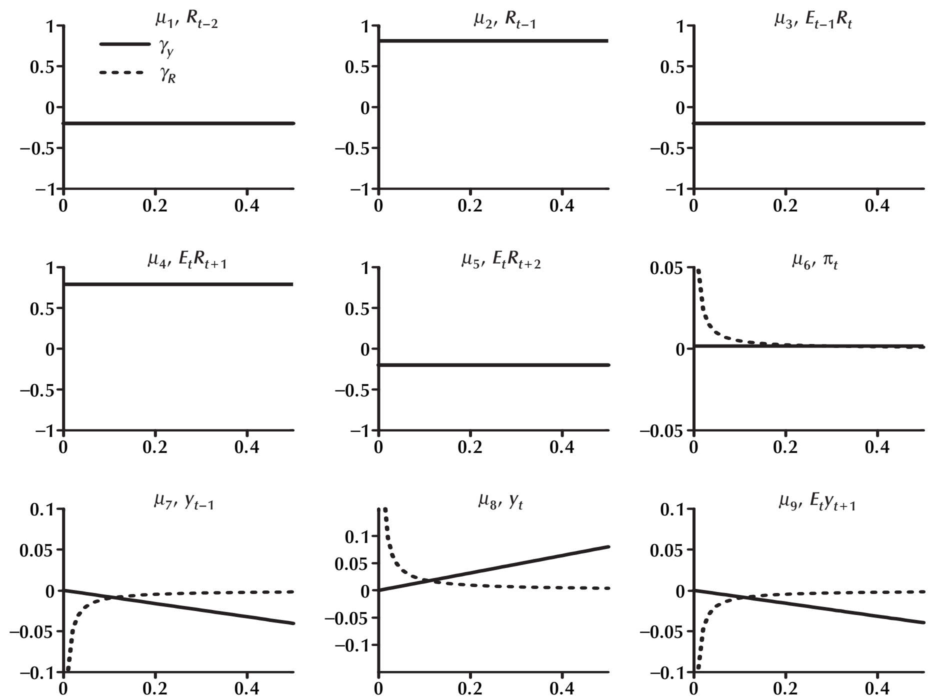
because it moves only within a very narrow range when altering ϕ_1 from 0.0 to 1.0 (between 0.80 and 0.86 as shown in Figure 2). The impact of different settings for θ_1 or ϕ_1 on the other optimal coefficients of (TR) are also displayed in Figure 2. A higher AD curve slope (θ_1) entails higher responsiveness of the optimal policy to inflation deviations and the current output gap (higher μ_6 and μ_8). In addition, the reaction to both the past and expected future output gap would also be more significant (higher μ_7 and μ_9 in absolute value). Regarding the slope of the AS curve (ϕ_1), it determines only the coefficients on inflation and the lagged nominal interest rate (see Figure 2). Both coefficients (μ_6 and μ_2) are positively affected by a higher ϕ_1.

Finally, it can be observed in (TR) that the parameters that provide the central-bank stabilizing preference, γ_y and γ_R, also play some role in the design of the optimal coefficients. In particular, their values have influence on the way the optimal policy should respond to inflation (μ_6) and the output gap terms (μ_7, μ_8, and μ_9) because the coefficients on the internal dynamics of the nominal interest rate (from μ_1 to μ_5) do not depend on either γ_y or γ_R. Figure 3 shows the reaction of the μ's coefficients (if any).[18] When the preference for stabilizing the output gap rises (higher γ_y), the reactions of the nominal interest rate involving output gap terms become more significant as implied by a higher (absolute) value of the coefficients μ_7, μ_8, and μ_9. The inflation coefficient μ_6 is not affected by a change in γ_y. In the case of a central bank more oriented to stabilizing the nominal interest rate (higher γ_R), the inflation and output gap coefficients lose ground rapidly. As shown in Figure 3, they approach zero as γ_R increases.

[18] Note that the reactions overlap in many cases displayed in Figure 3 because there is no influence from either γ_y or γ_R.

Figure 3

Coefficients of the Targeting Rule (TR) Depending on the Central-Bank Stabilizing Preference Parameters, γ_y and γ_R



Summarizing, the backward-looking coefficients of the (AD)-(AS) structure are of great importance for the computation of the optimal interest-rate reaction function. A counterbalance assignment for optimal policy was issued: More backward-lookingness in the economy would lead to more forward-lookingness in monetary policy actions and vice versa. The slope coefficients matter only for the size of the responses to changes in the output gap or inflation. Thus, the slope of the (AD) curve has a positive impact on the reactions to inflation and the output gap while the slope of the (AS) curve exerts a positive impact only on the first of the two. The central-bank stabilizing preference, expressed by the weights of its target variables in (L), also plays a role in the determination of the optimal reaction to inflation and the output gap.

...AND IN A MIS-SPECIFIED MODEL

The analysis of the previous section was done assuming that the central bank was able to correctly identify the parameters of the (AD)-(AS) relationships. However, this is something that should not be taken for granted, because the central bank may make a mistake when estimating the true values of the parameters. Here, we will assume that the central bank feels confident about the canonical (AD)-(AS) model as a good representation of the economy but some identification error may arise when estimating θ_0, θ_1, ϕ_0, or ϕ_1. Perhaps the central bank should no longer apply (TR) because its optimality vanishes if the model parameters are wrongly identified. In other words, the possibility of generating macroeconomic instability may discourage the central bank from using the model-dependent (TR). Alternatively,

Table 4

Stabilizing Performance of (TR) with One Mistake on Parameter Identification
Relative to Either Optimal Policy (denoted by superscript *) or Taylor Rule (denoted by superscript TayR)

	Relative standard deviations						Relative loss value	
	$\sigma_\pi^{TR}/\sigma_\pi^*$	σ_y^{TR}/σ_y^*	σ_R^{TR}/σ_R^*	$\sigma_\pi^{TR}/\sigma_\pi^{TayR}$	$\sigma_y^{TR}/\sigma_y^{TayR}$	$\sigma_R^{TR}/\sigma_R^{TayR}$	L^{TR}/L^*	L^{TR}/L^{TayR}
Mistake in θ_0, error in parentheses								
θ_0 = 0.0 (–0.50)	1.65	1.52	0.47	1.35	1.32	0.44	1.96	1.45
θ_0 = 0.25 (–0.25)	1.34	1.30	0.60	1.10	1.13	0.57	1.39	1.03
θ_0 = 0.75 (+0.25)	1.17	0.87	1.21	0.96	0.76	1.15	1.26	0.93
θ_0 = 1.0 (+0.50)	1.44	0.90	1.35	1.18	0.78	1.28	1.73	1.28
Mistake in ϕ_0, error in parentheses								
ϕ_0 = 0.0 (–0.50)	1.53	1.18	0.65	1.25	1.03	0.62	1.62	1.20
ϕ_0 = 0.25 (–0.25)	1.33	1.16	0.66	1.09	1.01	0.63	1.32	0.98
ϕ_0 = 0.75 (+0.25)	1.43	0.93	1.14	1.17	0.81	1.08	1.58	1.27
ϕ_0 = 1.0 (+0.50)	1.82	1.01	1.30	1.49	0.88	1.23	2.37	1.75
Mistake in θ_1, error in parentheses								
θ_1 = 0.02 (–0.04)	1.24	1.10	0.76	1.01	0.96	0.72	1.21	0.90
θ_1 = 0.10 (+0.04)	0.94	0.99	1.18	0.77	0.86	1.12	1.04	0.77
θ_1 = 0.15 (+0.09)	0.90	1.01	1.37	0.74	0.88	1.30	1.13	0.84
θ_1 = 0.50 (+0.44)	0.85	1.14	2.22	0.70	0.99	2.11	1.97	1.46
Mistake in ϕ_1, error in parentheses								
ϕ_1 = 0.001 (–0.009)	1.59	1.09	0.89	1.30	0.95	0.84	1.77	1.31
ϕ_1 = 0.02 (+0.01)	0.92	1.07	1.24	0.75	0.93	1.18	1.09	0.81
ϕ_1 = 0.06 (+0.05)	0.91	1.47	2.17	0.74	1.28	2.06	2.16	1.60
ϕ_1 = 0.25 (+0.24)	2.34	4.14	6.88	1.91	3.60	6.52	19.28	14.28

the central bank could rely on a model-invariant policy rule, such as the Taylor-type rule (TayR), for example. This issue is going to be examined in exercises of policy simulation assuming either one or two mistakes in the identification of the (AD)-(AS) model parameters.

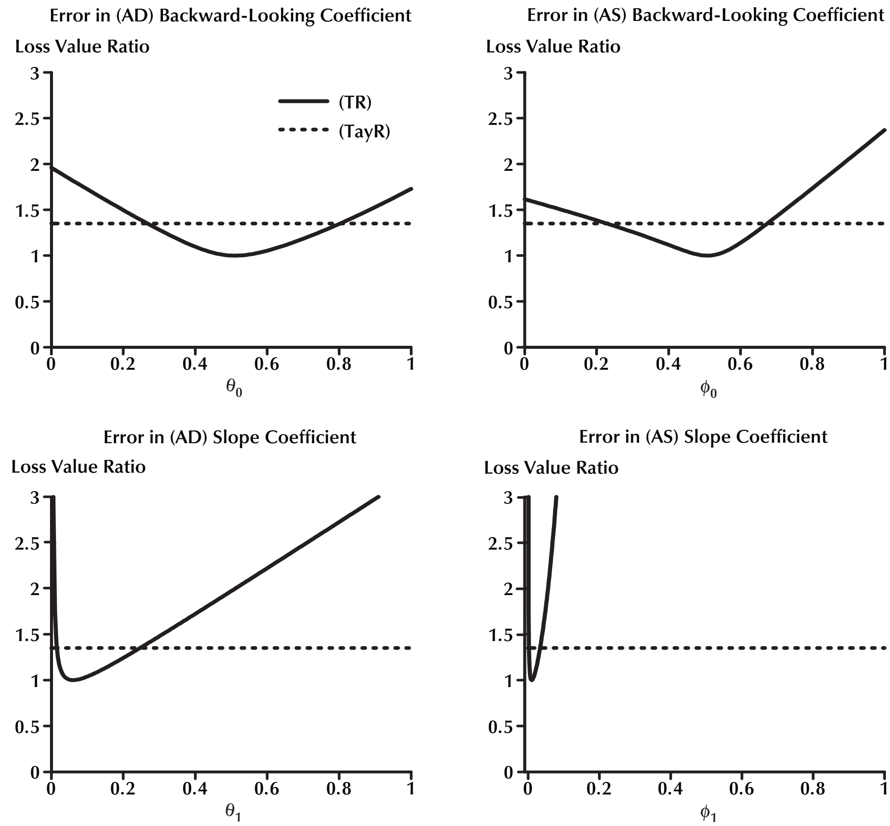
Our first simulation exercise consists of evaluating the performance of the (TR) when the central bank makes only one mistake in the identification of the model parameters. More concretely, it is supposed that the true parameters are those of the baseline calibration (Table 1) and the central bank is capable of correctly identifying all of them except one. To measure the stabilizing performance, we compute the standard deviations of the target variables and compare them with those obtained if the model parameters had been successfully identified. In addition, the unconditional expectation of the central-bank loss function (L) will also be computed to provide an overall performance mark. This (long-run) loss value has been used to rank alternative monetary policy rules in recent work such as Levin and Williams (2003), Adalid et al. (2005), Smets (2003), Walsh (2005), Casares (2006), and Coenen (2006).

Table 4 reports several cases of the performance of (TR) with one identification mistake. The results are expressed in relative terms with respect to both the well-identified (optimal) targeting rule and the calibrated Taylor-type rule (TayR).[19] The former will tell us the deviation from optimal-

[19] The numerical values of the annualized percent standard deviations with the well-identified (TR) and (TayR) were reported in Table 2.

Figure 4

Performance of Targeting Rules When One Parameter Is Mistakenly Identified



ity, and the latter will tell us the deviation from applying a model-independent simple rule such as (TayR). The first line of Table 4 shows what happens when the central bank mistakenly believes that the output gap is purely forward-looking and sets $\theta_0 = 0.0$ instead of its true value, $\theta_0 = 0.5$. This mistake will make the policy rule much more backward-looking as the lagged coefficients, μ_1 and μ_2, gain significance; whereas, the lead coefficients, μ_4 and μ_5, lose significance. As a consequence, the inflation standard deviation will be 65 percent higher than that obtained with the optimal policy ($\sigma_\pi^{TR}/\sigma_\pi^* = 1.65$), the output gap standard deviation will be 52 percent higher ($\sigma_y^{TR}/\sigma_y^* = 1.52$), and the interest-rate volatility will drop by more than one-half ($\sigma_R^{TR}/\sigma_R^* = 0.47$). Moreover, the calibrated (TayR) outperforms the (TR) with that mistake because the variabilities of inflation and the output gap are significantly higher with the latter ($\sigma_\pi^{TR}/\sigma_\pi^{TayR} = 1.35$ and $\sigma_y^{TR}/\sigma_y^{TayR} = 1.32$). In loss-value terms, it is reported $L^{TR}/L^* = 1.96$ and $L^{TR}/L^{TayR} = 1.45$, which means that the incorrect identification of θ_0 gives rise to a 96 percent higher loss value compared with the optimal (TR) and still a higher 45 percent loss value in comparison with (TayR). In this particular example the identification mistake gives rise to a substantial worsening of monetary policy performance with (TR), which leads us to recommend its replacement by the model-independent (TayR). With smaller deviations of the specified θ_0 from the true parameter such as $\theta_0 = 0.25$ or $\theta_0 = 0.75$, the misspecified targeting rule provides a stabilizing performance closer to the well-specified

Table 5

Allowance Intervals for a Mistakenly Identified (TR) Over the Calibrated (TayR), $(L^{TR}/L^*) < (L^{TayR}/L^*) = 1.35$

	Allowance interval	True value
One mistake		
θ_0	$\theta_0 \in [0.28, 0.80]$	$\theta_0 = 0.5$
ϕ_0	$\phi_0 \in [0.24, 0.67]$	$\phi_0 = 0.5$
θ_1	$\theta_1 \in [0.016, 0.245]$	$\theta_1 = 0.06$
ϕ_1	$\phi_1 \in [0.002, 0.033]$	$\phi_1 = 0.01$
Two mistakes		
θ_0 with $\phi_0 = 0.40$	$\theta_0 \in [0.42, 0.64]$	$\theta_0 = \phi_0 = 0.5$
θ_0 with $\phi_0 = 0.25$	$\theta_0 \in [0.48, 0.52]$	$\theta_0 = \phi_0 = 0.5$
ϕ_0 with $\theta_0 = 0.40$	$\phi_0 \in [0.42, 0.61]$	$\theta_0 = \phi_0 = 0.5$
ϕ_0 with $\theta_0 = 0.25$	$\varnothing$	$\theta_0 = \phi_0 = 0.5$

targeting rule, although it still provides significant differences in the standard deviations of the target variables and the loss function (see Table 4).

Figure 4 contains graphs of the loss value ratio L^{TR}/L^* for different model misidentifications. The upper-left graph represents the case of an identification mistake on the output gap backward-looking coefficient θ_0. The value of L^{TR}/L^* has a minimal value of 1 when there is no identification mistake ($\theta_0 = 0.5$) and starts rising when the value of θ_0 deviates to the right or the left. There is a horizontal dotted line that marks the ratio obtained with the implementation of the model-invariant (TayR). The overall performance of (TayR) is better than the mistakenly identified (TR) when the solid line is above the dotted line. For a mistake in θ_0, (TayR) happens to be preferred when θ_0 takes a value either lower than 0.28 or higher than 0.80. Let us define that interval as the "allowance interval" to keep the wrongly identified (TR) over the calibrated (TayR).[20] As shown in Table 5, the central bank can make an identifying mistake in the range $\theta_0 \in [0.28, 0.80]$ and still carry out a monetary policy with stabilizing performance superior to that of the calibrated (TayR).

Results are alike if the backward-looking coefficient of inflation, ϕ_0, is incorrectly identified. The stabilizing capacity of the mistakenly identified (TR) is poor when the identification error is of large magnitude (see lines with $\phi_0 = 0.0$ or $\phi_0 = 1.0$ in Table 4). The upper-right graph of Figure 4 shows that the wrong ϕ_0 must lie inside the range $\phi_0 \in [0.24, 0.67]$ to yield a loss value lower than the one produced by applying the calibrated (TayR). Precisely, this is the allowance interval for a mistake in ϕ_0 reported in Table 5.

Table 4 and Figure 4 also show the performance of (TR) if the identification mistake is made in one of the slope coefficients, θ_1 or ϕ_1. When looking at the bottom panels of Figure 4, one can clearly observe that a good identification for the slope coefficient of the (AS) equation ϕ_1 is required to avoid bad policies, whereas the (AD) slope coefficient θ_1 seems to be less important. (Note how quickly the loss value ratio rises when ϕ_1 deviates from its true value of 0.01.) A slight mistake such as setting $\phi_1 = 0.02$ instead of $\phi_1 = 0.01$ would result in nearly a 10 percent higher loss value (see Table 4). With a higher mistake ($\phi_1 = 0.06$), the standard deviations and the loss value change substantially, relative to the optimal policy. Moreover, the loss value ratio relative to (TayR) is 1.60, which means that (TayR) would clearly outperform a (TR) holding this identification error. By contrast, the (AD) slope, θ_1, allows

[20] The loss value obtained with the calibrated (TayR) is 35 percent higher than the one obtained with the well-designed (TR). Therefore, the "allowance interval" can also be understood as the parameter set that results in a loss value that never exceeds the minimum by more than 35 percent.

Table 6

Stabilizing Performance of (TR) with Two Mistakes on Parameter Identification
Relative to Either Optimal Policy (denoted by superscript *) or Taylor Rule (denoted by superscript TayR)

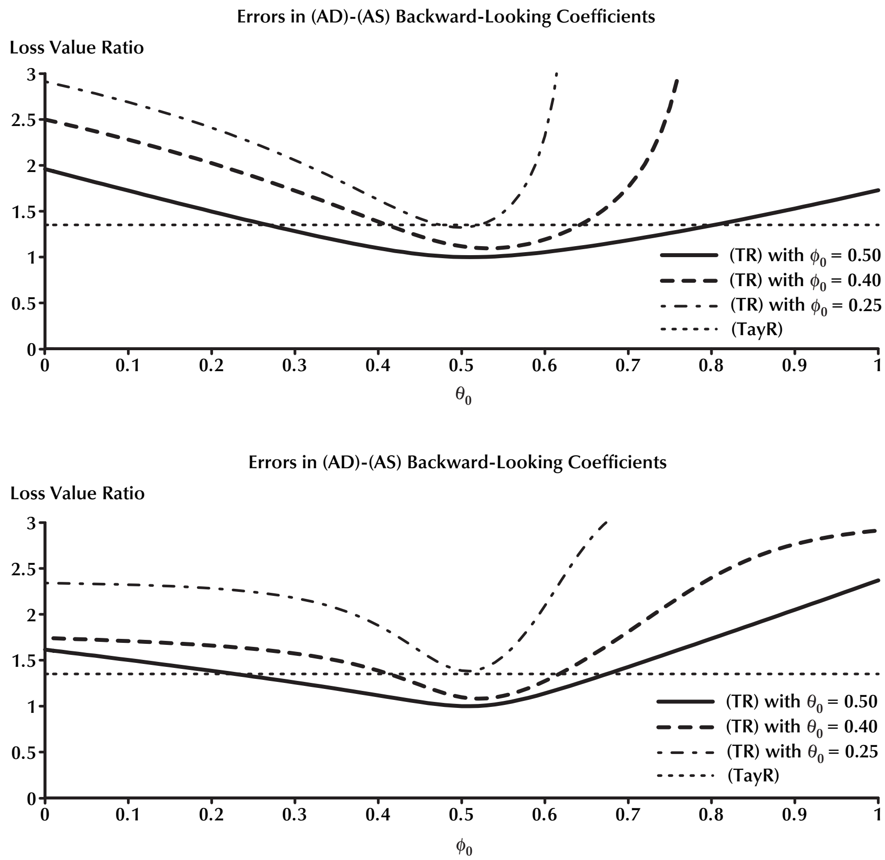
Mistakes in θ_0 and ϕ_0, error in parentheses	Relative standard deviations						Relative loss value	
	$\sigma_\pi^{TR}/\sigma_\pi^*$	σ_y^{TR}/σ_y^*	σ_R^{TR}/σ_R^*	$\sigma_\pi^{TR}/\sigma_\pi^{TayR}$	$\sigma_y^{TR}/\sigma_y^{TayR}$	$\sigma_R^{TR}/\sigma_R^{TayR}$	L^{TR}/L^*	L^{TR}/L^{TayR}
θ_0 = 0.40 (–0.10), ϕ_0 = 0.0 (–0.50)	1.89	1.72	0.34	1.55	1.49	0.32	2.50	1.85
θ_0 = 0.40 (–0.10), ϕ_0 = 0.25 (–0.25)	1.60	1.52	0.47	1.31	1.32	0.45	1.88	1.39
θ_0 = 0.40 (–0.10), ϕ_0 = 0.75 (+0.25)	1.96	1.23	1.11	1.61	1.07	1.05	2.63	1.95
θ_0 = 0.40 (–0.10), ϕ_0 = 1.0 (+0.50)	5.25	3.61	1.07	4.30	3.14	1.01	17.3	12.8
θ_0 = 0.25 (–0.25), ϕ_0 = 0.0 (–0.50)	2.06	1.80	0.25	1.69	1.56	0.24	2.91	2.15
θ_0 = 0.25 (–0.25), ϕ_0 = 0.25 (–0.25)	1.79	1.60	0.36	1.47	1.39	0.34	2.24	1.66
θ_0 = 0.25 (–0.25), ϕ_0 = 0.75 (+0.25)	4.83	3.31	1.02	3.96	2.87	0.97	14.6	10.8
θ_0 = 0.25 (–0.25), ϕ_0 = 1.0 (+0.50)	3.77	2.89	0.39	3.09	2.51	0.37	9.16	6.78
ϕ_0 = 0.40 (–0.10), θ_0 = 0.0 (–0.50)	1.58	1.35	0.47	1.30	1.17	0.45	1.74	1.29
ϕ_0 = 0.40 (–0.10), θ_0 = 0.25 (–0.25)	1.50	1.36	0.51	1.23	1.18	0.48	1.62	1.20
ϕ_0 = 0.40 (–0.10), θ_0 = 0.75 (+0.25)	1.76	1.25	0.83	1.44	1.08	0.79	2.12	1.57
ϕ_0 = 0.40 (–0.10), θ_0 = 1.0 (+0.50)	2.13	1.43	0.71	1.75	1.24	0.67	2.91	2.15
ϕ_0 = 0.25 (–0.25), θ_0 = 0.0 (–0.50)	1.85	1.58	0.33	1.52	1.37	0.31	2.34	1.73
ϕ_0 = 0.25 (–0.25), θ_0 = 0.25 (–0.25)	1.79	1.60	0.36	1.47	1.39	0.34	2.24	1.66
ϕ_0 = 0.25 (–0.25), θ_0 = 0.75 (+0.25)	2.25	1.69	0.49	1.85	1.47	0.46	3.28	2.43
ϕ_0 = 0.25 (–0.25), θ_0 = 1.0 (+0.50)	2.25	1.61	0.34	1.85	1.40	0.32	3.20	2.37

a greater margin for an identification error without causing severe damage to the stabilizing performance. Medium-size mistakes ($\theta_1 = 0.02$ or $\theta_1 = 0.10$) result in moderate increases of the loss value, which remains lower than the value obtained with (TayR). The consequences of making one identification mistake on θ_1 are only grave when the parameter is assumed to be much lower than its real value (see θ_1 approaching zero in the bottom left panel of Figure 4). Summarizing, the allowance ranges for making mistakes in specifying θ_1 or ϕ_1 while still preferring (TR) to the calibrated (TayR) are, respectively, $\theta_1 \in [0.016, 0.245]$ and $\phi_1 \in [0.002, 0.033]$. Therefore, the allowance interval is substantially narrower for the (AS) slope coefficient ϕ_1.

Our second policy exercise consists of assuming that the central bank makes mistakes in identifying both backward-looking parameters, θ_0 and ϕ_0, while the slope coefficients, θ_1 and ϕ_1, are correctly estimated (see Table 6 and Figure 5). Actually, one of the misidentifications is set to be rather small by setting the parameter at either 0.40 or 0.25 instead of its true value, 0.50. The other wrong parameter takes a value within the set [0.0, 0.25, 0.75, 1.0] in Table 6 and the full range of possible values in Figure 5. The overall impression perceived in Table 6 is that the implementation of a (TR) with two identification mistakes always leads to significant increases in the variability of inflation and the output gap relative to optimal policy while the interest-rate variability decreases. The deviations are quantitatively large in all the cases, even in those with smaller identification mistakes. For example, when $\theta_0 = 0.40$ and $\phi_0 = 0.25$ instead of their true values at 0.50, the inflation and output gap standard deviations are, respectively, 60 percent and 52 percent higher than the ones obtained with the optimal (well-identified) policy. By jointly looking at Table 4

Figure 5

Performance of Targeting Rules When Either One Parameter (solid lines) or Two Parameters (dashed and dash-dotted lines) Are Mistakenly Identified



and Table 6, one can realize that making a single "large" mistake such as $\theta_0 = 0.0$ in Table 4 is roughly equivalent to making two "small" mistakes such as $\theta_0 = 0.40$ and $\phi_0 = 0.25$ in Table 6. The standard deviations and loss function ratios are similar in both cases. Thus, allowing the central bank to make two identification mistakes implies that the stabilizing performance of the wrong (TR) is substantially poorer than the one with a single mistake. If we compare its performance with that of the model-invariant (TayR), we come to the conclusion of recommending the implementation of (TayR) when there is moderate uncertainty on both θ_0 and ϕ_0. In the last column of Table 6 the ratio L^{TR}/L^{TayR} is always clearly greater than 1, which means that the loss value when applying (TayR) is significantly lower than the loss value obtained by applying the mistakenly identified (TR). With one mistake (see Table 4), L^{TR}/L^{TayR} was greater than 1 in 10 of 16 total cases.

The same conclusion is reached by looking at the graphical display of Figure 5. The plots show that the deviation from optimal policy (measured by the loss value ratio defined above) rapidly rises as the parameters deviate from their true value (0.5).[21] The ratios are higher as the model param-

[21] The solid lines of Figure 5 represent cases with only one identification mistake. Accordingly, the solid line in the upper panel of Figure 5 is also shown in the upper-left panel of Figure 4. Likewise, the solid line in the lower panel of Figure 5 is also displayed as the upper-right panel of Figure 4.

eters deviate more from their true value (compare dashed and dash-dotted lines in the two panels of Figure 5). Meanwhile, the loss value ratio relative to optimal policy when implementing (TayR) is represented by a flat (dotted) line in Figure 5 because its design is independent of the model parameters. With two identification mistakes, (TR) performs better than the model-independent (TayR) only if the mistakes are very small. The allowance intervals can be seen from Figure 5 as the parameter interval in which the loss value ratio with (TR) is below the dotted horizontal line. As Table 5 informs, these allowance intervals are clearly narrower than the ones found under a single identification error.

In review, our simulation results give support to the use of a model-dependent targeting rule for monetary policy design only if the central bank has little uncertainty on the identification of the true parameters of the (AD)-(AS) model. By contrast, a moderate uncertainty on model parameters (e.g., significant errors in the two backward-looking coefficients) can result in a substantial increase of macroeconomic instability. In such situations, a model-independent rule such as (TayR) is more appropriate for monetary policy conduct because of its better stabilizing performance.

CONCLUSIONS

This article has examined the influence of model parameters on monetary policy design under targeting rules. The reference model consists of one pair of (AD)-(AS) equations that allow for both backward-looking and forward-looking dynamics on both inflation and the output gap. Using Woodford's timeless perspective approach, we derived the targeting rule for the hybrid (AD)-(AS) model as a nine-term reaction function of the nominal interest rate. Coincidently, the targeting rule resembles Taylor's (1993) famous policy prescription: The nominal interest rate must positively respond to current fluctuations of inflation and the output gap. Also, the reaction function for the nominal interest rate includes rich internal dynamics (with coefficients on two lags, two leads, and its expected value computed one period ago) and a reaction to one lag and one lead of the output gap.

The analysis of the influence of the model parameters on the monetary policy design was implemented in two different scenarios. First, it was assumed that the central bank can exactly identify the true values of the model parameters (in the section on sensitivity analysis in a well-specified model). In this case, the degree of backward-lookingness of either inflation or the output gap is key for the optimal design of monetary policy. Thus, a "counterbalance assignment" was set: Monetary policy should be more backward-looking when either inflation or the output gap are more forward-looking, and monetary policy should turn more forward-looking when either one happens to be more backward-looking. This result is an extension of similar policy recommendations from Giannoni and Woodford (2003), Smets (2003), and Leitemo (2006). The role of other model parameters (slope coefficients in (AD)-(AS) and central-bank policy parameters) is limited in determining the response coefficients involving inflation or the output gap because these parameters have no practical influence on the internal interest-rate dynamics.

The second policy scenario incorporates the possibility that the central bank makes mistakes when identifying the parameters of the (AD)-(AS) equations (see the previous section). With such uncertainty, the model-dependent targeting rule is no longer optimal because it contains the identification error. As a result, the stabilizing performance of the targeting rule may worsen in a significant way. As expected, the stabilizing capacity of the targeting rule is poorer with larger identification mistakes. This scenario may lead the central bank to conduct monetary policy with a model-independent rule. Concretely, some simulation exercises show that a calibrated Taylor-type rule performs better than the targeting rule in cases of moderate or severe uncertainty on the coefficients of the (AD)-(AS) equations. This finding can be understood as a call for a more cautious monetary policy design when there is model uncertainty. It brings back the old prescription from Brainard (1967), contradicting the opposite recommendation recently found in the literature

(Onatski and Stock, 2002; Söderström, 2002; Leitemo and Söderström, 2004; and Giannoni, 2006).

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APPENDIX

Optimality Discussion

As argued by Jensen and McCallum (2002), Woodford's "timeless perspective" targeting rule (TR) is suboptimal if the optimality criterion is to minimize the unconditional expectation of the loss function (L). The optimal (Jensen-McCallum) rule for that case can be obtained from the timeless perspective rule when eliminating the discount factor in the central-bank optimizing program, i.e., setting $\beta = 1.0$. In practical terms, the Jensen-McCallum rule and the timeless perspective rule are very much alike because they differ only in the treatment of the central-bank discount factor. Thus, the (TR) according to the Jensen-McCallum criterion would be

$$\text{(TR}'\text{)} \qquad R_t = \mu_1' R_{t-2} + \mu_2' R_{t-1} + \mu_3 E_{t-1} R_t + \mu_4' E_t R_{t+1} + \mu_5' E_t R_{t+2} + \mu_6 \pi_t + \mu_7' y_{t-1} + \mu_8 y_t + \mu_9' E_t y_{t+1},$$

where $\mu_1' = -\frac{(1-\phi_0)(1-\theta_0)}{1+\phi_0(1-\theta_0)}$, $\mu_2' = \frac{\phi_1\theta_1 + (1-\phi_0) + (1-\theta_0)}{1+\phi_0(1-\theta_0)}$, $\mu_4' = \frac{\phi_0 + \theta_0}{1+\phi_0(1-\theta_0)}$, $\mu_5' = -\frac{\phi_0\theta_0}{1+\phi_0(1-\theta_0)}$, $\mu_7' = -\frac{\gamma_y(1-\phi_0)\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)}$, and $\mu_9' = -\frac{\gamma_y\phi_0\theta_1}{\gamma_R\left(1+\phi_0(1-\theta_0)\right)}$.

The coefficients are very similar to the ones in (TR), although they are not exactly the same. The deviation between the performance of (TR) and (TR′) is quantitatively very small. Taking the unconditional expectation of the loss function under the baseline calibration ($\beta = 0.99$), the loss value ratio is $L^{TR}/L^{TR'} = 1.0012$, which implies that the loss value with (TR) is only 0.12 percent higher than the loss function value with (TR′). For related issues on monetary policy optimality, see McCallum (2005).

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