REGULATORY CHANGES AND HOUSING COEFFICIENTS

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Abstract

This study assesses whether regulatory actions account for major changes in estimates of important housing coefficients since the late-1970s. Results imply that the bulk of these changes owe to the end of Reg Q and that Reg Q measures need to account for the introduction of deposit instruments in the late-1970s. Findings imply that models of the aggregate housing stock are unlikely to yield coefficients that are stable enough for practical use unless they accurately control for regulatory changes. In this regard, accounting for small saver or money market certificates yields significant improvements over a naive Reg Q measure.

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I. Introduction

A number of studies have argued that the impact of real interest rates on economic activity has changed because of financial innovation and deregulation. This concern is particularly relevant to housing given the large institutional changes in mortgage finance, the sensitivity of housing to interest rates, deposit deregulation, and the important role of housing in U.S. business cycles [e.g., Gordon (1988)] and the transmission of monetary policy [e.g., Bosworth (1989) and Mauskopf (1990)].

This study investigates whether and to what extent changes in deposit regulations (Reg Q) account for changes in estimates of key housing parameters since the 1970s. Although Reg Q ceilings were lifted over a decade ago, its impact on estimated housing coefficients is still with us because the post-Reg Q era is relatively short from a time series perspective. With the first passing of a post-Reg Q business (and interest rate) cycle, empirical analysis of this issue is now more feasible. In addition, while the behavior of housing has always been important to industry analysts, its importance to policy makers has risen of late since the Federal Reserve (1993) deemphasized M2 and put more stress on real interest rates as economic indicators.[1]

In assessing the impact of Reg Q on estimated housing coefficients, this study proceeds as follows. The next section clarifies how this study's Reg Q measures improve upon those in prior studies. Then, the baseline housing model and the data are described. Thereafter, estimation results are presented and the conclusion discusses the implications of these findings.

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[1] The Fed alters short-term rates in light of GDP forecasts based partly on estimates of the effects of long-term real rates on housing. Typical objections to using real rates as Fed policy guides include that financial innovations and deregulation have altered the rate sensitivity of GDP, measuring expected inflation is difficult, the rate sensitivity of investment varies over the business cycle, and monetary policy regimes affect observed rate elasticities. This study sheds light on the first of these concerns.

II. Previous Work on Reg Q Effects on Housing

Several studies have argued that the impact of interest rates on housing has been altered and reduced by deposit deregulation, the advent of adjustable rate mortgages (ARMs), and the development of the mortgage-backed securities market [e.g., Bosworth (1989), Brueckner and Follain (1989), Kahn (1989), Pozdena (1990), Ryding (1990), and Throop (1986)]. The larger impact of interest rates before the 1980s has been attributed to disintermediation; it has been argued that mortgages had been rationed more with non-price terms by depositories when households shifted out of deposits because market interest rates rose above deposit rate ceilings [e.g., Jaffee and Rosen (1978, 1979), Mauskopf (1990), Pozdena (1990), Ryding (1990), and Throop (1986)].[2]

Not controlling for this structural change has three major implications for housing equations. First, the observed interest elasticity of housing has fallen since deregulation, implying that full sample estimation will yield a rate elasticity that is too low for the pre-deregulation period and too high for the post-deregulation period. Second, given the role of finance in housing, omitted variable bias may affect other coefficients in such models. Third, given that most household deposit rates were deregulated in the early-1980s, this omitted variable bias is likely to cause parameter instability.

Each of these implications is borne out by the Federal Reserve Board

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[2] In a post-Reg Q era, mortgages may be partially rationed with nonprice terms, consistent with the findings of Duca and Rosenthal (1991), because of adverse selection/moral hazard effects [Jaffee and Russell (1976) and Stiglitz and Weiss (1981)] and because lenders face deadweight costs of default [Williamson (1986)]. Rosenthal, Duca, and Gabriel (1991) find that the interest sensitivity of housing is boosted by mortgage-payment-to-income ratios which are more likely to be binding as mortgage payments rise with mortgage rates. Thus, lifting Reg Q has likely reduced, but not eliminated, the effect of nonprice terms on the observed interest sensitivity of housing.

staff's model ("FRB model") of the growth rate of the real U.S. housing stock. First, if one drops the dummy variable for disintermediation in the FRB model, the long-run real rate elasticity of housing drops by 18% as the end of sample is extended from 1979:Q4 to 1992:Q4. Second, estimated coefficients of key variables differ greatly when a better Reg Q measure and a dummy for the credit controls of 1980:Q2 are added to this model. Third, these parameter estimates move much less over time when the FRB model is altered in this way.

Three approaches have been used to control for disintermediation. The first and seminal approach adds deposit outflows at thrifts as an independent variable to housing regressions [see Hendershott (1980) and Jaffee and Rosen (1978, 1979)]. With respect to identifying the nonReg Q interest sensitivity of housing, a shortcoming of this approach is that deposit outflows reflect not only disintermediation induced by Reg Q, but also the impact of interest rates and declining income on money demand.[3] In addition, using a thrift deposit variable is problematic in samples including the late-1980s and early-1990s because of the shrinkage of the thrift industry. Finally, such deposit flow variables are sometimes marginally significant, as in Jaffee and Rosen (1979), though Hendershott (1980) finds them to be significant with an implied impact that is half the size implied by the Jaffee and Rosen estimates.

A second approach to handling Reg Q effects is to separate out periods of credit rationing when estimating the interest sensitivity of housing. This strategy, as employed in old versions of the MPS model [Brayton and Mauskopf (1985)], has two drawbacks. First, it throws out much of the sample when interest rates rose sharply, thereby limiting our ability to identify the

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[3] Money demand still falls in the short-run when interest rates rise because deposit rates adjust sluggishly [see Moore, Porter, and Small (1990)].

nonReg Q interest sensitivity of housing. Second, after periods of disintermediation, large deposit inflows accompanied declining interest rates, and housing starts tended to surge as pent-up demands were met. Rather than dummy out rate terms in disintermediation periods, the current FRB housing model uses a non-interactive dummy for these periods. Nevertheless, the rate sensitivity in this model may still shift over time [Mauskopf (1990, p. 997)].

A third approach is to use measures of how binding Reg Q ceilings were and thereby sort out the underlying interest sensitivity. These variables are typically defined as the difference between a market rate and some deposit rate ceiling when the ceiling is binding, and 0 otherwise. However, studies indicate that estimated coefficients on such Reg Q measures are unstable over the mid-1970s and the late-1970s/early 1980s [Ryding (1990)]. This may reflect that some partially deregulated substitutes for small time deposits (e.g., small saver certificates) were introduced in the late-1970s before most deposit ceilings were lifted in 1983 [see Mahoney, et al. (1987)] and that Reg Q effects were cushioned in the late-1970s by the secondary mortgage market and Federal Home Loan Bank Board (FHLBB) advances to thrifts.

In adopting the third approach to handling Reg Q, this study adds Reg Q measures accounting for the introduction of new deposit instruments to the FRB model. By doing so, this study provides both explanations for and measurements of the evolution of key housing coefficients that are based not on loose references to financial innovations, but rather on explicit measures of them. Results show that, by preventing substantial omitted variable bias, the inclusion of a carefully measured Reg Q variable can largely explains the fall in the interest sensitivity of housing since the 1970s and yields interest rate and permanent income coefficients that are relatively stable.

III. The Baseline Housing Specification

The housing specification used in this study is the FRB error correction model of the growth rate of the real stock of residential housing (single- and multi-family). The long-run determinants of the stock (HS) are the one quarter lags of the real user cost of capital for housing (R^h) and the log of a permanent income proxy (CON). These three variables have a unit root and are cointegrated. The short-run determinants are a dummy for credit rationing induced by disintermediation at S&Ls in the 1960s and early-1970s (DCR) and the one- and two-quarter lags of the growth rate of residential construction. More formally, the FRB model is:

$$\Delta[\log(HS)]_t = \beta_0 - \beta_1\log(HS)_{t-1} + \beta_2\log(R^h)_{t-1} + \beta_3\log(CON)_{t-1}$$
$$+ \beta_4\Delta[\log(HS)]_{t-1} + \beta_5\Delta[\log(HS)]_{t-2} + \beta_6\Delta[\log(R^h)]_t + \beta_7 DCR_t, \qquad (1)$$

where β_0 is a constant, Δ denotes the first difference operator, and the long-run and short-run coefficients are estimated in a single stage.

Because the model is a one-stage error-correction model that jointly estimates long-run and short-run relationships, it includes the one-quarter lags of the logs of the income, interest rate, and housing stock variables instead of an error-correction term that would be estimated in an initial first stage. For our purposes, it is advantageous to use a one-stage approach because it directly shows how properly controlling for regulation can lead to different estimates of long-run relationships. In other regression runs, a two-stage approach was used, where long-run cointegrating relationships were estimated in a first stage and were then added to a second stage housing regression which dropped the variables $\log(HS)_{t-1}$, $\log(R^h)_{t-1}$, and $\log(CON)_{t-1}$ from equation (1). Where comparable, qualitative results were similar to one-stage estimation findings presented later in the text and the tables.[4]

IV. Data and Variables

The variables used fall into three categories: (a) user cost of capital, (b) income, and (c) Reg Q/financial innovation variables.

The Real User Cost of Capital for Housing

The user cost of capital (R^h) is the product of the relative price of housing (P^h/P^c) and the nominal effective mortgage rate (R^m) adjusted for the marginal income tax rate (t) for a family of four earning the median level of income (Treasury data), the average property tax rate (t^p), and the four-year moving average annualized percent change in median existing home prices (π^{he}):

$$R^h = (P^h/P^c)[(1-t)(R^m+t^p) + 2.4 - \pi^{he}], \qquad (2)$$

where P^h = the price index for new housing, P^c = the implicit price deflator for personal consumption expenditures, and 2.4 reflects depreciation. For a discussion of this and other FRB model variables, see Brayton and Mauskopf (1985) as many variables they describe are used in the current FRB model.

Income Variables

Real permanent income (Y^p) is proxied by real spending on consumer nondurables and services plus the real imputed flow of services from the stock of consumer durable goods (*CON*). This proxy embodies the notion that consumption is based on household perceptions of permanent income and avoids

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[4]Specifically, as the end-of-sample was extended from 1979 to 1993, second-stage estimates of coefficients on the error-correction and Reg Q terms changed much less when the one-quarter lag of REGQSSC or REGQMMC replaced DCR. This parallels one-stage estimation results presented later that show how coefficients on long-run variables (log(R^h), log(CON), and log (HS)) and on short-run Reg Q terms are more stable when REGQSSC or REGQMMC replaced DCR.
An appendix available from the author provides two-stage results.

two types of problems posed by creating a permanent income proxy based on past disposable income. The first is associated with the implicit use of adaptive expectations of income. The second stems from the difficulty of identifying the short-run effects of changes in permanent income [$\Delta(\log(Y^P))_t$] when the underlying disposable income data are affected by temporary changes in taxes, subsidies, or other federal transfers lasting more than one quarter.

Reg Q/Financial Innovation Variables.

Several regulatory variables were tested, including measures of Reg Q, the FRB model's Reg Q dummy, and a dummy for the credit controls of 1980:Q2.

Reg Q Spreads. Three Reg Q variables were based on spreads between market rates and deposit rate ceilings, which raises three issues: (1) which retail deposit rate to use, (2) whether rate ceilings for thrifts or banks should be used, and (3) how to handle the introduction of market-rate based deposits prior to the lifting of rate ceilings on nontransactions deposits in 1983.

With respect to issue (1), the Reg Q spreads reflected regulations affecting small time deposits for two reasons. First, small time deposits have maturities closer to that of mortgages than those of demand or passbook savings deposits. Second, most market-based deposits that were introduced in the late-1970s were, by design, substitutes for small time deposits.

In handling issue (2), rate ceilings on thrifts were used. Thrifts were much more important home mortgage lenders owing to tax incentives that encouraged thrifts to hold mortgages and because rate ceilings on thrift accounts were as high or if not higher than those on bank deposits.

In handling issue (3), there were two basic types of partially regulated deposits that were introduced before 1983 by law: small-saver certificates (SSCs) and money market certificates (MMCs). Using SSC regulations to construct a Reg Q variable is preferable on two grounds. First, the maturity of SSCs (2 to 4 years) was more relevant for funding mortgages than that of MMCs (6-months). Second, the minimum balance requirements on SSCs ($500-$1,000) were much more similar to those on retail deposits than were the requirements on MMCs ($10,000) over the late-1970s and early-1980s. This latter factor made SSCs more substitutable for small time deposits.

On the other hand, because they lacked rate ceilings, MMCs had an advantage over SSCs. In addition, different minimum balance requirements may not have made SSCs substantially more effective in reducing disintermediation than MMCs for two reasons. First, the minimum balance requirement on MMCs equaled the minimum size of Treasury securities in the late-1970s and early 1980s, and Treasuries were the main competing financial asset for retail deposits. Second, because they were federally-insured, MMCs allowed many thrifts and small- to mid-size banks to issue a nontraded substitute for uninsured large time deposits. Since this market was not very deep at the time, many depositories were not effectively able to issue large time deposits until the mid-1980s. Because mortgage markets had been dominated by such institutions up through the mid-1980s, MMCs enabled many thrifts and nonmoney center banks to raise loanable funds when Reg Q was binding in the late-1970s and early 1980s. Thus, the advent of MMCs, rather than of SSCs, may have ended Reg Q-induced disintermediation. Therefore, it is an empirical issue whether Reg Q effects more closely reflected regulations on MMCs or on SSCs.

Given these considerations, three Reg Q measures were defined using spreads between market interest rates and small time deposit and/or SSC rate ceilings. One (*REGQU*) equaled the quarterly average spread between the three-year Treasury rate and the rate ceiling on three-year small time deposits when the ceiling was binding, and 0 otherwise. In May 1982, ceilings on 2-1/2 to 3-1/2 year small time deposits were lifted. This measure is similar to that of Ryding (1990) and serves as a benchmark for comparing the performance of more detailed Reg Q measures. The second Reg Q variable (*REGQSSC*) equals REGQU before 1979:Q3. Starting in 1979:Q3 when SSCs were created, *REGQSSC* equals one of the following based on quarter averages of monthly data: (a) any legislated spread between market interest rates and SSC rates (0 to 50 basis points in certain quarters), (b) the maximum of 0 and the 2-1/2 year Treasury yield (constant maturity) minus any legislated cap on SSC rates, or (c) 0 since August 1981 when rate ceilings on SSCs were removed.[5] The third Reg Q variable (*REGQMMC*) equals *REGQU* until 1978:Q2 and 0 thereafter on grounds that MMCs did not have any rate ceilings on them. For details on deposit regulations, see Mahoney, et al. (1987). Accounting for SSCs results in a Reg Q variable that is smaller over 1979-1981 (see Figure 1).[6]

1980 Credit Controls. A dummy was included for the imposition of credit

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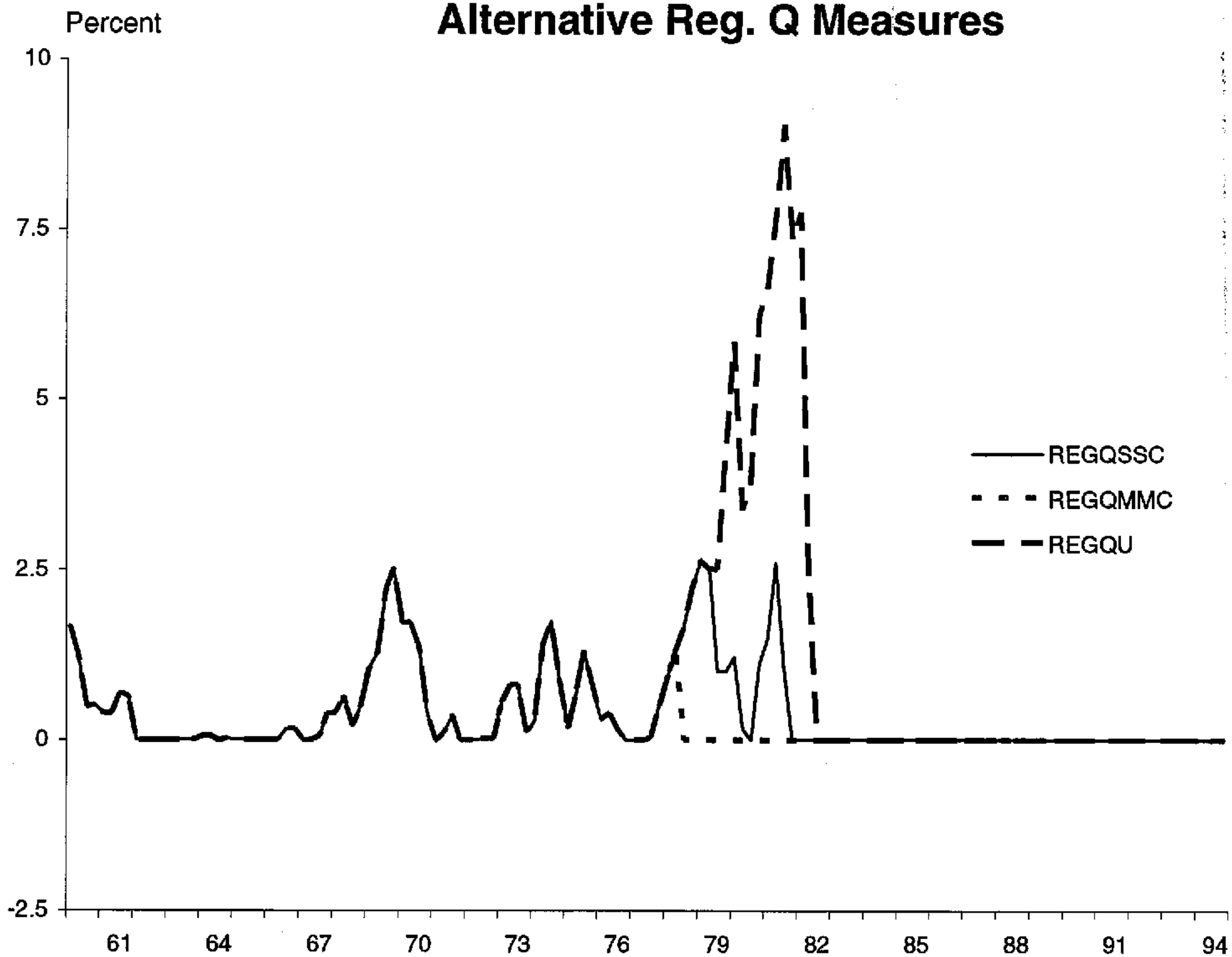
[5] In January and February 1980, SSC rates were set at 50 basis points below the 2-1/2 year constant maturity Treasury yield. In March and April 1980, SSC yields could be as high as the maximum of 12 percent and the 2-1/2 year constant maturity Treasury yield minus 50 basis points. From June 1980 through July 1981, SSC yields could equal the 2-1/2 year constant maturity Treasury yield when this yield was between 9.5 and 12.0 percent, could be as high as 9.5 percent when this Treasury yield was below 9.5 percent, and could be as high as 12.0 percent when this Treasury yield exceeded 12.0 percent.

[6] One drawback of these measures is that they do not control for the declining role of deposits in funding mortgages. The secondary mortgage markets also reduced the impact of Reg Q by allowing originators to sell mortgages. However, these markets were not very well developed until the mid-1980s and thus, may not have altered the impact of Reg Q effects much. In regressions not presented here, multiplying the Reg Q terms by the shares of mortgage originations held by depositories did not improve model fit, nor did multiplying Reg Q measures by the liability share of retail deposits at thrifts to control for the growing use of large time deposits which were not subject to rate ceilings (this shift was small up through the early-1980s).

Figure 1
Alternative Reg. Q Measures



controls (*CONTROL*) in 1980:Q2, which equaled 1 in 1980:Q2.[7] Although they exempted household borrowing, the controls depressed borrowing because many consumers thought that it was illegal to borrow and because many lenders curtailed all types of loans in order to meet overall loan targets and to limit their credit risk exposure during this depressing regulatory episode.

The FRB Model's Credit Rationing Dummy. The FRB model includes a dummy (*DCR*) for credit rationing at S&Ls during periods of Reg Q-induced disintermediation up through the early-1970s. *DCR* equals 1 only in 1966:Q2-Q3, 1969:Q3-1970Q3, and 1973:Q4-75:Q1. *DCR* does not control for disintermediation in the late-1970s and early-1980s on grounds that the secondary mortgage market was created in the early-1970s and that ceilings on large-time deposit rates were lifted in 1976. *DCR* also ignores that Reg Q was binding in the early-1960s.

However, deposit rate ceilings likely induced disintermediation up through the early-1980s because the mortgage-backed securities market was not well-developed nor thick until the mid-1980s and because many thrifts were not well-known enough to issue uninsured large-time deposits.[8] An additional

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[7] Real GDP fell at a annual rate of 10% in 1980:Q2. In a comment on Hendershott (1980), Jaffee (1980, p. 447) remarked that, "the 1980 credit crunch would rank among the best.., albeit it is something of a new breed."

[8] The lifting of ceilings on uninsured large time deposits in 1973 was of limited help in alleviating Reg Q effects for two reasons. First, back in the 1970s, it was difficult for smaller, less well-known banks and thrifts to issue uninsured large time deposits. Second, when rate ceilings were binding on insured deposits, banks flooded the market with uninsured large CDs in periods when default risk was high partly due to monetary tightening. As a result, the risk premium that investors demanded on large CDs typically soared well above the then normal premium of one-half a percentage point above Treasury rates (e.g., when the funds rate peaked in July 1974, six-month CD rates were 4 percentage points higher than six-month Treasury rates. Such high CD "premiums" were passed on to borrowers in the forms of wider spreads between loan and Treasury rates and more restrictive credit standards. The lack of insurance on large CDs coupled with restrictive ceilings on insured deposits effectively gave monetary tightening moves more of a kick.

Note also that brokered small time deposits were not substantial until shortcoming is that this dummy variable treats all disintermediation periods as having the same size effect on housing even though the degree of Reg Q bindingness differed. As a result, the variable *DCR* may not control for the bias that Reg Q imposes on estimates of the rate coefficients on housing.

V. Empirical Results

This section assesses the impact of regulatory changes by reviewing regressions of FRB model variants with and without regulatory variables and then comparing ex post forecasts from these models.

Regression Results

Several patterns arise from the regression results (table 1). First, *CONTROL*, *REGQU*, *REGQSSC*, and *REGQMMC* are significant with the expected signs. Second, over the longer sample, the regulation-modified models have somewhat higher corrected R^2's than the FRB model. Third, unlike the models using *REGQSSC* and *REGQMMC*, the coefficients of the FRB model change substantially as the sample is extended beyond 1979;[9] the lagged stock coefficient [*log(HS)*] jumps 59%, the coefficient on the FRB Reg Q dummy (*DCR*) falls by 35%, the coefficient on the lagged user cost of capital [$\log(R^h)$] rises 94%, and the implied long-run interest elasticity rises by 22%.[10]

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the mid-1980s. These instruments are deposits marketed by third parties whose size plus expected interest payments were under the maximum limit covered by deposit insurance. The raising of this limit from $25,000 to $100,000 in 1982 coupled with perverse deposit insurance incentives for bankrupt thrifts likely explains the strong growth in such accounts after the early-1980s.

[9] Nevertheless, all models easily pass Chow tests on model residuals. In a related study, Duca (1995) finds that *REGQSSC* is highly significant in explaining real GDP growth and that without *REGQSSC*, estimates of the elasticity of real GDP growth with respect to the real federal funds rate change greatly as samples are extended beyond the early-1980s.

[10] The long-run elasticity of the stock of housing equals the coefficient on $\log(R^h)_{t-1}$ divided by the coefficient on $\log(HS)_{t-1}$. Since the *magnitudes* of

As shown in table 2, this particular qualitative finding was also obtained in models that did not include lags of the dependent variable or CONTROL. Fourth, unlike the regulation-modified models, the lagged log-level of the user cost of capital in the FRB is insignificant using the pre-1980 sample. Fifth, coefficients on the lagged stock (*HS*) and permanent income (*CON*) change substantially in the presence of the credit control dummy.

Lastly, *REGQSSC* and *REGQMMC* perform better than *REGQU* on two grounds. First, their models yield somewhat higher full sample fits. Second, unlike the case for *REGQU*, coefficients in models using *REGQSSC* and *REGQMMC* do not change dramatically in size as the end of sample is extended from 1979:Q4 to 1993:Q4. By contrast, in the models using *REGQU*, the estimated long-run rate elasticity rises by 34% and the coefficients on the one quarter lags of the housing stock (*HS*), permanent income (*CON*), and *REGQU* fall by 31%, 34%, and 65%, respectively, as the sample is extended.[11]

Real Rate Elasticity and Coefficient Results

It may seem odd that the absolute magnitude of the real rate elasticity from the FRB model increases rather than decreases as the sample is extended into the 1980s. However, it is important to recognize that the FRB model

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the coefficients in the numerator and denominator both rise as the sample is changed, the percentage increases in the magnitudes of these coefficients (94% and 59%, respectively) are bigger than that of the elasticity (22%). The long-run rate elasticities are of the stock, rather than the flow of housing. Since the housing stock is about $5 trillion ($1987), estimated elasticities and stock adjustment speeds imply that a 100% rise in the real after-tax mortgage rate will, ceteris paribus, cut the total housing stock by about $40 billion in one year and $100 billion at the end of three years; this is nontrivial compared to annual residential construction of about $225 billion.

[11] Ryding (1990) found that the impact of his Reg Q measure (which is similar to REGQU) is one-third smaller over 1978-82 than in earlier periods. In runs not shown in the tables, a Reg Q variable based on spreads between six-month Treasury yields and ceilings on six-month small time deposit rates yielded results that were qualitatively similar to those obtained with REGQU.

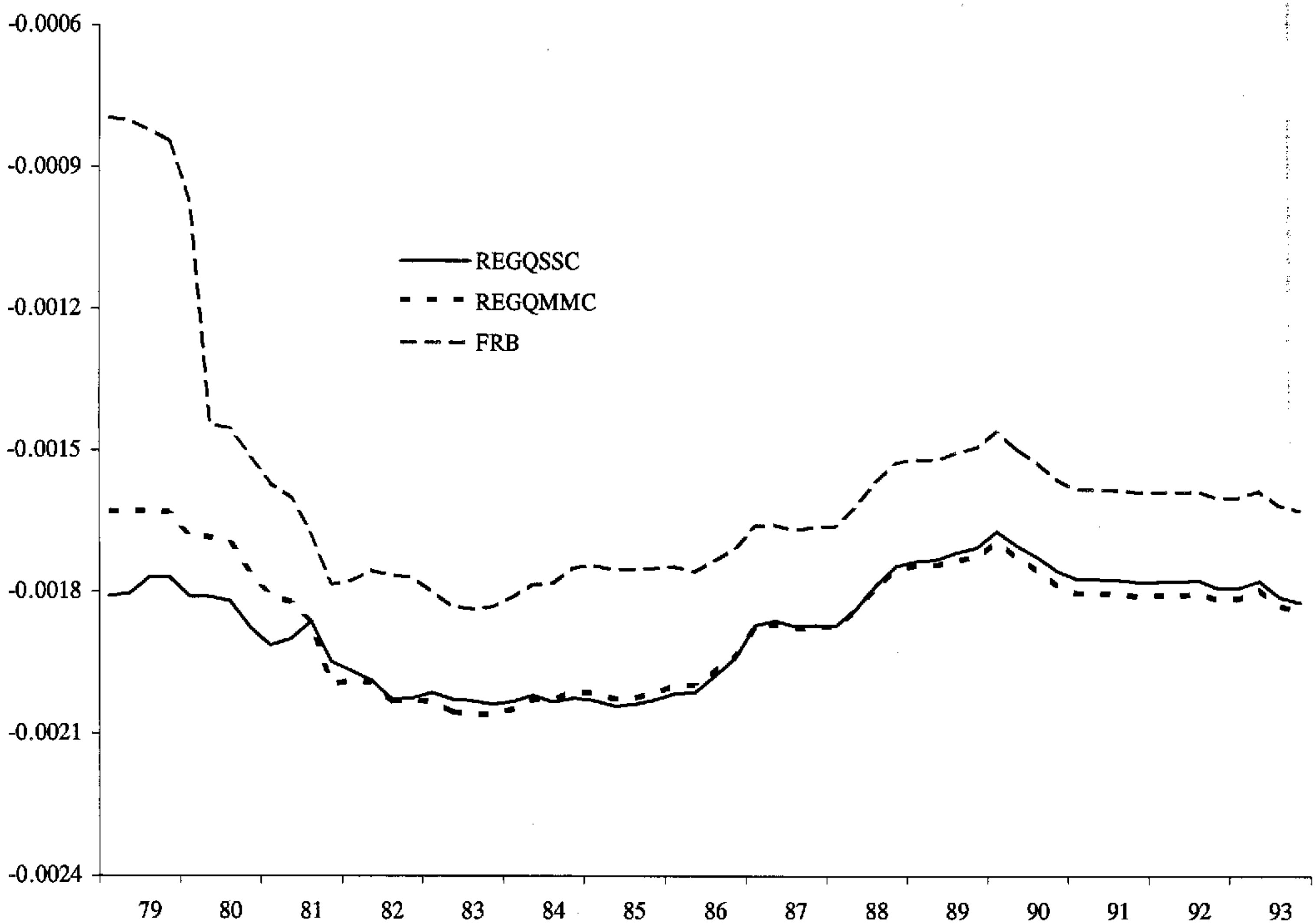
includes a dummy variable (DCR) for some periods of disintermediation that affected mortgage markets in the 1960s and early-1970s, but does not control for Reg Q effects in the mid-1970s, late-1970s, and early-1980s. As a result, the real rate elasticity for the 1960:Q1-1979:Q4 sample is reduced by including *DCR*, and at the same time, the real rate elasticity for the longer sample 1960:Q1-93:Q4 may be upwardly biased by not controlling for periods of disintermediation between the early-1970s and early-1980s. Together, both effects could account for why the FRB model yields a higher real rate elasticity using the longer sample as opposed to the pre-1980 sample. Consistent with this view, when the FRB model is estimated without *DCR*, the long-run real rate elasticity declines by 18% in size as the end-of-sample is extended from 1979:Q4 to 1993:Q4 (table 3), whereas the elasticity rises 22% in size when DCR is included.

One major problem with the FRB model is that as samples are extended, the estimated coefficient on the lagged real rate moves a good deal over time. This is illustrated in Figure 2 which plots the estimated coefficient on $\log(R^h_{t-1})$ from the FRB, REGQSSC, and REGQMMC models using samples that all begin in 1960:Q1 and end in the quarter plotted on the horizontal axis. For example, the data plotted for 1979:Q1 are estimated coefficients over the sample period 1960:Q1-79:Q1. As is evident from Figure 2, the real rate coefficient estimates from models using *REGQSSC* and *REGQMMC* move within a much narrower range since the late-1970s than those those from the FRB model.

Ex Post Forecasts

The models in table 1 were used to forecast 1980:Q1-93:Q4, 1983:Q1-93:Q4, and 1988:Q1-93:Q4 using in-sample periods beginning in 1960:Q1 (table 4). For the forecasts beginning in 1980, the FRB model yields larger

Figure 2
Evolving Real Mortgage Rate Coefficient Estimates



annualized average overpredictions (.68%) than do the *REGQSSC* (.41%) and *REGQMMC* (.50%) models and a larger sum of squared forecast errors (4.45E-4 versus 2.30E-4 and 2.94E-4, respectively). However, using the more recent forecast period, the models yield similar S.S.E.'s and an average error near 0. These findings reflect that for the FRB model, the coefficients of the long-run variables (permanent income, housing stock, and interest rates) change greatly as samples are extended from the late-1970s to the early 1980s, but then settle down at levels near those of the *REGQSSC* and *REGQMMC* models.

Does the Advent of ARMs Explain the Evolution of Housing Coefficients?

To assess whether the advent of ARMs explains the change in observed interest rate elasticities, corresponding models were estimated that replace the variable R^h with an alternative real interest rate term (R^{ha}) which, in its construction, replaces the nominal rate on fixed rate mortgages (R^m) with a weighted average of effective (initial) rates on fixed-rate and adjustable-rate mortgages. The regression results provided in table 5 are qualitatively similar to results reported in table 1. In addition, the ARM share of mortgage originations was very insignificant when added as a separate r.h.s. variable to the models in tables 1 and 3. While adjusting the user cost of housing for ARMs may be important for explaining the stock of single-family homes, it is plausible that the advent of ARMs may affect the share of the housing stock that is owner-occupied without noticeably altering the aggregate stock of residential structures. These findings suggest that changes in coefficients for the aggregate stock of housing largely reflect the passing of Reg Q rather than the advent of ARMs.[12]

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[12] The simple adjustments for ARMs did not cause the two interest rate variables to diverge that much. Furthermore, the differences in the rate

VI. Conclusion

This study improves upon previous research assessing Reg Q's effects by using Reg Q measures which account for new deposit instruments that were introduced before Reg Q ceilings were lifted. Findings indicate that models of the aggregate housing stock are unlikely to yield rate coefficients that are stable enough for practical use unless they accurately control for deposit regulation. In this regard, accounting for small saver or money market certificates yields significant improvements over a naive Reg Q measure that ignores these instruments.

The evidence is mixed on whether the introduction of money market certificates was a more important deregulatory step than the advent of small-saver certificates. On the one hand, accounting for small saver certificates appears to result in slightly less variable estimated housing coefficients than does controlling for money market certificates. On the other hand, accounting for money market certificates tends to yield a somewhat better in-sample fit.

Nevertheless, a naive Reg Q measure which accounts for neither innovation does not prevent substantial post-1979 movements in coefficient estimates and is clearly inferior. By providing better Reg Q measures, this study may help analysts better gauge aggregate housing activity. In this sense, although Reg Q ended more than a decade ago, it is still with us.

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series would be even smaller if one instead modelled the interest rate on ARMs as weighted average of the initial rate and expected future interest rates. There are two reasons for this result. First, the expiration of initial ARM teaser rates implies that the effective rate would be higher than the initial rate under a flat yield curve. Second, the yield curve was upward sloping during virtually all of the period when ARMs were allowed nationally (since 1981). Thus, it is very unlikely that using a rational expectations approach to modelling ARM rates would affect the qualitative results.

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Table 1: Regression Results for the Growth Rate of the <u>Total Stock</u> of Residential Structures

Variables	FRB 60-93	FRB+CONTROL 60-93	FRB 60-79	REGQSSC 60-93	REGQSSC 60-79	REGQU 60-93	REGQU 60-79	REGQMMC 60-93	REGQMMC 60-79
constant	0.1614** (6.37)	0.1477** (6.13)	0.0920* (2.22)	0.1533** (6.39)	0.1490** (3.67)	0.1223** (4.76)	0.1446** (3.56)	0.1847** (7.09)	0.1757** (4.27)
$\log(HS)_{t-1}$	-0.0950** (-5.31)	-0.0853** (-5.01)	-0.0599* (-2.15)	-0.0857** (-5.08)	-0.0913** (-3.16)	-0.0607** (-3.19)	-0.0880** (-3.06)	-0.1083** (-5.99)	-0.1109** (-3.75)
$\log(CON)_{t-1}$	0.0799** (5.08)	0.0715** (4.79)	0.0518* (2.12)	0.0714** (4.82)	0.0778** (3.04)	0.0493** (2.93)	0.0750** (2.94)	0.0910** (5.76)	0.0948** (3.61)
$\log(R^h)_{t-1}$	-0.0016** (-5.50)	-0.0016** (-5.71)	-0.0008 (-1.51)	-0.0018** (-6.55)	-0.0018** (-3.43)	-0.0016** (-5.71)	-0.0017** (-3.38)	-0.0019** (-6.66)	-0.0017** (-3.37)
$\Delta\log(R^h)_t$	-0.0005 (-0.78)	-0.0009 (-1.61)	-0.0023 (-1.70)	-0.0007 (-1.17)	-0.0015 (-1.10)	-0.0005 (-0.90)	-0.0013 (-0.93)	-0.0009 (-1.60)	-0.0018 (-1.38)
DCR_t	-0.0020** (-2.92)	-0.0022** (-3.36)	-0.0031** (-3.35)						
$\Delta\log(HS)_{t-1}$	1.0577** (12.90)	1.0353** (13.37)	1.0107** (9.27)	1.0432** (13.80)	1.0488** (9.55)	1.0676** (13.94)	1.0550** (9.61)	1.0208** (13.26)	1.0181** (9.41)
$\Delta\log(HS)_{t-2}$	-0.2855** (-3.91)	-0.2472** (-3.56)	-0.1946 (-1.85)	-0.2610** (-3.89)	-0.2691** (-2.66)	-0.2885** (-4.27)	-0.2746** (-2.71)	-0.2657** (-3.99)	-0.2690** (-2.66)
$CONTROL_t$		-0.0088** (-4.17)	n.a. due to sample	-0.0076** (-3.61)	n.a. due to sample	-0.0069** (-3.13)	n.a. due to sample	-0.0084** (-4.02)	n.a. due to sample
$REGQ_{t-1}$				-0.0010** (-3.72)	-0.0011** (-2.69)	-0.0004** (-2.79)	-0.0011** (-2.61)	-0.0015** (-3.79)	-0.0017** (-3.35)
$\bar{R}^2$	.9548	.9599	.8914	.9607	.8859	.9589	.8853	.9608	.8914
l-run elas.	-.0171	-.0187	-.0141	-.0213	-.0194	-.0266	-.0199	-.0171	-.0153
Durbin h	-0.074	0.341	-3.224**	0.334	-1.775*	0.636	-1.613*	0.4031	-2.379*
Q(24)	29.85	25.68	25.10	26.87	20.13	27.11	20.86	32.34	21.37

* (**) denotes significant at the 95% (99%) level.
l-run elas. denotes long-run interest elasticity ≡ coefficient on $\log(R^h)_{t-1}$/coefficient on $\log(HS)_{t-1}$.

Table 2: Key Results From FRB Models Without Lags of the Dependent Variable and CONTROL

Variables	FRB Model 60:1-93:4	FRB Model 60:1-79:4	REGQSSC -Modified FRB Model 60:1-93:4	REGQSSC -Modified FRB Model 60:1-79:4
$\log(HS)_{t-1}$, lagged stock	-0.35797	-0.27329	-0.35422	-0.31230
(Δ since 79:4)	(+42%)	n.a.	(-6%)	n.a.
$\log(CON)_{t-1}$, permanent income	0.29922	0.22850	0.29534	0.26362
(Δ since 79:4)	(+38%)	n.a.	(-9%)	n.a.
$\log(R^h)_{t-1}$, lagged real rate	-0.00576	-0.00540	-0.00601	-0.00620
(Δ since 79:4)	(+89%)	n.a.	(+3%)	n.a.
long-run real rate elast.[1]	-0.01610	-0.01976	-0.01698	-0.01985
(Δ since 79:4)	(+32%)	n.a.	(+10%)	n.a.
Disintermediation[2]	-.002293	-.003578	-.001403	-.002715
(Δ since 79:4)	(-30%)	n.a.	(-9%)	n.a.
R^2	.7636	.4530	.7663	.4990

Variables	REGQU -Modified FRB Model 60:1-93:4	REGQU -Modified FRB Model 60:1-79:4	REGQMMC -Modified FRB Model 60:1-93:4	REGQMMC -Modified FRB Model 60:1-79:4
$\log(HS)_{t-1}$, lagged stock	-0.30900	-0.30580	-0.39023	-0.34433
(Δ since 79:4)	(-31%)	n.a.	(-2%)	n.a.
$\log(CON)_{t-1}$, permanent income	0.25521	0.25802	0.32654	0.29293
(Δ since 79:4)	(-34%)	n.a.	(-4%)	n.a.
$\log(R^h)_{t-1}$, lagged real rate	-0.00569	-0.00617	-0.00572	-0.00478
(Δ since 79:4)	(-8%)	n.a.	(+10%)	n.a.
long-run real rate elast.[1]	-0.01840	-0.02019	-0.01466	-0.01525
(Δ since 79:4)	(+34%)	n.a.	(+12%)	n.a.
Disintermediation[2]	-.000674	-.002601	-.004232	-.004782
(Δ since 79:4)	(-65%)	n.a.	(-13%)	n.a.
R^2	.7665	.4962	.7967	.5741

1. Long-run real interest rate elasticity ≡ coefficient on $\log(R^h)_{t-1}$ divided by the coefficient on $\log(HS)_{t-1}$.

2. DCR for the FRB models, one-quarter lags of the levels of various Reg Q terms for regulation-modified models.
None of the models include CONTROL.

Table 3: Key Estimated Coefficients From FRB Model Variants Omitting DCR

Variables[2]	Non-ARM Adjusted Real Mortgage Rate Models: FRB 60:1-93:4	FRB + CONTROL 60:1-93:4	FRB 60:1-79:4	ARM Adjusted Real Mortgage Rate Models[1]: FRB 60:1-93:4	FRB + CONTROL 60:1-93:4	FRB 60:1-79:4
lagged stock	-0.092387	-0.082966	-0.074277	-0.095344	-0.084783	-0.074277
(Δ since 79:4)	(+24%)	(+12)	n.a.	(+28%)	(+14%)	n.a.
permanent income	0.077661	0.069530	0.061524	0.079118	0.070092	0.061524
(Δ since 79:4)	(+26%)	(+13%)	n.a.	(+29%)	(+14%)	n.a.
real rate elast.	-0.018452	-0.020214	-0.022434	-0.019361	-0.020947	-0.022434
(Δ since 79:4)	(-18%)	(-10%)	n.a.	(-14%)	(-7%)	n.a.

1. The ARM-adjusted real mortgage rate models replace the variable R^h with an alternative real interest rate term (R^{ha}) which, in its construction, replaces the nominal rate on fixed rate mortgages (R^m) with a weighted average of effective (initial) rates on fixed-rate and adjustable-rate mortgages. These models are similar to those later presented in table 5.

2. The lagged stock term refers to $\log(HS)_{t-1}$, permanent income refers to $\log(CON)_{t-1}$, and the real rate elast. denotes the long-run real interest rate elasticity which ≡ coefficient on $\log(R^h)_{t-1}$ divided by the coefficient on $\log(HS)_{t-1}$.

Table 4: Ex Post Housing Forecast Results
(All in-sample periods begin in 1960:Q1)

Average Annualized Error

Forecast Period	Model			
	NonReg	REGQSSC	REGQMMC	REGQU
1980:Q1-93:Q4	-.682%	-.412%	+.501%	+.223%
1983:Q1-93:Q4	+.046%	-.290%	+.021%	+.015%
1988:Q1-93:Q4	-.023%	+.014%	+.095%	+.026%

Sum of Squared Forecast Errors

Forecast Period	Model			
	NonReg	REGQSSC	REGQMMC	REGQU
1980:Q1-93:Q4	.0004453	.0002296	.0002939	.0004268
1983:Q1-93:Q4	.0000874	.0001153	.0001167	.0000945
1988:Q1-93:Q4	.0000612	.0000602	.0000688	.0000619

Table 5: ARM-Adjusted Regressions of the Growth of the Total Stock of Housing

Variables	FRB 60-93	FRB + CONTROL 60-93	FRB 60-79	REGQSSC 60-93	REGQSSC 60-79	REGQU 60-93	REGQU 60-79	REGQMMC 60-93	REGQMMC 60-79
constant	0.1703**	0.1534**	0.0920*	0.1560**	0.1490**	0.1322**	0.1446**	0.1879**	0.1757**
	(6.39)	(6.00)	(2.22)	(6.10)	(3.67)	(4.80)	(3.56)	(6.93)	(4.27)
$\log(HS)_{t-1}$	-0.0958**	-0.0846**	-0.0599*	-0.0833**	-0.0913**	-0.0637**	-0.0880**	-0.1054**	-0.1109**
	(-5.32)	(-4.91)	(-2.15)	(-4.82)	(-3.16)	(-3.26)	(-3.06)	(-5.81)	(-3.75)
$\log(CON)_{t-1}$	0.0796**	0.0701**	0.0518*	0.0685**	0.0778**	0.0511**	0.0750**	0.0875**	0.0948**
	(5.07)	(4.66)	(2.12)	(4.55)	(3.04)	(2.98)	(2.94)	(5.56)	(3.61)
$\log(R^h)_{t-1}$	-0.0017**	-0.0016**	-0.0008	-0.0018**	-0.0018**	-0.0017**	-0.0017**	-0.0019**	-0.0017**
	(-5.48)	(-5.49)	(-1.51)	(-6.10)	(-3.43)	(-5.55)	(-3.38)	(-6.42)	(-3.37)
$\Delta\log(R^h)_t$	-0.0007	-0.0012+	-0.0023	-0.0010+	-0.0015	-0.0009	-0.0013	-0.0012+	-0.0018
	(-1.07)	(-1.95)	(-1.70)	(-1.60)	(-1.10)	(-1.39)	(-0.93)	(-1.93)	(-1.38)
DCR_t	-0.0018*	-0.0020**	-0.0031**						
	(-2.56)	(-3.00)	(-3.35)						
$\Delta\log(HS)_{t-1}$	1.0555**	1.0391**	1.0107**	1.0584**	1.0488**	1.0696**	1.0550**	1.0256**	1.0181**
	(12.84)	(13.36)	(9.27)	(13.82)	(9.55)	(13.87)	(9.61)	(13.22)	(9.41)
$\Delta\log(HS)_{t-2}$	-0.2836**	-0.2475**	-0.1946	-0.2698**	-0.2691**	-0.2866**	-0.2746**	-0.2641**	-0.2690**
	(-3.88)	(-3.56)	(-1.85)	(-3.98)	(-2.66)	(-4.23)	(-2.71)	(-3.94)	(-2.66)
$CONTROL_t$		-0.0086**	n.a. due	-0.0075**	n.a. due	-0.0069**	n.a. due	-0.0081**	n.a. due
		(-3.36)	to sample	(-3.52)	to sample	(-3.13)	to sample	(-3.86)	to sample
$REGQ_{t-1}$				-0.0008**	-0.0011**	-0.0003*	-0.0011**	-0.0013**	-0.0017**
				(-2.93)	(-2.69)	(-2.38)	(-2.61)	(-3.40)	(-3.35)
$\bar{R}^2$	.9549	.9597	.8914	.9596	.8859	.9587	.8853	.9605	.8914
l-run elas.	-.0180	-.0193	-.0141	-.0216	-.0194	-.0262	-.0199	-.0179	-.0153
Durbin h	-0.206	0.328	-3.224**	0.389	-1.775*	0.574	-1.613*	0.447	-2.379*
Q(24)	26.44	23.42	25.10	23.65	20.13	24.50	20.86	25.73	21.37

* (**) denotes significant at the 95% (99%) level.

(Not Intended for Publication, available upon request from the author.)
Appendix A: Regression Results For Housing From Two-Stage Estimation

This appendix assesses whether regression results in section 5 are robust to using two-stage error-correction models which, in the first stage estimate cointegrating relationships to define error correction terms used in a second stage that includes short-run dynamic terms, such as Reg Q terms.

All models used the same error correction term (ECFRB) from a first stage in which a cointegrating vector containing log(HS), log(CON), and R^h was estimated with a trend following Johansen's and Juselius' (1990). In the second stage, the models contain $\Delta(R^h)$, $\Delta\log(HS)_{t-1}$, and $\Delta\log(HS)_{t-2}$, and may or may not include CONTROL. The models vary in using different Reg Q terms. Each Reg Q variable was significant, and in terms of R^2, REGQMMC performed best, REGQSSC and DCR performed similarly, and REGQU performed the least well (1960-93, table A1). A comparison with a 1960-79 sample was impossible because a significant cointegrating vector with a trend was not found.

However, significant cointegrating vectors were found among log(HS), log(CON), and R^h when a trend was not included. Over 1960-93, the REGQMMC model had the best fit, followed by the FRB model, then the REGQSSC model, and finally the REGQU model (table A2). For the 1960-79 sample (table A3), FRB and REGQMMC variants have similar fits, the REGQSSC model has a slightly lower R^2, and the REGQU model had the worst fit (table A3). However, the error correction coefficient in the FRB model rises by 80% in size while that of DCR falls 31% in size when the sample is extended from 79:Q4 to 93:Q4 (table A4). The respective changes are +15%, and +2% for the REGQSSC, +5% and -23% for the REGQMMC, and +5% and -70% for the REGQU models. Like table 2, table A4 shows that key coefficients are more stable when Reg Q effects are properly measured and that, in this respect, REGQSSC and, to a somewhat lesser extent, REGQMMC outperform the FRB model's Reg Q dummy (DCR) and a naive Reg Q term (REGQU).

Table A1: Two-Stage FRB Model Variants (1960-93)--Trend

Variables	FRB Model	Credit Control-Modified FRB Model	REGQSSC -Modified FRB Model	REGQMMC -Modified FRB Model	REGQU -Modified FRB Model
constant	0.1645**	0.1532**	0.1630**	0.1909**	0.1441**
	(6.80)	(6.66)	(7.01)	(7.77)	(5.99)
$ECFRB_{t-1}$	-0.0992**	-0.0923**	-0.0982**	-0.1153**	-0.0864**
	(-6.74)	(-6.60)	(-6.95)	(-7.71)	(-5.90)
DCR_t	-0.0020**	-0.0023**			
	(-3.04)	(-3.57)			
$REGQ_{t-1}$			-0.0010**	-0.0015**	-0.0002*
			(-3.52)	(-4.12)	(-1.99)
$Control_t$		-0.0086**	-0.0071**	-0.0083**	-0.0068**
		(-4.11)	(-3.40)	(-4.04)	(-3.08)
$\Delta[\log(R^h)]_t$	-0.0005	-0.0009	-0.0005	-0.0009	-0.0005
	(-0.77)	(-1.52)	(-0.95)	(-1.61)	(-0.89)
$\Delta[\log(HS)]_{t-1}$	1.0561**	1.0347**	1.0535**	1.0079**	1.0875**
	(13.03)	(13.49)	(13.98)	(13.13)	(14.13)
$\Delta[\log(HS)]_{t-2}$	-0.2831**	-0.2471**	-0.2733**	-0.2547**	-0.3066**
	(-3.97)	(-3.64)	(-4.16)	(-3.90)	(-4.59)
Corrected R^2	.9554	.9603	.9602	.9615	.9577
Durbin H	-0.036	0.4120	0.5971	0.4821	0.9745*
Q(24)	30.09	26.37	26.43	33.27	27.00

* (**) denotes significant at the 95% (99%) level.
n.a.--not applicable.
t-statistics in parentheses.

Table A2: Two-Stage FRB Model Variants--No Trend (1960-93)

Variables	FRB Model	Credit Control-Modified FRB Model	REGQSSC-Modified FRB Model	REGQMMC-Modified FRB Model	REGQU-Modified FRB Model
constant	-0.0006	-0.0005	-0.0005	-0.0010	0.0002
	(-0.94)	(-0.72)	(-0.75)	(-1.65)	(0.32)
$ECFRB_{t-1}$	-0.0902**	-0.0835**	-0.0878**	-0.1076**	-0.0773**
	(-6.59)	(-6.38)	(-6.62)	(-7.58)	(-5.69)
DCR_t	-0.0022**	-0.0024**			
	(-3.19)	(-3.70)			
$REGQ_{t-1}$			-0.0010**	-0.0017**	-0.0003*
			(-3.47)	(-4.34)	(-2.22)
$Control_t$		-0.0085**	-0.0070**	-0.0081**	-0.0066**
		(-4.03)	(-3.30)	(-4.04)	(-2.95)
$\Delta[\log(R^h)]_t$	-0.0003	-0.0007	-0.0004	-0.0007	-0.0004
	(-0.57)	(-1.32)	(-0.74)	(-1.34)	(-0.66)
$\Delta[\log(HS)]_{t-1}$	1.0751**	1.0543**	1.0813**	1.0244**	1.1064**
	(13.36)	(13.82)	(14.43)	(13.44)	(14.45)
$\Delta[\log(HS)]_{t-2}$	-0.3029**	-0.2664**	-0.2991**	-0.2767**	-0.3248**
	(-4.26)	(-3.92)	(-4.55)	(-4.27)	(-4.85)
Corrected R^2	.9549	.9597	.9592	.9611	.9570
Durbin H	-0.5199	0.1255	0.3539	0.1487	0.7043
Q(24)	30.54	26.31	26.72	33.32	27.07

* (**) denotes significant at the 95% (99%) level.
n.a.--not applicable.
t-statistics in parentheses.

Table A3: Two-Stage FRB Model Variants--No Trend (1960-79)

Variables	FRB Model	REGQSSC -Modified FRB Model	REGQMMC -Modified FRB Model	REGQU -Modified FRB Model
constant	-0.0004 (-0.11)	-0.0033 (-1.08)	-0.0050+ (-1.71)	-0.0031 (-0.97)
$ECFRB_{t-1}$	-0.0501* (-2.03)	-0.0761** (-3.03)	-0.1030** (-9.71)	-0.0734** (-2.91)
DCR_t	-0.0031** (-3.75)			
$REGQ_{t-1}$		-0.0010* (-2.41)	-0.0018** (-3.73)	-0.0009* (-2.28)
$\Delta[\log(R^h)]_t$	-0.0022+ (-1.72)	-0.0014 (-1.01)	-0.0017 (-1.32)	-0.0012 (-0.66)
$\Delta[\log(HS)]_{t-1}$	1.0280** (9.69)	1.1250** (10.69)	1.0295** (9.71)	1.1330** (10.79)
$\Delta[\log(HS)]_{t-2}$	-0.2090* (-2.04)	-0.3229** (-3.26)	-0.2805** (-2.94)	-0.3293** (-3.32)
Corrected R^2	.8933	.8822	.8931	.8814
Durbin H	-2.6771	-1.7333**	-2.4965**	-1.7200
Q(24)	25.76	22.32	24.55	22.87

* (**) denotes significant at the 95% (99%) level.
n.a.--not applicable.
t-statistics in parentheses.

Table A4: Key Estimated Coefficients From Two-Stage FRB Model Variants
(Error-correction terms based on cointegrating vectors with no trend)

Variables	FRB Model 60:1-93:3	Credit Control-Modified FRB Model 60:1-93:3	FRB Model 60:1-79:4	RegQSSC -Modified FRB Model 60:1-93:3	RegQSSC -Modified FRB Model 60:1-79:4
error-correction	-0.090248	-0.083462	-0.050159	-0.087799	-0.076073
(Δ since 79:4)	(+80%)	(+66%)	n.a.	(+15%)	n.a.
Disintermediation[1]	-.002154	-.002366	-.003127	-.000975	-.000959
(Δ since 79:4)	(-31%)	(-24%)	n.a.	(+2%)	n.a.

Variables	REGQU -Modified FRB Model 60:1-93:4	REGQU -Modified FRB Model 60:1-79:4	REGQMMC -Modified FRB Model 60:1-93:4	REGQMMC -Modified FRB Model 60:1-79:4
error-correction	-0.077323	-0.073364	-0.107579	-0.102728
(Δ since 79:4)	(+5%)	n.a.	(+5%)	n.a.
Disintermediation[1]	-0.000266	-.000885	-.001667	-.001822
(Δ since 79:4)	(-70%)	n.a.	(-23%)	n.a.

1. DCR for the FRB models, various Reg Q terms for regulation-modified models.

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