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Monetary policy transmission and trade-offs in the United States: Old and new

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Abstract

This study shows that monetary policy transmission in the United States has evolved considerably over the postwar period. Since the mid-1980s, the effects of monetary policy on credit and housing markets have become much stronger relative to the impact on gross domestic product, while the effects on inflation have become weaker. We show that these changes in the relative effects of monetary policy can be explained by several important changes in the monetary transmission mechanism and in the composition of credit aggregates. Most notably, the increasing impact of monetary policy on credit was predominantly driven by an extraordinarily higher responsiveness of mortgage credit and a larger share of mortgages in total credit. These findings imply important changes over time in short-term monetary policy trade-offs between inflation and output stability on the one hand and between financial and macroeconomic stability on the other.

KEYWORDS

credit, house prices, inflation, monetary policy trade-offs, monetary transmission mechanism

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1 | INTRODUCTION

For most of the postwar period, the debate about monetary policy trade-offs has focused on the one between inflation and output stabilization. The trade-off arises because monetary policy affects both inflation and output so that a monetary policy aimed at stabilizing inflation could come at the cost of undesirable output volatility (Barnichon & Mesters 2021; Mankiw 2001). Specifically, a monetary policy tightening to bring inflation back to target would involve a potentially undesirable dampening of economic activity.

In the wake of the Great Financial Crisis (GFC), the debate has broadened to the question of whether monetary policy also faces a short-run intertemporal trade-off between macroeconomic and financial stability. Such a trade-off may arise because monetary policy affects both the macroeconomy and financial conditions. Monetary policy aimed at stabilizing the macroeconomy may induce undesirable swings in credit and asset prices, possibly affecting financial stability going forward. In this context, it has been suggested that central banks should explicitly take into account the impact of their monetary policy on financial stability risks by pursuing a 'leaning against the wind' policy (e.g., Adrian & Liang 2018; Borio 2014; Filardo & Rungcharoenkitkul 2016). Such a policy would involve implementing a tighter policy than would be indicated by macroeconomic conditions alone to lean against the build-up of financial imbalances. Sceptics, however, have argued that the output costs of such a policy would exceed its benefits (see Assenmacher-Wesche & Gerlach 2010; Benati 2021; IMF 2015; Svensson 2016).

In this paper, we re-examine the monetary policy transmission process and its implications for monetary policy trade-offs in the United States over the postwar period. The US economy and financial system have gone through significant changes in the late 1970s and early 1980s that could have altered monetary transmission, and hence monetary policy trade-offs. These include in particular the transition to a regime of low inflation and of greater macroeconomic stability ('Great Moderation'), financial liberalization and innovation with the phasing out of Regulation Q and the rise of mortgage securitization, and a tightening of home building regulation.[1]

We assess this question using standard vector autoregressions (VARs). More precisely, following Boivin et al. (2010) and Den Haan and Sterk (2011), we estimate VARs over the subsamples 1955–1979 and 1984–2008, reflecting the widespread notion that a change in macro-financial interrelations might have occurred sometime in the early 1980s as a consequence of the structural changes mentioned above. Our sample period ended in 2008, when the federal funds rate fell to the zero lower bound. However, extending the sample period beyond 2008 using the shadow rate of Wu and Xia (2016) does not materially affect the results, suggesting that the transmission mechanism has not changed much in the wake of GFC.

Based on this approach, we first explore monetary transmission at the aggregate level, assessing changes in transmission to the macroeconomy as well as to total credit and house prices. Based on the estimates, we characterize the short-term monetary policy trade-offs between output, inflation, credit and house price stabilization. In the second step, we analyse changes in transmission to the components of output and credit as well as to the mortgage holdings of bank and nonbank intermediaries. This second step of the analysis helps to shed light on the underlying forces driving changes in transmission at the aggregate level. It further reveals how the aggregate effects of monetary policy are distributed across the different sectors of the economy and of the financial system.

Our findings suggest that there have been substantial changes in US monetary policy transmission and trade-offs since the mid-1980s.

We find that the effects of monetary policy on credit and house prices became considerably stronger in the Great Moderation period. This is a new result. We further find that the effects on the price level became considerably weaker while those on real gross domestic product (GDP stayed broadly unchanged, in line with evidence reported in, for example, Boivin et al. (2010) and Belongia and Ireland (2016).

These changes in transmission have profound implications for monetary policy trade-offs. They imply a significant change in the macroeconomic stability–financial stability trade-off. Specifically, a monetary expansion that raised the price level (real GDP) by 1% in the Great Moderation period led to a rise in real house prices and real credit by, respectively, 8.8% (3.8%) and 5.2% (2.3%). Before the 1980s, this was only 0.4% (0.3%) and 1.2% (0.9%), respectively. This suggests that macroeconomic stabilization, in particular inflation stabilization, by means of monetary policy has become associated with greater fluctuations in credit and housing markets. In reverse, leaning against credit and house prices has become less costly in terms of macroeconomic volatility. At the same time, our results suggest that price stability-oriented monetary policy became more costly in terms of real output volatility in the short run. Specifically, the decline in real GDP associated with a lowering of the price level through tighter monetary policy almost doubled in the recent sample period. In reverse, stabilizing output became less costly in terms of price level volatility.

The disaggregated analysis of transmission to the components of aggregate credit and output highlights important changes in the distributional effects of monetary policy. The stronger effects of monetary policy on aggregate credit since the mid-1980s were the result of (i) an increased share of mortgage credit in total credit combined with (ii) a substantial rise in the sensitivity of mortgages to monetary policy shocks over time. Over this period, monetary policy thus mainly affected credit to households and noncorporate (small) firms, as these borrowers rely heavily on mortgage credit. In contrast, the impact on corporate debt was much weaker, reflecting this sector's increasing ability to smooth monetary shocks through debt securities issuance and commercial and industrial (C&I) loan drawdowns. This change in the transmission to the credit components is reflected on the output side in greater effects of monetary policy on consumption, residential investment and noncorporate nonresidential investment.

Stronger monetary transmission to mortgages over time in turn reflects primarily a stronger interest elasticity of banks' direct mortgage lending. By contrast, for Agency- and governement sponsored enterpise (GSE)-related mortgage lending, a countercyclical response emerged over the Great Moderation period, probably reflecting the public policy mandate and implicit government backing of these institutions. Increasing mortgage securitization has, therefore, tended to dampen the responsiveness of mortgage credit to monetary policy over the Great Moderation period.

Our findings contribute to the literature on monetary policy transmission and trade-offs in various ways. We offer new insights on monetary transmission and on the macroeconomic-financial stability trade-off by documenting a considerable strengthening of transmission to credit and housing relative to the macroeconomy in the Great Moderation. Previous studies have focused on estimates from the Great Moderation period only (e.g., Alpanda & Zubairy 2017; Assenmacher-Wesche & Gerlach 2010; Benati 2021; Calza et al. 2013) or longer periods cutting across different macroeconomic regimes (e.g., Bauer & Granziera 2017). Our estimates suggest that, while leaning against house prices and credit has become less costly in terms of macroeconomic stability, doing so would still involve significant output losses, as highlighted by Benati (2021). At the same time, however, our results also suggest that systematically stimulating the real economy and fine-tuning inflation in a low-inflation environment can come at the cost of large swings in house prices and credit, in particular mortgage credit. This is in line with evidence suggesting that accommodative monetary policy aimed at stimulating the economy and countering persistent low inflation have played a significant role in the build-up of financial imbalances before the GFC (e.g., Eickmeier & Hofmann 2013; Iacoviello & Neri 2010; Taylor 2007 2009).

We also provide new insights into the output-inflation trade-off. Our findings indicate a worsening of the trade-off, in line with evidence of a flattening of the Phillips Curve (e.g., Del Negro et al. 2020; Stock & Watson 2019) and better-anchored inflation expectations mitigating second-round effects of supply and demand shocks.[2] Our analysis of the inflation-output trade-off based on the impulse responses of output and prices to a monetary policy shock is comparable to the 'Phillips multiplier' proposed by Barnichon and Mesters (2021). They find a worsening of the trade-off post-1990 (i.e., a decline in the inflation impact relative to the output impact of monetary policy). Our results corroborate their findings and further highlight that the change in the aggregate trade-off involves important distributional changes in the form of stronger transmission to consumption, residential investment and investment of noncorporate firms.

The remainder of the paper is organized as follows. Section 2 presents evidence of changes in the effects of monetary policy on the US economy at the aggregate level and analyses the implications for monetary policy trade-offs. Section 3 then explores differences in monetary transmission at the disaggregate level to the US national and financial accounts. Finally, Section 4 concludes.

2 | CHANGES IN THE EFFECTS OF MONETARY POLICY OVER TIME

2.1 | Methodology

We start the analysis by assessing changes in the aggregate effects of US monetary policy in the postwar period, following the large VAR-based literature on the macroeconomic and financial effects of an unexpected change in policy-controlled interest rates (e.g., Belongia & Ireland 2016; Bernanke & Mihov 1995; Christiano et al. 1996 1999; Coibion 2012; Leeper et al. 1996; Peersman 2005; Sims 1992). We estimate a six-variable VAR including in addition to the standard macro variables also house prices and credit to capture monetary transmission to these variables and their interaction with the macroeconomy. As such, the setup is similar to, for example, Goodhart and Hofmann (2008), Assenmacher-Wesche and Gerlach (2010) and Benati (2021).

Our baseline VAR has the following representation:

$$Y_t = c + A(L)Y_{t-1} + B\varepsilon_t, \tag{1}$$

where c is a matrix of constants and seasonal dummies and Y_t is a vector of endogenous variables comprising: (i) log real GDP; (ii) the log GDP deflator; (iii) log commodity prices; (iv) log real house prices; (v) the effective federal funds rate and (vi) log real credit to the private nonfinancial sector. Real GDP, the GDP deflator and the federal funds rate are taken from the FRED database. For commodity prices, we use the Thomson-Reuters commodity price index retrieved from Global Financial Data. Real house prices are obtained by deflating the nominal house price index from

Shiller (2015) with the GDP deflator. For total credit to the private nonfinancial sector, we use a broad measure given by the sum of total credit market debt (debt securities and loans) and total trade credit liabilities (trade payables) of the household and nonfinancial business sectors from the Financial Accounts of the United States (Federal Reserve Statistical Release Z.1). Real credit is obtained by deflating nominal credit by the GDP deflator.[3]

Real GDP and the GDP deflator form the macroeconomic block of the VAR model. We use the GDP deflator as our aggregate price level measure, but the results are similar when we use the CPI or the personal consumption deflator. The commodity price index is included to eliminate a price puzzle, that is, a counter-intuitive increase in the price level after a monetary contraction that plagues many VAR studies.[4] House prices and credit are included to capture developments in the housing and credit market. Finally, the federal funds rate is the monetary policy instrument.

The monetary policy shock is identified using timing assumptions, a widely used approach to identify and estimate the effects of monetary policy (Belongia & Ireland 2016; Boivin et al. 2010; Coibion 2012; Den Haan & Sterk 2011). Alternative approaches to identify monetary policy shocks, such as the narrative approach by Romer and Romer (2004) or the high-frequency approach by Gertler and Karadi (2015), cannot be used for our analysis because the required data are not available for the early part of our sample period. More specifically, for identification, we use a Cholesky identification scheme with the variables ordered as they are listed above. Monetary policy shocks are, therefore, assumed to have no contemporaneous impact on output, the price level and real house prices but could affect real credit flows immediately. The policy interest rate, in turn, is assumed to respond to contemporaneous changes in all variables except for credit. This ordering, which is consistent with previous studies (e.g., Belongia & Ireland 2016; Christiano et al. 1996 1999; Coibion 2012; Den Haan & Sterk 2011), reflects the notion that real output and goods and house prices are rather sluggish and do not respond within a quarter to monetary impulses, while financial flows are more flexible so that an immediate response cannot be ruled out. That said, changing the ordering of the variables, in particular ordering the federal funds rate last, hardly affects the results.

We estimate the VAR in (log) levels with four lags, which allows to account for implicit cointegrating relationships in the data (Sims et al. 1990). This is particularly important in the present case, given the evidence of a long-run relationship between credit and house prices that significantly influences the dynamics of both variables in the short run (see Goodhart & Hofmann 2008; Hofmann 2004).[5] It is also for this reason that we prefer the use of (log) level VARs throughout the analysis (also in the disaggregate analysis that follows later), as opposed to a factor-augmented VAR as developed by Bernanke et al. (2005) where all variables are required to be stationary. In our application, that would mean estimating the model in first differences and thus losing any long-run relationship in the dynamics of the system.

We assess changes in the effects of monetary policy by estimating the VAR over two sample periods. The first is 1955Q1-1979Q4 and the second is 1984Q1-2008Q4. The sample split follows Boivin et al. (2010) and Den Haan and Sterk (2011). It is motivated by the evidence of a structural change in the macroeconomic landscape in the early 1980s with a significant drop in macroeconomic volatility (Great Moderation) and the transition to a low-inflation regime in the wake of the Volcker disinflation. Since the exact date of the break in macroeconomic volatility cannot be identified with any precision, several years of data around the likely break are excluded from the estimation, that is, the years 1980–1983 which is essentially the period of the Volcker disinflation.[6] We also exclude the post-2008 period because policy rates were at the zero lower bound and additional monetary policy stimulus was provided through other policy tools, in particular large-scale asset purchases, rendering the policy rate an inaccurate summary indicator of the monetary policy stance. That said, running our VAR also including data for the period 2009–2019, and using a so-called shadow federal funds rate as the proxy policy instrument over this period, yields very similar results, as discussed in more detail below.

2.2 | Empirical results

Figure 1 shows the median impulse responses of each variable to a monetary policy shock over horizons of up to 32 quarters, together with 16th and 84th percentile error bands. The impulse responses for the early sample period are in red (dotted lines), and those for the Great Moderation period are in blue (full line with grey error bands). The peak effects on the key variables are reported in Table 1. To eliminate the effect of a change in the size of the interest rate innovation on the impulse responses, we re-scale the size of the shock to be the same in both sample periods, that is, to 100 basis points.

Comparing the subsample results, we observe several significant changes in the effects of monetary policy. Specifically, the effects of monetary policy on the price level became relatively weaker over time compared to the effects on real GDP. In the first period, the price level displayed a very persistent response, with a peak drop of 1.3% after 32 quarters. This compares with a trough in the aggregate price level response of −0.5% after 18 quarters in the second period. We also note

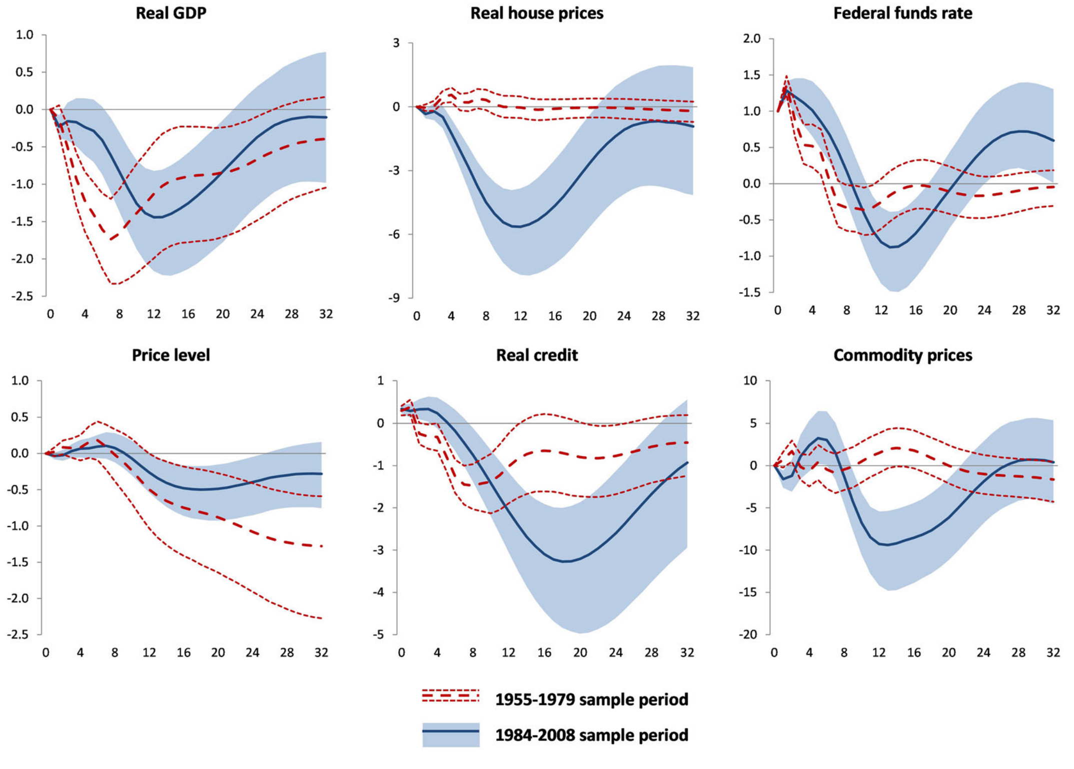

FIGURE 1 Impulse responses to a monetary policy shock in the United States. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 1 Peak effects of monetary policy.

	1955–1979		1984–2008	
	Impact	**Horizon**	**Impact**	**Horizon**
Real GDP	−1.74	7	−1.44	12
Price level	−1.28	32	−0.50	18
Real house prices	−0.20	32	−5.64	12
Real credit	−1.47	8	−3.27	18

Note: Peak effects of a 100 bps interest rate shock with corresponding horizon (quarter).

that there was a more delayed impact on real GDP in the second sample period, with the trough reached after 12 instead of seven quarters. The maximum decline was somewhat smaller in the second period (1.4% vs. 1.7% in the first period), but the error bands overlap.

By contrast, the dynamic effects of monetary policy on house prices and credit, as well as on commodity prices, became much larger over time compared to those on output and the price level. While real house prices did essentially not respond in the first period, they dropped by 5.6% after 12 quarters in the second sample period. The impact on credit more than doubled in size and became more persistent, that is, real credit fell by up to 1.5% after eight quarters in the first period and by up to 3.3% after 18 quarters in the second.[7] Finally, we also find a stronger negative response of commodity prices over time. Commodity prices did not respond significantly in the first sample but dropped by more than 9% after 13 quarters in the second period.

The finding that the macroeconomic effects of monetary policy became more delayed and weaker in the early 1980s is broadly in line with the existing literature, for example, Boivin et al. (2010), Den Haan and Sterk (2011) and Belongia and Ireland (2016). On the other hand, the substantially stronger impact of monetary policy on house prices and credit is a new result.[8] It is consistent with the cross-county evidence reported by Iacoviello and Minetti (2003) and Calza et al. (2013) that house prices and credit respond significantly more strongly in countries with more liberalized financial systems.

The results are broadly robust to an extension of the sample to the post-2008 period. From 2008 till 2015, the federal funds rate was at its zero lower bound and additional monetary policy stimulus was provided through other policy tools, in particular large-scale asset purchases. As a consequence, the policy rate did not represent an accurate summary indicator of the monetary policy stance over this period, which complicates the analysis of monetary transmission in a VAR setup like ours. Following Belongia and Ireland (2016), we re-run the VAR including data for the period 2009–2019 using the Wu and Xia (2016) shadow federal funds rate as the policy instrument over this period.[9] The appendix shows that this exercise yields qualitatively very similar results, albeit quantitatively the effects become somewhat smaller. That said, since the macro-financial dynamics that unfolded in the wake of the crisis were as unusual as the policy responses that they triggered, we prefer to proceed in the following disaggregated analysis with the model estimated up to 2008.[10]

2.3 | Implications for monetary policy trade-offs

As a consequence of these changes in monetary transmission, the short-run monetary policy trade-offs between output and price stability, on the one hand, and between macroeconomic and financial stability, on the other hand, changed considerably over this period. The weaker impact of monetary policy on the price level compared to real output rendered price stability-oriented policy more costly in real output terms. This is illustrated in Table 2, which reports for both periods the peak effects on real GDP induced by a monetary policy shock that shifts the price level by 1% (at its peak). The table reveals that reducing the GDP deflator by 1% came at the cost of a 1.3% fall in real output in the first period, compared to a drop of 2.4% in the second. Conversely, a monetary policy-induced 1% output stimulus was associated with a 0.8% and 0.4% rise in the price level in, respectively, the first and second periods. Thus, maintaining price stability had become more costly in real output terms in the Great Moderation, while output stabilization gave rise to less inflation volatility compared to the pre-1980 period.

On the other hand, the stronger impact on credit and house prices relative to real GDP and the price level suggests that stimulating or reducing output and inflation in the short run now came at the cost of larger credit and house price swings than before. Specifically, as can be seen in Table 2, engineering a 1% impact on real GDP through monetary policy involved essentially no effect on house prices and a 0.9% peak change in real credit in the first period. However, in the second period, the maximum changes in house prices and credit were, respectively, 3.7% and 2.2%. The rise in house price and real credit volatility was even stronger for a monetary stimulus that engineered a 1% increase in the price level, that is, house prices and credit increased by, respectively, 0.4% and 1.2% in the early sample period, compared to 8.8% and 5.2%, respectively, in the second period.

Another implication of the changes in transmission is that monetary policy apparently became a more effective tool for leaning against house price and credit booms, owing to the greater interest rate sensitivity of these variables and the weaker macroeconomic repercussions of monetary policy shocks. A monetary policy-induced 1% impact on real credit implied a maximum effect on real GDP of more than 1% in the first period but of <0.5% in the second. Furthermore, the output costs of lowering real house prices by 1% declined from 3.2% to 0.3%. That said, a fully fledged analysis of the net benefits of leaning-against-the-wind policies is beyond the scope of this paper.[11] The main point to take away here is that monetary transmission in the United States seems to have changed in the mid-1980s in a way that increased the net benefits of a leaning against the wind policy.[12]

3 | WHAT EXPLAINS THE CHANGES? A DISAGGREGATED ANALYSIS

In this section, we delve deeper into the economic and financial accounts to assess how monetary policy was transmitted to the components of output and credit. This exercise serves two purposes: (i) understanding which underlying factors were driving the changes in monetary transmission at the aggregate level and (ii) shedding light on potentially policy-relevant changes in monetary transmission at the disaggregated level.

3.1 | Methodology

We analyse monetary transmission to the economic and financial accounts based on an extended version of our baseline VAR. Specifically, we re-estimate the VAR separately including output and credit subaggregates, akin to the VAR analysis of transmission to the flow of funds

TABLE 2 Monetary policy trade-offs.

	Shifting real GDP		**Shifting the price level**		**Shifting real house prices**		**Shifting real credit**	
	1955–1979	**1984–2008**	**1955–1979**	**1984–2008**	**1955–1979**	**1984–2008**	**1955–1979**	**1984–2008**
Real GDP	1.00	1.00	1.34	2.42	3.26	0.27	1.08	0.46
	[1.00 1.00]	[1.00 1.00]	[0.88 2.27]	[1.62 3.83]	[1.90 6.78]	[0.19 0.36]	[0.85 1.39]	[0.37 0.57]
Price level	0.75	0.41	1.00	1.00	2.43	0.11	0.81	0.19
	[0.44 1.14]	[0.26 0.62]	[1.00 1.00]	[1.00 1.00]	[1.30 4.89]	[0.07 0.16]	[0.42 1.42]	[0.11 0.32]
Real house prices	0.31	3.67	0.41	8.83	1.00	1.00	0.33	1.70
	[0.15 0.53]	[2.79 5.14]	[0.20 0.77]	[6.17 14.58]	[1.00 1.00]	[1.00 1.00]	[0.15 0.61]	[1.34 2.30]
Real credit	0.93	2.17	1.23	5.23	3.04	0.59	1.00	1.00
	[0.72 1.17]	[1.74 2.68]	[0.70 2.41]	[3.16 9.16]	[1.63 6.69]	[0.43 0.75]	[1.00 1.00]	[1.00 1.00]

Note: Estimated peak impacts on the variables in the respective row, induced by a monetary policy shock that shifts the variables in the column by 1%. 16th and 84th percentiles are in brackets.

of Christiano et al. (1996). However, to keep the identified monetary policy shock invariant to the inclusion of additional variables in the system, we assume, following Peersman and Smets (2001), that each additional variable does not affect the variables that were included in the benchmark VAR.

Formally, we estimate a block exogenous system of the form:

$$\begin{bmatrix} Y_t \\ z_t \end{bmatrix} = c + \begin{bmatrix} A(L) & 0 \\ C(L) & D(L) \end{bmatrix} \begin{bmatrix} Y_{t-1} \\ z_{t-1} \end{bmatrix} + \begin{bmatrix} B & 0 \\ b & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^Y \\ \varepsilon_t^z \end{bmatrix}, \tag{2}$$

where Y is the vector of endogenous variables defined as before and z is the additional variable included in the model, which is assumed to be affected by but not to affect itself the variables in Y.[13] We use the same Cholesky ordering as in Equation (1) to identify the monetary policy shock. For the additional variables added to the VAR, we further impose impact restrictions that are consistent with the Cholesky scheme used to identify the monetary policy shock. Specifically, for real GDP components we impose the restriction that they do not respond to the monetary policy shock on impact ($b = 0$), consistent with the identifying restrictions on aggregate real GDP. Credit subaggregates are allowed to react on the impact of a change in monetary conditions (b unrestricted), just like aggregate credit.

The interest rate elasticity of an economic or financial aggregate to an interest rate shock can be written as $\frac{\partial Y}{\partial i} = \sum_j \frac{\partial Y_j}{\partial i}\frac{Y_j}{Y}$, where $\frac{\partial Y}{\partial i}$ is the interest rate elasticity of the aggregate, $\frac{\partial Y_j}{\partial i}$ is the interest rate elasticity of a subcomponent and $\frac{Y_j}{Y}$ is the component's share in the aggregate. The contribution of a component to the aggregate elasticity is thus given by the component's elasticity weighted by its share. A rise in the interest rate elasticity of the aggregate could, therefore, be due to two factors: an increase in the interest rate elasticity of one or several subcomponents, or a rise in the share of more interest rate-sensitive subcomponents. Thus, the evolution over time of both the subaggregates' shares and interest rate elasticities needs to be assessed to understand the changes at the aggregate level documented in the previous section. Note that the sum of the estimated contributions may not exactly equal the aggregate elasticities because the respective components' elasticities are estimated without such a restriction imposed.

3.2 | Transmission to GDP components

We start by exploring changes in transmission to the components of aggregate GDP, using data from the National Income and Product Accounts (NIPA) provided by the Bureau of Economic Analysis. Figure 2 reports the impulse responses of the components. Table 3 shows for the two sample periods the respective average share of components in total GDP, the elasticity of the components at the peak real GDP response and the estimated contribution of the components to the peak response.

The results suggest that the interest rate elasticity of private consumption and private residential investment increased over time, but that this increase was offset by greater import leakage and, to a lesser extent, a less procyclical reaction of government expenditures. The contribution of personal consumption to the peak decline in real GDP went up from −0.85% to −1.10% points, while that of residential investment almost doubled from −0.17% to −0.32%

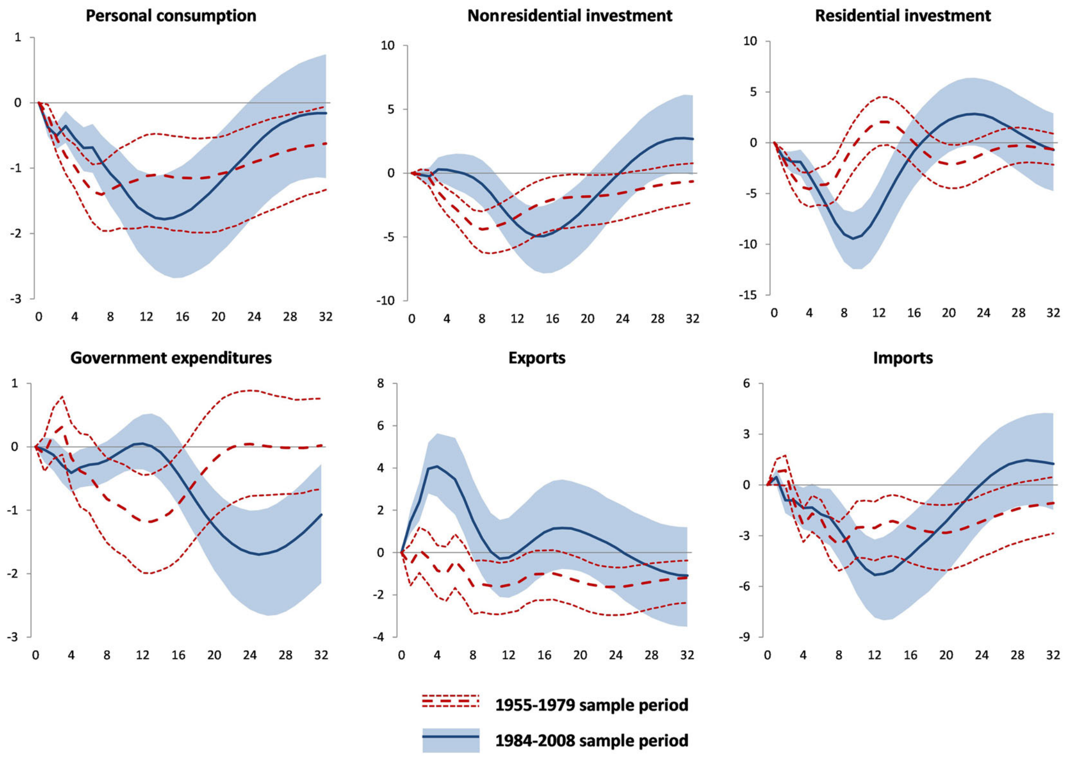

FIGURE 2 Impulse responses of GDP components. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

points. Figure 2 shows that residential investment was the GDP component that responded fastest and strongest to a monetary impulse in both periods. The peak impact of monetary policy on this aggregate more than doubled between the two periods, from −4.5% after four quarters in the first period to −9.5% after ninequarters in the second. The elasticity and contribution of nonresidential investment did essentially not change between the two periods.

In spite of the stronger impact of monetary policy on private GDP components, the peak impact on aggregate GDP was similar in the second period because of a considerable change in the dynamic reaction of imports and government expenditures. Real imports became more interest rate-sensitive over time. At the same time, the import-to-GDP ratio more than doubled between the two periods. As a result, the countervailing contribution of imports to the peak drop in GDP increased from 0.17% points to 0.66% points (Table 3).[14] The larger negative contributions of the private GDP components in the second period were, therefore, largely offset by greater import leakage. At the same time, the contribution of government expenditures decreased from −0.15% points to zero, reflecting a less procyclical reaction pattern (Table 3). While government expenditures dropped significantly in the wake of a monetary tightening in the first period, they decreased only slightly immediately after the shock and then moved back to baseline when the private GDP components contracted in the second period (Figure 2). Only after 16 quarters, when private GDP recovered, there was a significant fall in government expenditures.

A striking additional observation from the analysis of the NIPA aggregates is a substantial change over time in the relative effects of monetary policy on the corporate and the

TABLE 3 Effects of monetary policy on GDP components.

	Component/GDP (%)		Impact on component (%)		Contribution to total impact	
	1955–1979	1984–2008	1955–1979	1984–2008	1955–1979	1984–2008
Personal consumption	60.2	65.2	−1.40	−1.68	−0.85	−1.10
Nonresidential investment	11.4	12.8	−4.17	−4.05	−0.47	−0.52
Residential investment	4.9	4.7	−3.42	−6.77	−0.17	−0.32
Government expenditures	22.5	19.6	−0.65	0.05	−0.15	0.01
Export	5.8	9.6	−0.87	−0.24	−0.05	−0.02
Import	−5.5	−12.3	−3.08	−5.32	0.17	0.66
Change in inventories	0.8	0.4				
Total	100.0	100.0			−1.51	−1.29

Note: Component/GDP is calculated based on US National Income and Product Accounts data; impact on components is the estimated effect on the component in the quarter of the peak impact on real GDP; contribution to total impact is the product of component share and impact.

noncorporate business sectors' nonresidential investment, shown in Figure 3. While the peak impact on corporate nonresidential investment did not change over time, noncorporate investment responded much more strongly in the second period, with a peak impact that increased almost fourfold to −8.5%. Noncorporate investment became more sensitive to monetary policy than corporate investment, while the opposite was the case before the 1980s. This change in the response of corporate and noncorporate investment reflected significant changes in the impact of monetary policy on the two sectors' funding conditions, as discussed in the following subsection.

3.3 | Transmission to credit components

We next assess the drivers of the change in the response of aggregate credit. This assessment is based on a breakdown of total credit by instrument and by borrowing sector provided by the Flow of Funds, the Financial Accounts of the United States (Federal Reserve Statistical Release Z.1).[15] We analyse monetary transmission to the two broad instrument categories of total nonfinancial sector private credit (mortgages vs. other credit)[16] and to the three nonfinancial private borrowing sectors (households, corporates and noncorporates). Figure 4 displays the full impulse responses of the credit components. Table 4 shows the average component shares in total credit, the component elasticity at the peak response of total credit and the contribution of the components to the peak response of total credit.

The results reveal that the stronger reaction of credit in the second period was mainly driven by a significant increase in the interest rate elasticity of mortgage debt and a larger share of mortgages in total credit (Table 4). Since the bulk of mortgage loans is to households and noncorporate firms, it was the stronger response of these two borrowing sectors' mortgages that made the largest contribution to the increase in the aggregate credit response to a monetary policy shock over time. In particular, the contribution of household mortgages to the peak credit response increased from −0.3% to −1.2% points, while that of noncorporate mortgages went up from −0.1% to −0.7% points. Overall, the contribution of mortgage credit to the peak response of total credit increased from −0.5% points to −2.3% points (Table 4).

The elasticity and contribution of other (nonmortgage) types of credit did essentially not change between the two periods. There were, however, notable changes at the borrowing sector level. Specifically, the interest rate elasticity of nonmortgage debt of households and noncorporates increased, while that of corporates decreased (see Table 4). Figure 4 shows that the response of corporate nonmortgage debt was in fact never significantly negative in the second period. It significantly increased for up to eight quarters after a monetary tightening and then returned to baseline. This compares to a short-lived initial increase and a significant drop after six quarters in the first period. The weaker impact of monetary policy on corporates over time reflects this sector's increasing ability to smooth out monetary shocks through debt securities issuance and C&I loan drawdowns.

The differential impact of monetary policy on mortgage and nonmortgage debt translates into disparate total debt responses at the borrowing sectors' level, reflecting the significant cross-sectoral differences in funding structure. While the response of household and noncorporate debt was considerably stronger in the second period, that of corporate debt was much weaker (Figure 4). This result reflects primarily differences in the weight of mortgage debt across the three borrowing sectors, as documented in Table 4. Since the bulk of household and noncorporate debt took the form of mortgages, the changes in the mortgage responses were also

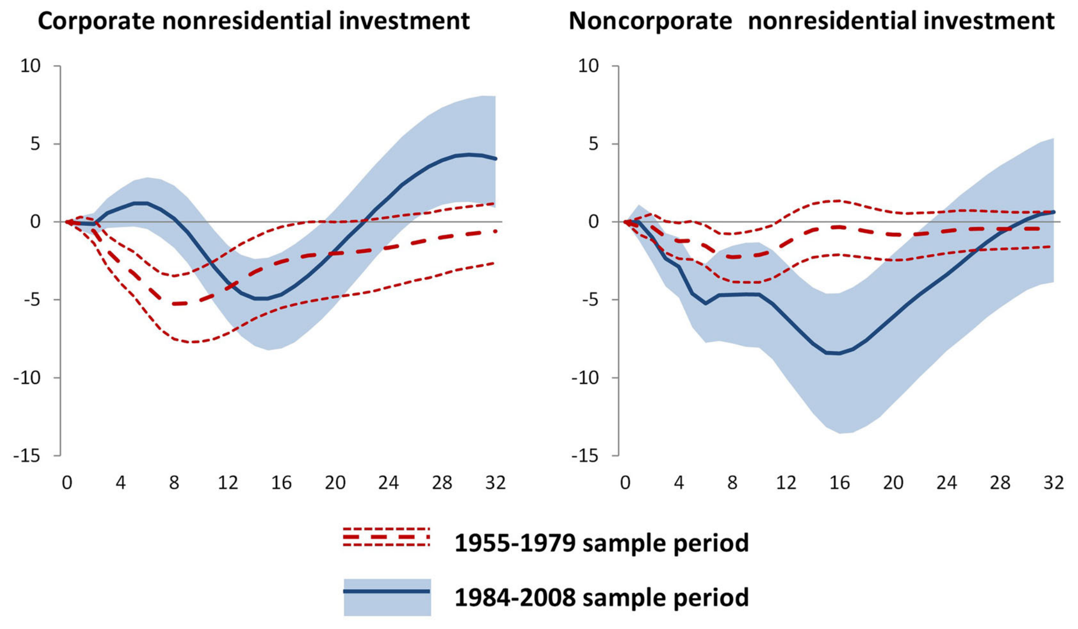

FIGURE 3 Impulse responses of nonresidential investment. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

reflected in these sectors' aggregate debt reactions. By contrast, since mortgages accounted only for a small share of corporate debt, the significant increase in interest rate sensitivity that was also registered for corporate mortgages did not feed through to the sector's aggregate debt impulse response.

These results also suggest that the notion that small (noncorporate) firms are more strongly impacted by monetary policy than large (corporate) firms because they are more financially constrained (Christiano et al. 1996; Gertler & Gilchrist 1994) held true only since the 1980s. In fact, corporate debt contracted more than noncorporate debt in the first sample period. For the second period, we find that noncorporate debt declined strongly, while corporate borrowing escaped essentially unscathed from a monetary tightening. This was the consequence of the ability of corporates to raise funds through many channels, including debt securities, while noncorporates were fully impacted by the stronger transmission of monetary policy to mortgage credit. This difference in the impact of monetary policy on the funding situation of the two sectors is also reflected in the reaction of their nonresidential investment, as discussed in the previous subsection.

3.4 | Transmission to mortgage credit

What has driven the stronger transmission to mortgage credit? To answer this question, we zoom in on the transmission of monetary policy to the mortgage finance sector, distinguishing between four different types of mortgage debt counterparties: (i) direct mortgage holdings of banks, or retained bank mortgages (banks are private depository institutions (PDIs), that is, commercial banks and credit unions); (ii) direct mortgage holdings of nonbanks (primarily of the household sector, the life-insurance sector, finance companies and mortgage real estate

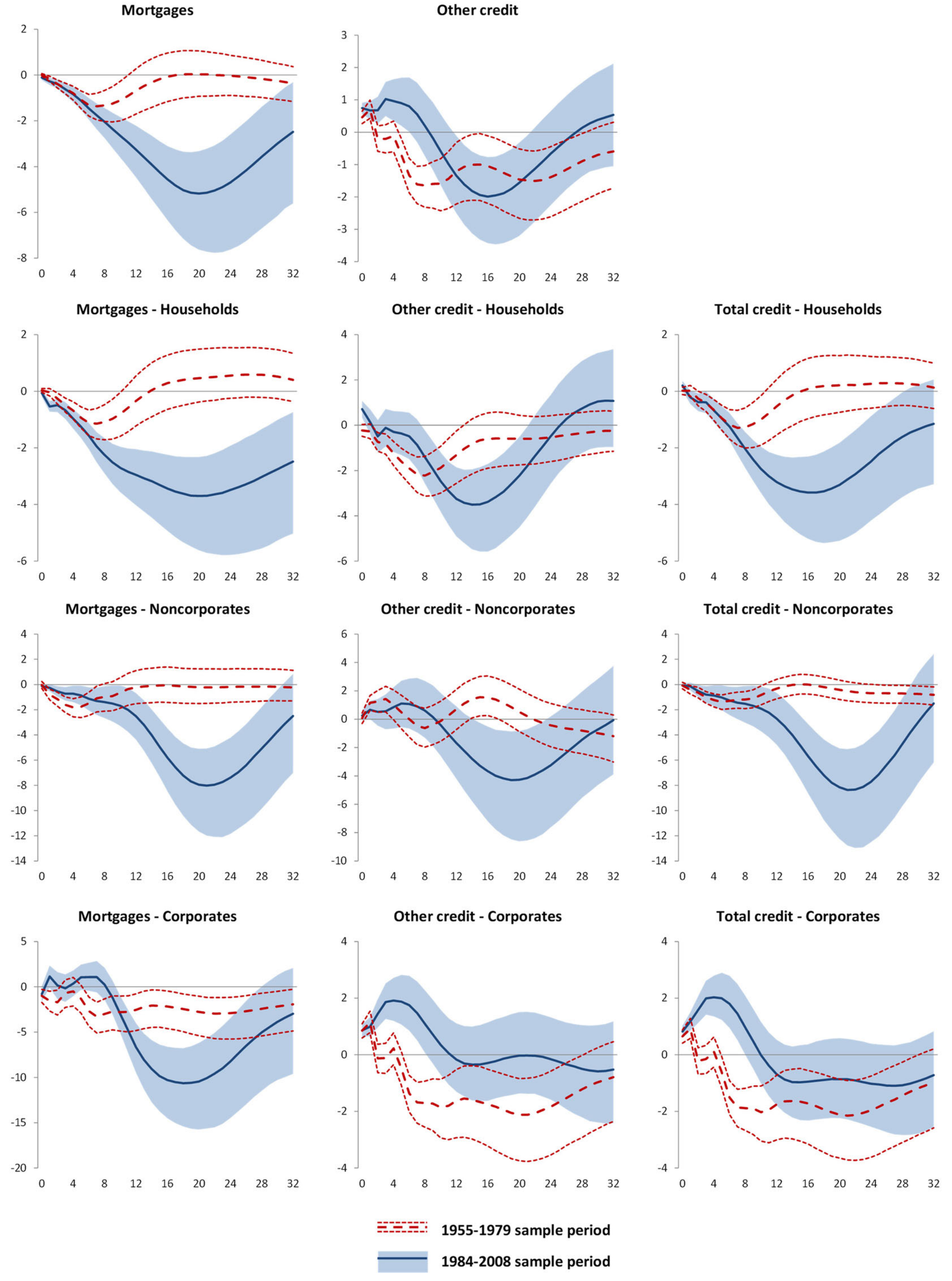

FIGURE 4 Impulse responses of private nonfinancial credit components. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

TABLE 4 Effects of monetary policy on private nonfinancial sector credit components.

	Component/total credit (%)		Impact on component (%)		Contribution to total impact	
	1955–1979	1984–2008	1955–1979	1984–2008	1955–1979	1984–2008
Mortgages	41.1	45.8	−1.33	−5.03	−0.55	−2.31
Other credit	58.9	54.2	−1.65	−1.89	−0.97	−1.02
Total	100.0	100.0			−1.51	−3.33
Households	43.2	48.0	−1.27	−3.53	−0.55	−1.70
Mortgages	*26.9*	*32.7*	*−1.09*	*−3.62*	*−0.29*	*−1.18*
Other credit	*16.3*	*15.3*	*−2.22*	*−2.93*	*−0.36*	*−0.45*
Noncorporates	15.2	15.0	−1.20	−7.20	−0.18	−1.08
Mortgages	*9.3*	*10.3*	*−0.98*	*−7.22*	*−0.09*	*−0.74*
Other credit	*5.9*	*4.7*	*−0.63*	*−4.18*	*−0.04*	*−0.20*
Corporates	41.7	37.0	−1.89	−0.89	−0.79	−0.33
Mortgages	*4.9*	*2.9*	*−2.99*	*−10.6*	*−0.15*	*−0.31*
Other credit	*36.7*	*34.1*	*−1.71*	*−0.14*	*−0.63*	*−0.05*
Total	100.0	100.0			−1.52	−3.10

Note: Component/total credit is calculated based on US Financial Accounts data; impact on the component is the estimated effect on the component in the quarter of the peak impact on total real credit; contribution to total impact is the product of component share and impact.

investment trusts (iii) mortgages securitized by Agencies and GSEs (GSE holdings and Agency- and GSE-backed mortgage pools) and (iv) mortgages securitized by private-label asset backed securities (ABS) issuers. The latter can only be analysed for the second period due to data availability. Figure 5 shows the full impulse responses while Table 5 shows the average component shares in total mortgages, the elasticities at the peak response of total mortgages and the contributions to the peak response.

The results reveal that the stronger response of mortgage credit over time reflects larger interest rate elasticities of the direct mortgage holdings of banks and nonbanks, although their combined share in total mortgages dropped from almost 95% to <60% between the two periods (Table 5). The interest rate elasticity of retained bank mortgages increased significantly (Figure 5), possibly reflecting a strengthening of the bank risk-taking channel linked to the dynamics of house prices and corresponding collateral values (Peersman & Wagner 2015). The contribution of bank-retained mortgages to the peak response of mortgages increased from −1.26% points to −2.29% points, accounting in both periods for the bulk of the overall effect. Nonbank direct mortgage holdings displayed a persistent fall in the second period, compared to a slight, albeit not statistically significant increase in the earlier period. The contribution to the peak mortgage response in the second period was, however, a mere −0.69% points.

Securitized mortgages, in contrast, dampened the response of aggregate mortgages (Table 5). Figure 5 further shows that securitized mortgages display reaction patterns that differ starkly from those of aggregate mortgages. Private-label securitized mortgages declined sharply and rapidly after a monetary tightening in the second sample period (by up to 7% after three

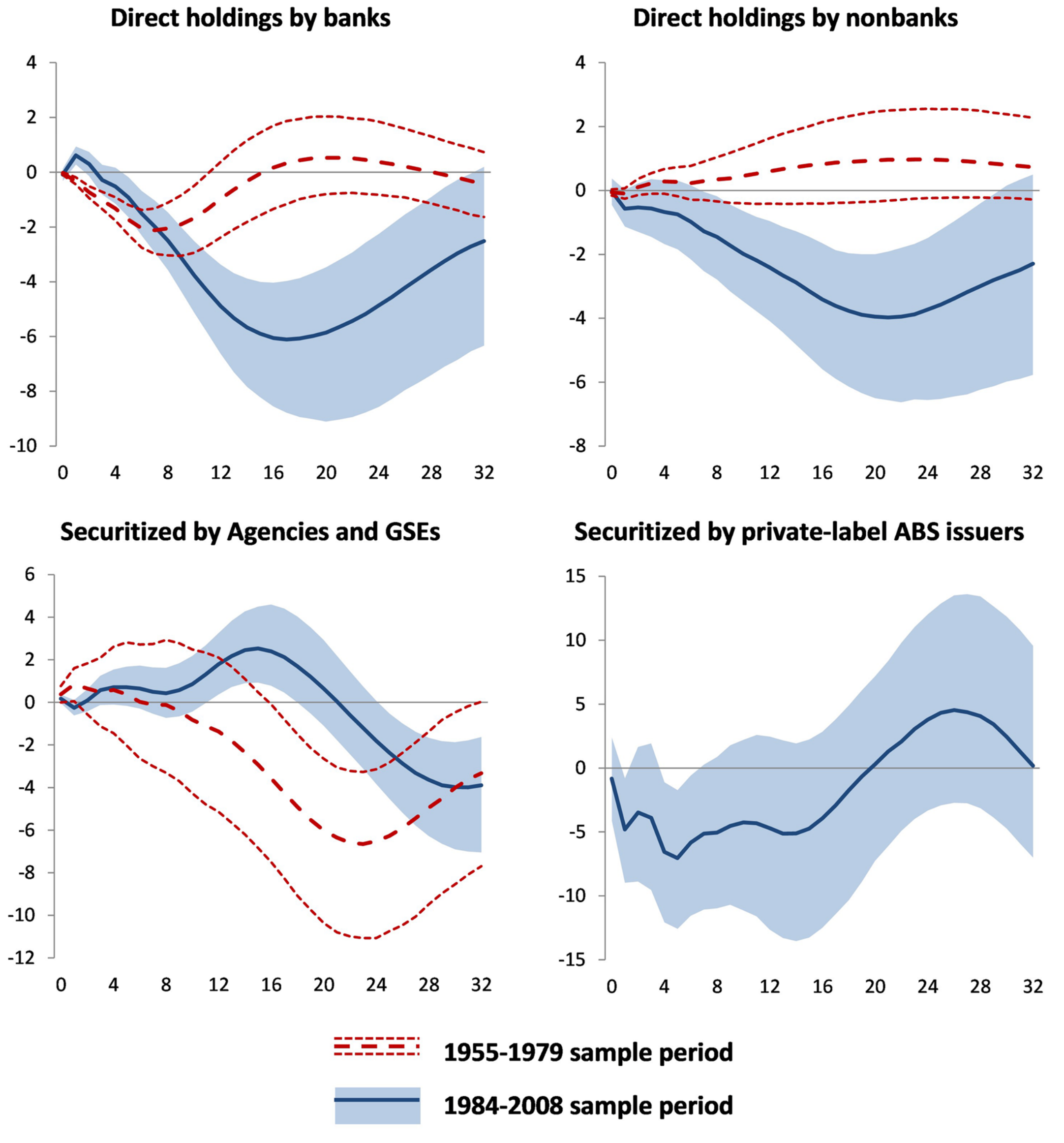

FIGURE 5 Impulse responses of mortgage counterparties. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

quarters), possibly indicating a strong investor risk-taking channel at work for these securities. However, the share of the private-label securitized mortgages in total mortgages was too small (7.3%) to have a notable impact on the aggregate mortgage reaction. By contrast, Agency- and GSE-securitized mortgages display a countercyclical response, which has become more pronounced over time.[17] In the first period, Agency-and GSE-securitized mortgages slightly increased initially after the shock and fell significantly only after 16 quarters. In the second period, they increased significantly by approximately 2% after 12–16 quarters (i.e., when retained bank mortgages register their largest decline), and only started to fall when mortgage lending by other institutions recovered. The countercyclical dynamics of Agency- and

TABLE 5 Effects of monetary policy on mortgage counterparties.

	Component/total mortgages (%)		Impact on component (%)		Contribution to total impact	
	1955–1979	**1984–2008**	**1955–1979**	**1984–2008**	**1955–1979**	**1984–2008**
Direct holdings by banks	59.3	40.6	−2.12	−5.65	−1.26	−2.29
Direct holdings by nonbanks	35.4	17.3	0.29	−3.98	0.10	−0.69
Securitized by Agencies and GSEs	5.3	34.8	−0.11	0.04	−0.01	0.02
Securitized by private-label ABS issuers	0.0	7.3	0.00	1.30	0.00	0.09
Total	100.0	100.0			−1.16	−2.87

Note: Component/total mortgages are calculated based on US Financial Accounts data; impact on the component is the estimated effect on the component in the quarter of the peak impact on total real mortgages; the contribution to the total impact is the product of component share and impact.

GSE-securitized mortgages over this period may have reflected these institutions' mandate to stabilize mortgage markets and foster home ownership as well as countercyclical investor demand for Agency and GSE securities because of their perceived lower riskiness.[18] These factors probably played out more strongly over the Great Moderation period when the Agencies and GSEs gained market share and the outstanding pool and hence the liquidity of Agency- and GSE-backed securities increased.

An alternative explanation for the countercyclical reaction of Agency/GSE securities is the collateral demand by banks for repurchase transactions (repos). Nelson et al. (2017) suggest

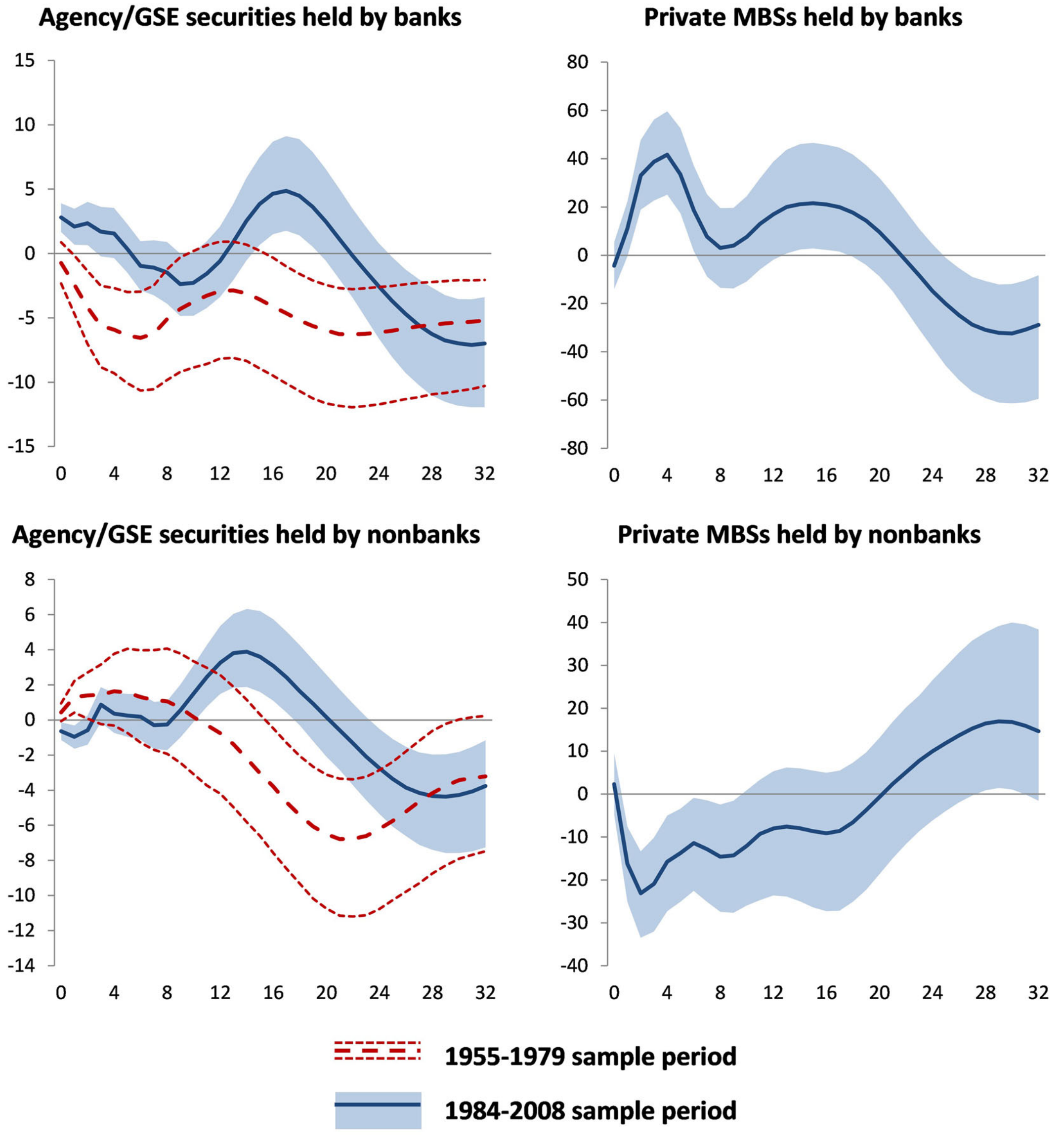

FIGURE 6 Impulse responses of Agency/GSE securities and private mortgage-backed securities. Median responses to a 100 bps shock with 16th and 84th percentile error bands; horizon is quarterly. [Color figure can be viewed at wileyonlinelibrary.com]

that banks increase securitization after a monetary tightening because they want to increase the pool of collateralizable assets available for repos. To assess the relevance of this channel, we explore differences in the impact of a monetary policy shock on the holdings of Agency/GSE securities and of private-label mortgage-backed securities (MBS) by banks and nonbanks. To do this, we use the information provided in banks' Consolidated Reports on Condition and Income (Call Reports) to back out banks' holdings of securitized mortgages following the approach described in Appendix A of Den Haan And Sterk (2011).[19] However, we go one step further and disentangle banks' Agency/GSE securities holdings from their private-label MBS holdings.[20]

The impulse responses of bank and nonbank holdings of Agency/GSE securities and of private-label MBSs lend support to the notion of a repo collateral channel. Figure 6 shows that banks increased their holdings in the second period, immediately after the monetary tightening and again after 18 quarters when the economic, housing and credit market downturns were playing out in full. In the first period, bank holdings instead displayed a significant decline. This change over time may have reflected the enormous growth of repo markets since the 1980s and the associated increase in the demand for collateralizable assets (Gorton & Metrick 2012). Nonbank investors, by contrast, aggressively shed private-label MBSs in the immediate aftermath of the tightening in the second period. The peak drop is almost 20% after two quarters. This response pattern further supports the notion of a strong investor risk-taking channel for private-label MBSs. For nonbank holdings of Agency/GSE securities we find, as for bank holdings, a significant increase around the peak of the monetary tightening-induced economic and credit downturn, probably reflecting investor flight to safety.

4 | CONCLUSIONS

Our analysis of the postwar US monetary transmission process indicates that a number of significant and policy-relevant changes have occurred since the mid-1980s. Comparing monetary transmission over the period covering the 1950s–1970s to that over the period from the mid-1980s until the outbreak of the GFC in 2008, we find that the effects of monetary policy on credit and house prices relative to those on the macroeconomy became considerably stronger. This is a new result with important policy implications. Macroeconomic stabilization through monetary policy was, therefore, associated with greater fluctuations in credit and housing markets. In reverse, stabilizing credit and house prices through monetary policy came at a lower cost in terms of macroeconomic volatility. We further find that the effects on the price level relative to those on output became weaker, in line with the findings of Barnichon and Mesters (2021). This implies that also the traditional trade-off between price and output stability changed, that is, price stability-oriented monetary policy became more costly in terms of real output volatility.

The stronger impact over time of monetary policy on housing and credit markets reflected important changes in transmission at the disaggregated level. The stronger transmission to aggregate credit was driven by mortgages, that is, the component that is most closely linked to housing market developments. As a consequence, monetary policy mainly affected funding conditions of households and noncorporate firms, who mainly rely on mortgage credit. The impact of monetary policy on corporates was much weaker, reflecting this sector's ability to smooth out monetary shocks through debt securities issuance and C&I loan drawdowns. The changes in the effects of monetary policy on house prices and credit were reflected in changes in the real effects of monetary policy, where we find a stronger transmission to consumption and in particular to residential investment and investment of noncorporate firms.

Our analysis of monetary transmission to the mortgage lending sector (i.e., the counterparties of mortgage debt) further shows that stronger transmission to mortgages was driven by a greater impact on direct mortgage holdings of banks and nonbanks. By contrast, Agency- and GSE-related mortgage lending increased in a countercyclical way after a monetary tightening. The rise of securitization has, therefore, dampened rather than driven the stronger transmission to housing and credit markets.

What are the implications of our results for policy going forward? Robustness checks suggest that our findings do qualitatively not change when we extend the sample beyond 2008 using a shadow rate (Wu & Xia 2016) as a proxy for the monetary policy instrument, but that the effects on all variables become quantitatively smaller. This may reflect the fact that some of the developments that have driven the strengthening of monetary transmission to housing and credit markets have been partly reversed in the wake of the GFC. In particular, mortgage lending has declined and private-label securitization activity essentially disappeared while Agency/GSE-related mortgage lending has become more important.[21] Yet, the implications for monetary transmission will remain an open question until enough observations from the postcrisis period are available.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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ENDNOTES

[1] For a detailed account of the transition to the low-inflation regime, see Sargent (2001); on the Great Moderation, see Bernanke (2004); on the phasing out of regulation Q, see for example, Mertens (2008); on mortgage securitization, see for example, Den Haan and Sterk (2011); on the tightening of US home building regulation, see Glaeser et al. (2005).

[2] Boivin et al. (2010) provide evidence of weaker effects of monetary policy shocks on inflation expectations since the mid-1980s. For evidence of reduced second-round effects following demand and supply shocks, see Hofmann et al. (2012).

[3] A number of studies have highlighted the importance of corporate credit spreads in the monetary policy transmission process (e.g., Gertler & Karadi 2015, Caldara & Herbst 2019). We have run our VAR with Moody's seasoned Baa corporate bond spread added as in Caldara and Herbst (2019) and found that it did not alter the responses of the other variables which are the focus of our analysis. For this reason, we decided not to include the corporate credit spread in our baseline VAR model.

[4] Sims (1992) first demonstrated this anomaly and showed that it tended to disappear when commodity prices were included in the VAR. He suggested that this was the case because the Federal Reserve responded to commodity prices as an indicator of future inflation so that its omission from the model would produce a price reaction that mainly reflected the response of monetary policy to perceived future inflation. Subsequent studies have, however, questioned the success of this modelling strategy (e.g., Den Haan & Sterk 2011). In our case, the inclusion of the commodity price index and total credit was instrumental in eliminating a price puzzle in the first sample period, while there was generally no price puzzle in the second sample period.

[5] Johansen cointegration tests indeed indicate the existence of long-run relationships between the variables in the VAR. A more explicit analysis of these long-run relationships is, however, not necessary for our purpose and is also beyond the scope of this paper.

[6] Ahmed et al. (2004) use the same sample split in their analysis of US GDP volatility, referring to empirical uncertainty about the precise break date. See, for instance, McConnell and Perez-Quiros (2000) and Stock and Watson (2002). The Volcker disinflation began in early 1980 when CPI inflation peaked at 14% and ended in late 1983 when CPI inflation had fallen to around 3%. See Goodfriend and King (2005) for a detailed discussion.

[7] Before decreasing, credit displays a small significant short-term increase after a monetary tightening in both periods. This initial increase is not a puzzle as it reflects increases in some components of credit that nonfinancial corporations in particular can draw on when monetary conditions tighten, as will be discussed and analysed in more detail later on.

[8] The response pattern of house prices over the second sample period is comparable to those reported by previous VAR-based studies estimated over a similar sample period, for example, Del Negro and Otrok (2007), Eickmeier and Hofmann (2013) and Bjørnland and Jacobsen (2013).

[9] Wu and Xia (2016) use a nonlinear term structure model to estimate a shadow federal funds rate that would capture conventional and unconventional monetary policy since 2009. Reflecting the range of expansionary unconventional monetary policy measures deployed by the Federal Reserve over this period, the shadow rate was in negative territory over this period, falling as low as −3%.

[10] The results of the disaggregated estimations over the sample extended beyond 2008 and using the shadow rate as the policy instrument are qualitatively similar to those reported in the following sections and are available upon request.

[11] Whether leaning against the wind is beneficial depends on a number of factors. One is the impact of monetary policy on the financial cycle, in particular on house prices and credit as leading indicators of financial crisis (see e.g., Schularick & Taylor 2012, Drehmann & Juselius 2013, Gertler & Hofmann 2018). Other factors include the ultimate effect of a policy-induced drop in house prices and credit on crisis probability and how this longer-term benefit compares with the short-term output costs of tighter policy. See Svensson (2016), Adrian and Liang (2018), and Filardo and Rungcharoenkitkul (2016) for quantitative analyses in this respect.

[12] Note also that, in the second period, the effect of a contractionary monetary policy shock on the credit-to-GDP ratio is initially positive but then turns significantly negative, with a drop of up to 2% over medium-term horizons. In the first period, by contrast, the response of the credit-to-GDP ratio is positive in the short term and then becomes insignificant at longer horizons.

[13] Note that the subaggregates are anyway part of the aggregates included in the benchmark VAR. The results are generally also very similar when we include the additional variable in the main block of the VAR model. These results are available upon request.

[14] The contribution of real exports to the peak response of GDP is in both periods very small, in the second even zero (Table 3). The impulse responses (Figure 2) show that exports display a somewhat counterintuitive initial increase in the second period. As it has no effect on the main results of the analysis, we do not further explore this 'puzzle' here.

[15] The Flow of Funds is a comprehensive set of accounts providing a detailed breakdown of the assets and liabilities of households, businesses, the governments as well as financial entities. They are widely used to

analyse the impact of structural changes (such as financial innovation) and cyclical factors (such as monetary policy) on assets and liabilities of the different sectors of the US economy. The sectoral and instrument breakdown of credit provided by the Flow of Funds was previously used, for example, by Christiano et al. (1996) and Den Haan and Sterk (2011).

[16] Nonmortgage credit comprises primarily consumer credit and trade credit for the household sector, and bank loans not elsewhere classified, other loans and advances and trade credit for the business sector.

[17] Peek and Wilcox (2003) find evidence of a countercyclical contribution of GSEs to mortgage credit flows.

[18] Such a perceived lower riskiness may have been the result of an implicit government guarantee and the requirement that the securitized loans conform with Office of Federal Housing Oversight (OFHEO) guidelines, including maximum loan amounts and minimum down payment and credit requirements.

[19] For more details on the Call reports, see https://www.fdic.gov/accounting/consolidated-reports-condition-and-income.

[20] These calculations reveal that, in the second period, the overall share of mortgages held by banks increase by 10% points when the indirect holdings through securities are also taken into account. Over this period, banks held on average around a quarter of outstanding Agency/GSE securitized mortgages, and about 15% of the outstanding stock of private-label securitized mortgages.

[21] According to the Flow of Funds, the share of mortgages in total nonfinancial private credit fell from 53% in 2008 to 43% in 2020 while the share of mortgages held/backed by Agencies/GSEs has increased from 39% in 2008 to 51% in 2020. Both developments would be expected to weaken the transmission of monetary policy to private nonfinancial credit from the point of view of our findings.

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APPENDIX A

VAR model with shadow federal funds rate

Figure A1 shows the impulse response functions when the second sample period is extended to 2019Q4, by using the Wu and Xia (2016) shadow federal funds rate for the post-2008 period. It turns out that the conclusions of the paper are robust for this extension. The peak effects on real GDP, GDP deflator, house prices and credit as well as the implied trade-offs are qualitatively very similar to those obtained for the baseline sample period. Quantitatively, they are somewhat smaller, that is, −0.7%, −0.3%, −3.6% and −1.8% instead of −1.4%, −0.5%, −5.6% and −3.3% in the baseline VAR. However, these results imply that the corresponding trade-offs (relative effects) have changed even more over time than those reported in the main part of the paper.

A possible explanation of the quantitatively smaller estimated impacts when post-2008 data are added to the sample is the smaller weight of mortgages in nonfinancial private credit and the greater role of Agencies/GSEs in mortgage markets post-2008. The share of mortgages in

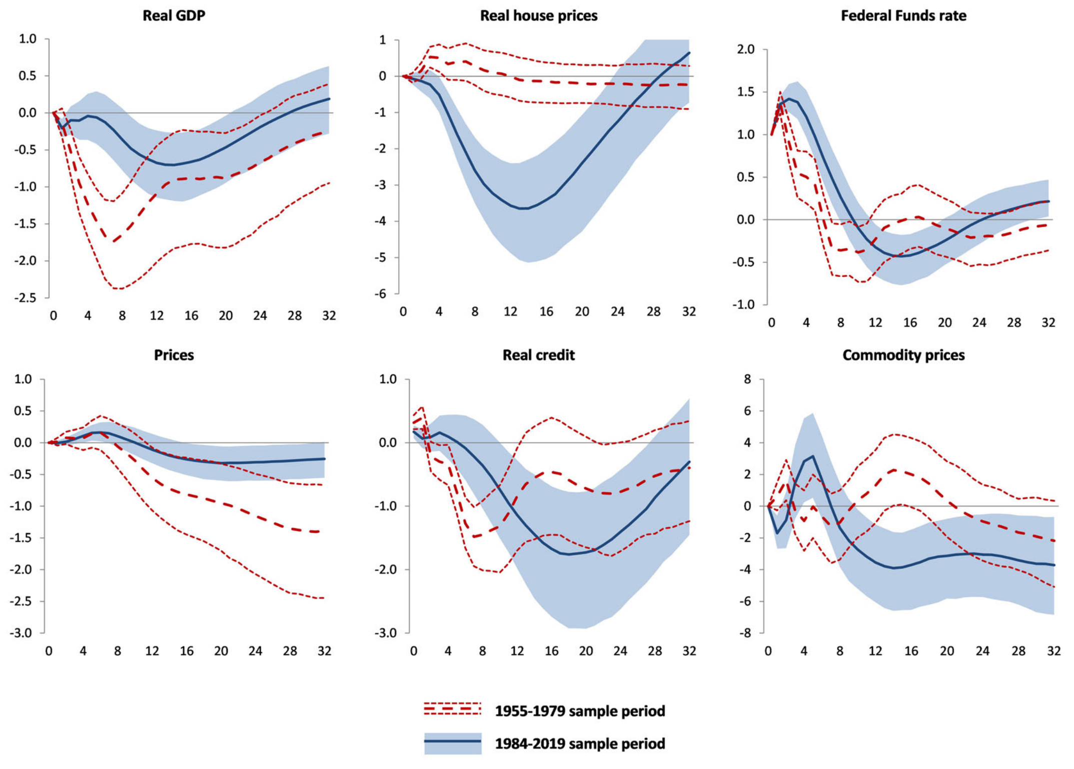

FIGURE A1 Impulse responses based on shadow federal funds rate over extended sample period. Figures show median responses, together with 16th and 84th percentile error bands; horizon is quarterly; Shadow federal funds rate from Wu and Xia (2016) for the period 2009–2019.

total private nonfinancial credit fell from 53% in 2008 to 43% in 2020. Since our analysis in Section 3.3 suggests that mortgages are the most interest-sensitive component of total credit, this development could explain the quantitatively smaller effects of monetary policy after 2008.

At the same time, the share of mortgages backed by Agencies and GSEs rose from 39% to 51% between 2008 and 2020 while that of private label ABS-issuers fell from 18% to 5%. The share of mortgages directly held by banks and nonbanks remained roughly unchanged. As documented and discussed in Section 3.4, Agency- and GSE-related mortgage lending reacted countercyclically to monetary policy shocks in the more recent period. Mechanically, a greater role of these institutions in the mortgage market would, therefore, imply a weaker impact of monetary policy on credit, which would in turn also weaken the impact on house prices and on the macroeconomy.