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Abstract

We apply the asymmetric ARDL model advanced by Shin, Yu and Greenwood-Nimmo (2009) to the analysis of the patterns of pass-through from policy-controlled interest rates to a variety of longer-term rates in the U.S. and Germany. Our results reveal three main phenomena. Firstly, while the effect of a rate hike is largely confined to the short-run, the effect of a rate cut is muted in the short-run but non-negligible at longer horizons. We characterise this pattern as a switch from *short-run positive asymmetry* to *long-run negative asymmetry*, a pattern that potentially reconciles the conflicting empirical evidence and theoretical conjectures that dominate the existing literature. Secondly, our results confirm that there has been a decoupling of long-term rates from policy-controlled rates during the period of the Great Moderation in both the U.S. and Germany, albeit in a complex and nonlinear way. Thirdly, by replicating Taylor's (2007) counterfactual exercise using our asymmetric models, we find that Taylor over-estimates the importance of policy-controlled rates for the broader economy. Equivalently, our results do not support Greenspan's belief that the decoupling is a recent phenomenon. In light of our findings, we conclude that a narrow focus on the interest rate as the sole instrument of monetary policy is likely to be sub-optimal under current institutional arrangements.

JEL Classifications: C22, E43, E52.

Keywords: Asymmetric ARDL Model and Dynamic Multipliers, Great Moderation, Asymmetric Interest Rate Pass-through.

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1 Introduction

Most economists regard interest rates as the principal avenue by which monetary policy affects economic activity. The interest rate channel of monetary policy transmission can be described as follows: "[c]entral banks exert a dominant influence on money market conditions and thereby steer money market interest rates. Changes in money market interest rates in turn affect long-term market interest rates and retail bank interest rates, albeit to varying degrees. Bank decisions regarding the yields paid on their assets and liabilities have an impact on the expenditure and investment behaviour of deposit holders and borrowers and thus real economic activity." (de Bondt, 2005, p. 6).

Two strands of empirical literature have been concerned with the linkage between money market rates and longer-term rates. In continental Europe, where the financial system is traditionally 'bank-based', central bankers and economists have analysed the pass-through from policy rates (or short-term money market rates) to commercial banks' retail rates. In the U.S. and other countries with 'market-based' financial systems, the focus has been on the relationship between short-term interest rates and long-term bond yields (*i.e.* the term structure of interest rates).

Empirical research of this type is of paramount importance to the conduct of monetary policy. In the absence of a clear understanding of the transmission from policy-controlled interest rates to the relevant lending rates, macroeconomic models in which the interest rate is treated as a single (or at least simple) entity which exerts a decisive influence on aggregate demand are of limited use (Walsh, 2009). A topical example has been provided by the Federal Reserve's behaviour in relation to the recent housing boom and the subsequent financial crisis. While some authors have argued that monetary excesses resulting from the Fed's deviation from the Taylor rule between 2003 and 2005 triggered the crisis (Taylor, 2007, 2009), many central bankers and economists alike have identified the decoupling of monetary policy from long-term rates as a key factor leading up to the crisis (Greenspan, 2005, 2009; Rudebusch *et al.*, 2006). Furthermore, during the global recession of 2008/9, banks in both the U.S. and in Europe have been repeatedly accused of failing to pass lower policy rates on to their clients (*e.g.* IMF, 2008; Čihák *et al.*, 2009). Hence, one could argue that it was not the failure of the Fed to follow the Taylor rule that instigated the crisis but rather that the limitations of monetary policy are much more structural.

In this paper, we apply the asymmetric ARDL model advanced by Shin, Yu and Greenwood-Nimmo (2009, henceforth SYG) to the analysis of the relationship between policy-controlled interest rates and longer-term interest rates. Based on the single-equation error correction model and the associated dynamic multipliers, we are able to model asymmetries in both the long-run relationship and the pattern of dynamic adjustment simultaneously and in a coherent manner. This represents an important innovation relative to existing empirical studies that have modelled asymmetries only in the short-run dynamics *or* the error correction mechanism. Following SYG, we argue that the linear models underlying much of the existing research may be seriously misspecified and that the conclusions adduced on this basis may be highly misleading when the unobserved data generating process (the 'true' transmission mechanism) displays short- and/or long-run asymmetries.[1] Hence, we expect that our approach may reconcile to some extent the conflicting evidence of previous studies in relation to the asymmetric nature of the transmission mechanism, both in terms of the degree of pass-through and the speed of adjustment.

We examine the U.S. as the archetypal market-based financial system and Germany, traditionally considered a bank-based system. Interestingly, our results are qualitatively similar for both countries

[1] This may also explain the relatively common failure to identify a cointegrating relationship between the relevant interest rates despite the general consensus that they follow non-stationary $I(1)$ processes.

despite the widely discussed differences between their financing arrangements. Based on our estimation results for the U.S. over the two sub-periods 1965:1-1979:12 and 1984:1-2009:6, and Germany over the period 1996:11-2009:6, we draw three broad conclusions. Firstly, we find that the long-run effects of monetary policy on long-term interest rates became very weak during the Great Moderation, with long-run pass-through coefficients falling from approximately unity in the previous period and coming to lie in the range of 0.1-0.6 during the Great Moderation.

Secondly, we observe that both short- and long-run asymmetries are highly significant and typically act in opposite directions during the Great Moderation period. This finding potentially reconciles the seemingly conflicting theoretical conjectures and empirical evidence presented in the literature (e.g. Borio and Fritz, 1995; de Bondt, 2002; Sander and Kleimeier, 2004; Gropp *et al.*, 2007). More specifically, we find that an interest rate hike exerts a considerable effect on longer-term rates in the short-run, but that pass-through is much more muted just one year after the tightening. By contrast, an interest rate cut fails to consistently affect longer-term rates within the first year but the long-run pass-through is typically larger than in the case of a rate hike. Hence, our results indicate that the Great Moderation period has been characterised by positive short-run asymmetry followed by a relatively rapid switch to long-run negative asymmetry. Positive short-run asymmetry supports the view that monetary policy is like a string that can be pulled but not pushed. Negative long-run asymmetry supports the view that monetary policy, alongside globalisation and the liberalisation of global financial and labour markets, has lowered inflation expectations over the longer-run. Indeed, the combination of financial innovation, weaker wage aspirations, higher interest-elasticity of credit demand and the reduced pricing power of banks in a setting of increasingly competitive loan markets populated by well-informed and foot-loose borrowers seems to have reduced the longer-term effects of monetary tightening on long-term interest rates.

Finally, our results shed new light on the current controversy over the Fed's responsibility for the housing boom that is thought to have led to the recent crisis. On the one hand, the very weak estimated long-run pass-through throughout the entire period of the Great Moderation suggests that John Taylor grossly overestimates the importance of policy-controlled interest rates. Equally, Alan Greenspan's argument that the decoupling of monetary policy from long-term interest rates was confined to the period running up to the crisis in the housing market starting around 2002 is also misled.

The implications of our findings for the conduct of monetary policy are far-reaching. While it seems that policymakers have the ability to cool an overheated economy via the interest rate channel in the short-run, the maintenance of higher interest rates in the long-run (in an attempt, say, to prevent a housing bubble) would require substantial and continual rate hikes. An attempt by the central bank to meet these contradictory challenges would tend to be associated with lower than optimal real growth, increased volatility and, thereby, uncertainty. Of more concern for demand management policies, it seems that policymakers are unable to stimulate the economy in the short-run without enacting very substantial rate cuts that may either create panic among market participants or lead the economy into a liquidity trap as it reaches the zero lower bound for the nominal interest rate.[2] This line of reasoning leads us inexorably to a controversial conclusion: when the pass-through from policy-controlled rates to lending rates is incomplete, sluggish, or asymmetric, then the use of the interest rate as the preferred tool for fine-tuning aggregate demand must be called into question. Whether a central bank acting in such

[2] A number of alternative measures have been proposed whereby central banks could ease the monetary policy stance once policy rates enter the neighbourhood of the zero lower bound. For example, Bernanke, Reinhart and Sack (2004) suggest increasing the money supply beyond the level necessary for setting the policy rate at zero, and/or the provision of liquidity to specific credit markets that are considered dysfunctional.

an environment opts to pursue the re-regulation of financial institutions to prevent asset price bubbles and strengthen interest rate pass-through or chooses to develop alternative tools of demand management such as countercyclical reserve requirements, what seems certain is that existing policy arrangements are inadequate.

The paper proceeds as follows. Section 2 briefly reviews the literature and summarises a range of theories that may explain positive and negative asymmetries acting over different time horizons in the pass-through mechanism. Section 3 outlines the non-linear ARDL model and Section 4 presents the main empirical results. Section 5 explicitly addresses the question of whether the Fed lost control over long-term rates during the Great Moderation while Section 6 discusses the policy-relevance of our findings. Section 7 concludes.

2 The Interest Rate Transmission Mechanism

The view that long-term interest rates depend largely on monetary policy is common, although not uncontroversial, in the academic debate. A case for the causality running from monetary policy to long-term interest rates, at least over the medium-term, is strongly argued by Blanchard (2003) in relation to the pattern described by real interest rates in the 70's and 80's. Although this view is not meant to deny the existence of an equilibrium long-term interest rate (to which monetary policy would have to adjust), it nevertheless implies that monetary policy can affect the real interest rate for a decade and perhaps more. We will follow this general view insofar as we treat the short-term market rate as the explanatory variable, to which long-term interest rates react. This description of the monetary transmission mechanism also underpins the understanding that central bankers themselves have about their job. As noted by Greenspan (2005), "experience suggests that, other things being equal, increasing short-term interest rates are normally accompanied by a rise in longer-term yields. Ten-year yields, for example, can be thought of as an average of ten consecutive one-year forward rates. A rise in the first-year forward rate, which correlates closely with the federal funds rate, would increase the yield on ten-year U.S. Treasury notes even if the more-distant forward rates remain unchanged. Historically, though, even these distant forward rates have tended to rise in association with monetary policy tightening."

The counterpoint has been argued powerfully by Greenwald and Stiglitz (2003). The authors question the role of central bank interest rate policies as a means of affecting long-term interest rates and, thereby, investment and aggregate demand. In particular, they hold that one should not expect long-term interest rates to respond strongly to changes in policy-administered short-term rates unless today's monetary policy affects interest rate expectations many years into the future (p. 20). Moreover, as a result of financial innovation, long-term market rates are likely to become increasingly insulated from policy rates. As a result, the impact of monetary policy will become increasingly concentrated in certain sectors of the economy, particularly small and medium enterprises that are naturally more reliant on bank finance than their larger counterparts and must, therefore, bear the brunt of higher interest rates to a greater extent (p. 197).

This debate raises two important questions. Firstly, has the monetary transmission mechanism changed with financial innovation and globalisation and changes in the conduct of monetary policy? Secondly, to what extent does the effect of monetary policy innovations differ between bond yields and retail bank lending rates, the former being more important in market-based systems and the latter in bank-based financial systems? Before tackling these issues, we will briefly review the existing empirical literature studying both the bank interest rate pass-through and the term structure of bond yields.

Furthermore, through careful consideration of a range of mechanisms that may cause asymmetries in the pass-through from short- to long-term interest rates, we will attempt to reconcile the seemingly conflicting conclusions reached by previous theoretical and empirical work in this respect.

2.1 Bank interest rate pass-through

The vast literature on interest rate pass-through starts from a simple mark-up pricing model (Rousseas, 1985):

$$r_t^b = \alpha + \beta r_t^m, \tag{2.1}$$

where r_t^b is the lending rate charged by banks, r_t^m the marginal cost approximated by a market interest rate, α a constant mark-up, and β the pass-through parameter, which depends on the demand elasticity of loans with respect to the retail bank interest rate.[3] Because interest rates are usually found to follow non-stationary $I(1)$ processes, (2.1) can be estimated in the form of an error correction model capturing both the long-run equilibrium between retail rates and market rates as well as the associated adjustment dynamics.

Two approaches have been popularised in the literature (Kwapil and Scharler, 2006). The 'cost-of-funds approach' investigates the linkage between bank lending rates and market rates of comparable maturities, which are seen as the accurate measure of banks' cost-of-funds (de Bondt, 2002, 2005). By contrast, the 'monetary policy approach' addresses the potentially cointegrating relationship between bank lending rates and the policy rate (or short-term market rate taken as a proxy), assuming that banks constantly engage in a process of maturity transformation in which they attempt to match the demand for long-term loans with the supply of short-term deposits (Gropp *et al.*, 2007). Notice that, as monetary policy also affects banks' cost-of-funds, the monetary policy approach implicitly addresses an important aspect of the cost-of-funds channel, particularly when one accounts for the forward-looking behaviour of market participants (Sander and Kleimeier, 2004). Hence, we will follow the monetary policy approach.

Empirical results on the bank interest rate pass-through are rather mixed (see Kwapil and Scharler, 2006, for a thorough survey). However, a consensus finding is that the pass-through from policy or market rates to retail rates is both sluggish and incomplete (*e.g.*, Cottarelli and Kourelis 1994; Mojon, 2000; Sorensen and Werner, 2007). This may be partially explained by imperfect competition, implicit contracts and the long-term relationships between banks and their customers: that is to say that banks insulate customers from volatile market rates (de Bondt, 2002; Allen and Gale, 2004). Furthermore, sluggish adjustment may reflect the presence of transaction costs including labour, computing and notification costs. Acting rationally, a bank will only change its interest rates when the gain strictly dominates the associated costs. Retail lending rates are likely to be sticky in inelastic markets and the demand for retail bank products is likely to be less elastic in the short-run. Hence, banks facing fixed adjustment costs will adjust their retail rates promptly only if the costs of keeping a disequilibrium rate exceed these adjustment costs (de Bondt, 2002; Liu *et al.*, 2008).

Two further stylised findings are apparent in the existing literature. Firstly, the pass-through from policy-administered interest rates to longer-term rates is smaller among the Euro area countries (estimates of the long-run pass-through coefficient β typically range between 0.4 and 0.75) than in the U.S., where it often approaches unity. Secondly, the degree of pass-through tends to decrease as the maturity of the loan increases.

[3] β is expected to be less than one if the demand for loans is not fully elastic.

2.2 Pass-through to bond yields: the term structure of interest rates

The expectations hypothesis of the term structure implies a cointegrating relationship between short- and long-term interest rates with the cointegrating vector, $[1, -1]$, as shown by Campbell and Shiller (1987). The implication is that, if the expectations hypothesis is upheld, pass-through from short- to long-term rates should be complete and presumably symmetric. However, the expectations hypothesis has not enjoyed much success empirically. For example, using monthly data in the regression of the 20-year T-bill rate on the one-month T-bill rate over the period 1959:1-1979:8, Campbell and Shiller obtain a long-run coefficient of only 0.74. Moreover, they report the failure of the residual-based Engle and Granger (1987) test to reject the null hypothesis of no cointegration.

A vast literature has subsequently analysed the predictive power of the long-short spread in explaining the evolution of both short- and long-term interest rates. Consider the following equations:

$$r_{m-1,t+1} - r_{m,t} = \alpha + \beta \frac{r_{m,t} - r_{1,t}}{m-1}, \tag{2.2}$$

$$\sum_{i=1}^{m-1} \frac{r_{1,t+i}}{m-1} - r_{1,t} = \alpha + \beta \frac{m-1}{m} \left(r_{m,t} - r_{1,t} \right) \tag{2.3}$$

where r_m is the long-term interest rate for a bond of maturity m, and r_1 is the short-term interest rate. Again, the empirical results have typically been disappointing, giving rise to the 'Campbell-Shiller paradox' that the estimate of β in (2.2) is typically different from one and even of the wrong sign. Using the second regression, (2.3), some weak support for the expectations hypothesis is confirmed only for bond yields with very short and very long maturities (Campbell and Shiller, 1991; Campbell, 1995). However, more advanced tests proposed by Thornton (2006) and Sarno *et al.* (2009) also fail to support the expectations hypothesis.

Various explanations for the empirical failure of the expectations hypothesis have been proposed, including Peso problems (Bekaert *et al.* 2001), the failure to take the central bank reaction function and interest rate smoothing into account (Mankiw and Miron, 1986; McCallum, 2005; Kugler, 1997; Hsu and Kugler, 1997), regime switching, time-varying liquidity premia and macro factors affecting the behaviour of the term structure (Ang and Bekaert, 2002; Bansal and Zhou, 2002; Clarida *et al.*, 2005).

2.3 Asymmetric interest rate pass-through

In general, different theories can be invoked to argue that the pass-through from policy-controlled interest rates to longer-term lending rates may be asymmetric. However, there is disagreement as to the direction of asymmetry and the timeframe over which it may operate. Furthermore, the mechanisms underlying asymmetric pass-through are likely to differ between retail bank rates and bond yields.

2.3.1 Positive asymmetry

We define positive asymmetry as the case in which increases in policy-controlled interest rates affect longer-term rates more quickly and/or strongly than decreases. Clearly this definition admits both short- and long-run effects. We will elaborate on this distinction in due course. It follows that positive asymmetric pass-through indicates that monetary policy may be more effective in containing an overheating economy rather than fighting a recession. This is the argument that monetary policy is like a string that can be pulled but not pushed.

Positive asymmetry in the case of bank lending rates may emerge for a variety of reasons:

(i.) The bank-borrower relationship may be characterised by switching costs or incomplete information on the part of bank clients. When market rates increase, banks quickly raise their lending rates, thereby maintaining their mark-up. On the contrary, when market rates decrease, banks take this opportunity to increase their mark-up by reducing their lending rates either incompletely or slowly or both. Switching and information costs may be particularly relevant in the case of consumer and mortgage loans and business loans (*e.g.* Borio and Fritz, 1995; Mojon, 2000).

(ii.) Lending rates may exhibit downward rigidity (*e.g.* Sander and Kleimeier, 2004; Wang and Thi, 2010). From the banks' point of view, the risk of triggering a price war through rate reductions tends to make downward revisions inherently costly in oligopolistic markets. Hence, positive asymmetry may result from the willingness of banks to raise rates but not to cut them.

(iii.) Positive asymmetry may arise as a demand-side phenomenon, linked to business cycle trends. The demand for bank funds may become more inelastic during recessions, as bank-borrower relationships are strengthened and borrowers become more captive to their traditional sources of funds. In this setting, a lower interest rate-elasticity of credit demand would allow banks to raise their mark-up as policy-controlled rates decrease during a recession. If market interest rates tend to fall during recessions, a positively asymmetric response would be detected in the data (*e.g.* Borio and Fritz, 1995; Clausen and Hayo, 2006).

Moving on to the bond market, longer-term interest rates reflect expected future short-term interest rates and a risk premium. However, when the perception of risk varies with bond market volatility and business cycle indicators, then the pass-through from short-term rates to longer-term yields can be asymmetric. At least two channels can be readily identified:

(i.) During recessions, in which policy rates tend to fall, bond markets may fail to pass-through the monetary loosening if market participants have a high liquidity preference and expect that bond prices will fall further (*e.g.* Greenwald and Stiglitz, 2003, pp. 40-1). By contrast, when the central bank raises the policy rate in reaction to an overheated economy, the transmission of monetary policy via the financial markets may be much more efficient.

(ii.) When investors and borrowers are highly leveraged, investors may overreact to a sudden increase in policy rates (which they take to indicate the end of the boom and an increasing likelihood of bankruptcies among leveraged firms) and may come to require higher excess returns on long-term corporate bonds (*e.g.* Campbell, 1995). Moreover, as global financial markets become increasingly integrated, this effect is likely to become more prominent. As Stiglitz (2010) notes, far from reducing risk through greater global diversification, the integration of financial markets may increase the likelihood that adverse circumstances at a national or regional level may be transmitted more widely. In the extreme case, this may lead to bankruptcy cascades or even financial contagion.

2.3.2 Negative asymmetry

We define negative asymmetry equivalently as the case in which increases in policy-controlled interest rates affect longer-term rates less quickly and/or less strongly than decreases. For bank lending rates, there are equally well-founded reasons to expect that the pass-through from policy-controlled rates to longer-term lending rates could be negatively asymmetric:

(i.) In the presence of asymmetric information, lending rates may be upwardly sticky due to adverse selection problems. In general, banks may fear that they will attract more risky borrowers when lending rates increase (*e.g.* Stiglitz and Weiss, 1981; de Bondt, 2002).

(ii.) Due to the development of new financial products and the emergence of globalised, highly competitive financial markets with increased availability of credit, it may be expected that there is a generalised downward pressure on lending rates. Indeed, the loss of pricing power of banks (and other firms) seems to be a generalised phenomenon associated with globalisation and the Great Moderation (*e.g.* Taylor, 2000; Greenspan, 2005). This could be reflected, *inter alia*, in a negatively asymmetric pass-through from policy rates to lending rates, as lenders are obliged to lower their rates during monetary expansions and to insulate their customers from rate rises during periods of monetary tightening. In particular, if refinancing costs are low (*e.g.* for fixed-rate mortgages), negative asymmetric pass-through may become endemic as borrowers will opt to refinance their fixed-rate mortgages and other loans only as interest rates fall (Sellon, 2002). Furthermore, banks have historically tended to offer low fixed 'teaser' rates on mortgages in the short-run in order to attract borrowers before a transition to higher floating rates in the medium- and long-run. Hence, banks may avoid adjusting their fixed mortgage rates upward but act quickly to bring them down whenever possible in order to either remain competitive or even to compete for market share (Liu *et al.*, 2008).

In the bond market, insofar as nominal long-term rates reflect expected future short-term rates, negative asymmetry can be linked to expectations about inflation and central bank policy reactions during periods of boom and slack:

(i.) When the central bank has gained credibility in fighting inflation, initial inflationary pressures may be alleviated quickly by the central bank's decision to raise the policy rate, thereby reducing output and inflation volatility (*e.g.* Taylor, 2007). Hence, market interest rates may underreact to the rate hike, reflecting a belief on the part of market participants that further substantial increases in the short-term rate are unlikely.

(ii.) Similarly, in the presence of generalised downward pressure on wages, which could be due to both globalisation (increasing the abundance of labour) or to labour market institutions, even low levels of unemployment may not lead to persistent inflationary pressures (*e.g.* Stiglitz, 1997). In this situation, market participants may not expect that continuous interest rate hikes will be necessary to cool down the economy, thus generating a weak reaction to a policy rate hike.

(iii.) By contrast, when economic downturns and disinflationary tendencies are difficult to overcome and the central bank has a strong preference for recession-avoidance, then the bond market may anticipate that an initial monetary expansion is likely to be followed by further rate cuts in the near future. Hence, market interest rates may react more strongly to the initial rate cut, generating negative asymmetry.

2.3.3 Empirical evidence

Very few studies have documented empirical evidence of asymmetric interest rate pass-through in a rigorous manner. An early contribution was made by Dueker and Thornton (1994). Employing an ordered probit model, they find that the changes in the U.S. prime bank rate are more likely to follow when policy rates increase than when they fall, see also Dueker (2000) for an extended results. This conclusion was reinforced by Mester and Saunders (1995), who estimate a logit model with monotonically increasing or decreasing prime rates. Their results suggest that adjustment costs are important to the prime rate adjustment process, and that changes in exogenous variables have a significantly larger effect on the probability of a prime rate increase than a decrease.

Borio and Fritz (1995) estimate error correction models (ECM) for various OECD countries and fail to find statistically significant evidence of asymmetric pass-through. However, where asymmetries are seemingly present, the response of lending rates is faster with respect to increases in market rates than to decreases. On the other hand, based on a study of selected European countries, Gual (1999) finds that higher competition tends to put pressure on banks to adjust lending rates more quickly when money market rates are decreasing than when they are increasing. Interestingly, he also shows that while higher competition tends to reduce the ability of banks to increase lending rates in response to increasing money market rates, this effect is not statistically significant.

Relying on visual inspection of 3-month windows across sub-sample periods for the Euro area, Mojon (2000) holds that the pass-through to credit rates was higher in periods with rising interest rates than in times of falling rates. Heinemann and Schüler (2002) derive similar conclusions for several European countries over sub-samples reflecting periods of either expansionary or restrictive monetary policies. They also argue that national differences in the speed of pass-through within the EU can be regarded as a retail-oriented indicator of financial integration, and that consumers could gain from a convergence of adjustment speeds around the fastest levels.

More recently, Sander and Kleimeier (2004) estimate a nonlinear ECM for the Euro area and find that upward adjustment is often faster than downward adjustment under the assumption that pass-through is common and symmetric in the long-run. Gropp *et al.* (2007) estimate a dynamic panel data model and find that loan rates in the Euro area tend to adjust more rapidly when market rates move upwards than when they move downwards, although this finding is statistically insignificant. Employing an asymmetric threshold ECM in conjunction with an EGARCH-in-mean, Wang and Thi (2010) find evidence of asymmetric adjustment speeds in both Hong Kong and Taiwan. More specifically, they find evidence of upward rigidity in the deposit rate and downward rigidity in the lending rate.

While the papers surveyed above are indicative of positive asymmetry, a notable reference to the contrary is Sellon (2002). Relying on visual inspection of U.S. interest rates, he provides evidence of negatively asymmetric pass-through from policy rates to mortgage rates. Similarly, Liu *et al.* (2008) examine the degree of pass-through and the adjustment speed of retail interest rates in response to changes in market rates in New Zealand during the period 1994-2004. The authors employ the Phillips-Loretan approach to cointegration analysis due to its strong performance in finite sample and find that banks appear to pass on decreases to fixed mortgage rates more rapidly than increases.

2.3.4 An apparent contradiction

While there is somewhat more evidence of positive than negative asymmetry in the literature, we have strong theoretical and practical reasons to doubt the validity of many of the existing empirical studies. As will become clear, we contend that these seemingly conflicting results derive from the failure to differentiate between positive and negative asymmetries, and over the short- and the long-run. The only paper of which we are aware that addresses the modelling of both short- and long-run asymmetries is Borio and Fritz (1995), which attempts to account for asymmetries both in first-difference and level coefficients. However, their approach suffers from a number of significant limitations, not least of which is their failure to account for unit roots and cointegration and the ambiguity surrounding their testing procedure.

A partial discussion of the long-run/short-run distinction is offered by de Bondt (2002, p. 10), who argues that the degree of market power and the costs associated with asymmetric information are both likely to have long-run effects, while switching costs are expected to play a particularly significant part in the short-run adjustment process of bank rates to market interest rates.[4] Continuing with this line of reasoning, we may attempt to classify each of the asymmetry generating mechanisms discussed above into those acting predominantly in the long- and in the short-run. Focusing first on those effects that are expected to generate positive asymmetry, we argue that it is trivially the case that switching costs, business cycle effects and liquidity preference will act mainly over the short- to medium-run. By contrast, it also seems relatively uncontroversial to assume that the influence exerted over banks' pricing behaviour by imperfect competition may act over any horizon while information costs are likely to play a role over the medium- to long-run. Moving on to the case of negative asymmetry, it is obvious that the generalised downward pressure on interest rates associated with financial innovation and globalisation will act over all horizons but, perhaps, particularly strongly in the long-run. By contrast, we may expect asymmetric information and refinancing effects to be limited to the long-run. Similarly, the effects of deregulation in the labour market in containing wage spirals are likely to act predominantly over the medium- to long-run. Table 1 offers a crude attempt at generality in light of this characterisation of asymmetry generating mechanisms into the short- and long-run.

TABLE 1 ABOUT HERE

In general, one can entertain the following four principal scenarios depending on the strength of downward rigidity relative to upward rigidity: (i) positive asymmetry in the short- and the long-run; (ii) positive asymmetry in the short-run and negative asymmetry in the long-run; (iii) negative asymmetry in the short-run and positive asymmetry in the long-run; and (iv) negative asymmetry in the short- and the long-run. At an over-arching level, we may expect to observe positively asymmetric pass-through in the short-run before a switch to negative asymmetry in the long-run. In particular, one may argue that the required increase in excess bond returns following a sudden bout of inflation and the associated monetary tightening will be only temporary when the central bank manages to stabilise inflation expectations quickly. More generally, if the central bank has established credibility in breaking inflationary pressures and the risk of persistent wage-price spirals is contained, then the effect of a monetary tightening on longer-term interest rates (both market rates and bank lending rates) may be relatively short-lived. By contrast, lower policy rates are likely to exert a weak short-run influence over longer-term rates, especially in a recessionary environment when agents are markedly risk-averse and exhibit a high liquidity preference. However, the degree of pass-through may be more substantial in the long-run when the central bank continues with its expansionary policy. In addition, the structural changes in global labour and financial markets can be expected to reinforce the overall downward pressure on bond yields and bank lending rates in the long-run.

[4]Note, however, that de Bondt (2002) estimates a linear error correction model which is inherently incapable of capturing dynamic asymmetric pass-through patterns.

3 The Asymmetric Nonlinear ARDL (NARDL) Model

SYG advance a simple technique for modelling both long- and short-run asymmetries in a coherent manner. The model is essentially an asymmetric extension of the linear ARDL approach to modelling long-run (cointegrating) levels relationships originated by Pesaran and Shin (1998) and Pesaran, Shin and Smith (2001, PSS). Consider the asymmetric cointegrating relationship:

$$y_t = \beta^{+\prime}\mathbf{x}_t^+ + \beta^{\prime -}\mathbf{x}_t^- + u_t, \tag{3.4}$$

where $\mathbf{x}_t$ is a $k \times 1$ vector of regressors decomposed as:

$$\mathbf{x}_t = \mathbf{x}_0 + \mathbf{x}_t^+ + \mathbf{x}_t^-, \tag{3.5}$$

$\mathbf{x}_t^+$ and $\mathbf{x}_t^-$ are partial sum processes of positive and negative changes in $\mathbf{x}_t$ defined by:[5]

$$\mathbf{x}_t^+ = \sum_{j=1}^{t} \Delta\mathbf{x}_j^+ = \sum_{j=1}^{t} \max\left(\Delta\mathbf{x}_j, 0\right), \ \mathbf{x}_t^- = \sum_{j=1}^{t} \boldsymbol{\Delta} x_j^- = \sum_{j=1}^{t} \min\left(\Delta\mathbf{x}_j, 0\right), \tag{3.6}$$

and β^+ and β^- are the associated asymmetric long-run parameters. The extension of (3.4) to the ARDL(p, q) case is straightforward, yielding the following asymmetric error correction model:

$$\Delta y_t = \rho y_{t-1} + \theta^+\mathbf{x}_{t-1}^+ + \theta^-\mathbf{x}_{t-1}^- + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} \left(\pi_j^+ \Delta\mathbf{x}_{t-j}^+ + \pi_j^- \Delta\mathbf{x}_{t-j}^-\right) + \varepsilon_t. \tag{3.7}$$

We refer to (3.7) as the asymmetric or non-linear ARDL (NARDL) model. This approach has a number of advantages over the existing class of regime-switching models. Firstly, once the regressors, $\mathbf{x}_t$, are decomposed into $\mathbf{x}_t^+$ and $\mathbf{x}_t^-$, (3.7) can be estimated simply by standard OLS. Secondly, the null hypothesis of no long-run relationship between the levels of y_t, $\mathbf{x}_t^+$ and $\mathbf{x}_t^-$ (*i.e.* $\rho = \theta^+ = \theta^- = 0$) can be easily tested using the bounds-testing procedure advanced by PSS and SYG, which remains valid irrespective of whether the regressors are $I(0)$, $I(1)$ or mutually cointegrated. Thirdly, (3.7) nests the following two special cases: (i) long-run symmetry where $\theta^+ = \theta^- = \theta$, and (ii) short-run symmetry in which $\pi_i^+ = \pi_i^-$ for all $i = 0, ..., q$.

SYG further differentiate between two forms of short-run symmetry restrictions: strong-form (pair-wise) symmetry and weak-form (additive) symmetry. Given that we will employ general-to-specific lag selection which is likely to include heterogeneous lags of the positive and negative partial sum processes in the model, it follows that we should limit our attention to the weak-form restrictions. Moreover, as SYG note that the small sample performance of the Wald test for additive short-run symmetry may be rather low, we shall use bootstrapped confidence intervals in order to identify short-run asymmetries. Reliable inference can be achieved in relation to the long-run symmetry restrictions using the standard

[5] At present, we evaluate the differential effects of positive and negative shocks to the explanatory variables under the assumption of a single known threshold value. Indeed, the construction of positive and negative partial sum processes relies on the imposition of a zero threshold. However, this assumption can be easily relaxed to accomodate the more general case of multiple unknown threshold decompositions (Greenwood-Nimmo, Shin and Van Treeck, 2010). Similarly, we currently work under the implicit assumption that positive and negative shocks to the explantory variables occur with equal probability. In the current context this is a largely innocuous simplification as the mean values of Δr^m are relatively close to zero over our sample, implying that $\Pr\left(\Delta r^m > 0\right) \approx \Pr\left(\Delta r^m < 0\right) \approx 0.5$. However, in the general case in which this condition is not satisfied, as with all regime-switching models, one must allow for the impact of the respective regime probabilities in the evaluation of the asymmetric dynamic multipliers.

Wald test as normal. Only when both the long- and short-run symmetry restrictions cannot be rejected should the restricted linear ARDL(p, q) model be entertained:

$$\Delta y_t = \rho y_{t-1} + \theta \mathbf{x}_{t-1} + \sum_{j=1}^{p-1} \varphi_j \Delta y_{t-j} + \sum_{j=0}^{q} \pi_j \Delta \mathbf{x}_{t-j} + \varepsilon_t. \tag{3.8}$$

Finally, the asymmetric ARDL model, (3.7) can be used to derive the asymmetric cumulative dynamic multiplier effects of a unit change in $\mathbf{x}_t^+$ and $\mathbf{x}_t^-$ (respectively) on y_t, defined by:

$$\mathbf{m}_h^+ = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial \mathbf{x}_t^+}, \ \mathbf{m}_h^- = \sum_{j=0}^{h} \frac{\partial y_{t+j}}{\partial \mathbf{x}_t^-}, \ h = 0, 1, 2... \tag{3.9}$$

By construction, as $h \to \infty$, $\mathbf{m}_h^+$ and $\mathbf{m}_h^-$ tend to approach the respective asymmetric long-run coefficients. The ability of the dynamic multipliers to illuminate the traverse from initial equilibrium, via short-run disequilibrium following a shock, to a new long-run equilibrium makes them a powerful tool for the combined analysis of (short-run) adjustment asymmetry and (long-run) response asymmetry. In this regard, the dynamic multipliers derived from the transfer function from $\mathbf{x}^+$ and $\mathbf{x}^-$ to y are likely to prove particularly advantageous in the analysis of positive and negative asymmetries in the dynamics of interest rate pass-through, as reviewed in subsection 2.3.

4 Empirical Results

4.1 The Dataset

In order to estimate the NARDL model, (3.7),[6] we collect data pertaining to various lending rates and bond yields for the U.S. and Germany. For the U.S., data are taken from the Federal Reserve interest rate series (H. 15). Firstly, we use the 3-month T-bill rate as a proxy for the monetary stance of the central bank. This is standard practice in the literature as the T-bill rate is preferable to the federal funds rate since it shows larger variation. For our lending rates and bond yields, we employ the 30-year conventional fixed mortgage rate, the 10-year T-bill rate, and finally the AAA- and BAA-rated corporate bond yields.[7] All data is at monthly frequency.

Monthly German data is collected from the Bundesbank and European Central Bank (ECB). In this case, we employ the 3-month money market rate, the lending rates for small and large long-term bank loans, the mortgage rate for mortgages with initial fixation of 10 years, and the composite bond yield.[8] Due to the limited availability of data, the sample period starts from 1996. Finally, we should note that since the adoption of the Euro area-wide harmonised reporting system, national statistical reporting has been withdrawn in Germany. Therefore, we chain-link the Bundesbank and the ECB series using the growth rates of the pre-2003 Bundesbank series.

[6] We estimate three different specifications of (3.7). Note that we choose to omit the case of long-run asymmetry and short-run symmetry in the interest of brevity and because it is the least interesting combination of asymmetries on theoretical grounds. Estimation results for this case are available on request. To improve estimation precision, we conduct general-to-specific lag selection starting from a maximum lag order of 12 (6 for the mortgage rate for the first sub-period) and applying a sequential 5% significance rule as implemented by Eviews version 6.

[7] The data for the mortgage rates are unavailable prior to 1971.

[8] Estimations using the mortgage rate with initial fixation of 5 years yield qualitatively very similar results.

4.2 Asymmetric pass-through in the U.S.

Table 2 reports estimation results for the U.S. over the two sub-periods 1965:1-1979:12 and 1984:1-2009:6[9]. Each of these periods is likely to correspond to an homogenous monetary policy regime (Smith and Taylor, 2007). The latter sub-period also corresponds to what has been dubbed the 'Great Moderation', during which the volatility of both output and inflation fell sharply (Bernanke, 2004). Moreover, this period is associated with the new approach to monetary policy that was initiated by Paul Volcker and has subsequently been pursued by his successors (Clarida *et al.*, 1999; Taylor, 1999; Woodford, 2003). Figures 1 and 2 report the cumulative dynamic multipliers associated with the fully asymmetric specification presented in Table 2. These figures trace the effect of a unit change in the policy-controlled interest rate both on bank lending rates and on bond yields.

TABLE 2 AND FIGURES 1 AND 2 ABOUT HERE

In the first sub-period, the correlation of the short-term, policy-controlled interest rate with the bank lending rates and the long-term bond yields is relatively tight, with an adjusted R^2 typically between 0.5 and 0.7. The PSS F-test confirms that a long-run (cointegrating) relationship exists between them in all cases. Moreover, we cannot reject the hypothesis of a unit cointegrating coefficient for the corporate bond yields, providing some support for the expectations hypothesis of the term structure and, thereby, for the hypothesis of complete pass-through. A common finding over the first sub-period is that the short-run asymmetries are either significantly positive or insignificant. Indeed, in the case of bond yields, the short-run asymmetry remains statistically significant for more than three years. By contrast, we observe mixed evidence of long-run asymmetry. While the null hypothesis of long-run symmetry cannot be rejected in the case of AAA and BAA bond yields, it is rejected for the 10-year T-bill and the mortgage rates, where we observe slight positive asymmetry.[10] Overall, we find that the long-run pass-through coefficients are close to unity. Furthermore, the dynamic transmission pattern is very similar for all long-term interest rates, indicating that they are (slightly) positively asymmetric in both the short- and the long- run.

Moving on to the second sub-period, we note that the estimation results differ sharply from those in the earlier period. Table 2 shows that the degree of pass-through is generally weaker, with the pass-through coefficients typically taking values considerably below unity for all interest rates. Indeed, the long-run pass-through coefficients vary widely, both across the different asymmetric specifications and across the different interest rate series. In particular, the estimates from the restricted models seem to be severely biased and overestimate the long-run pass-through. The Wald tests and bootstrapped confidence intervals indicate that both short- and long-run asymmetries are highly significant for all interest rates, and the PSS F-test confirms the existence of a long-run asymmetric levels relationship in the fully

[9] In order to conserve space we choose to tabulate estimates of the long-run parameters, key inferential statistics and a range of diagnostic statistics but we omit the estimated short-run dynamics. The salient features of the latter are captured by the cumulative dynamic multipliers. Moreover, note that all of the dynamic terms included in the various models are highly significant by construction given that we employ general-to-specific lag selection. Full estimation results are available on request.

[10] The estimation results for the mortgage rate warrant some additional discussion. These estimates are somewhat less reliable due to the relatively short sample period. In this case, the long-run coefficients are statistically significant only for the fully asymmetric specification, suggesting that the results obtained from the linear model are misleading. This is an interesting finding given that it is a common practice in the literature to estimate the model in first differences when no evidence of cointegration is found (*e.g.* Mojon, 2000; Kwapil and Scharler, 2006). We argue that the failure to confirm a cointegrating relationship may derive from the failure to account for fundamental asymmetries in the data generating process. In this case, models in first differences are clearly biased in the presence of an asymmetric cointegrating relationship (SYG).

asymmetric specification for all interest rates. A general pattern that emerges is the traverse from short-run positive asymmetry to long-run negative asymmetry, with the switch taking place approximately one year after the initial policy innovation. More specifically, longer-term rates initially react relatively strongly to a monetary tightening before the reaction dies away in the long-run. By contrast, the opposite pattern is observed in the case of a loosening of monetary policy: longer-term rates show only a small initial reaction which gradually becomes more pronounced in the long-run.

4.3 Asymmetric pass-through in Germany

Given that the dataset for Germany starts in 1996, we use the full sample in estimation. Although it would be desirable to have a longer span of data, the available data has the advantage that it avoids the issue of potential structural breaks related to the German unification in 1991 and the preparations leading to the adoption of the Euro after the Treaty of Amsterdam in 1996. The results are reported in Table 3 and the associated cumulative dynamic multipliers in Figure 3.

Overall, the results are strikingly similar to the U.S. results obtained for the second sub-period. The adjusted R^2 typically lies slightly below 0.4 for the fully asymmetric specifications, as in the case of the U.S. Both the Wald and the PSS tests suggest that the fully asymmetric models are the most reliable. Not only do the restricted models mostly fail to produce significant evidence of a levels (cointegrating) relationship, they also seem to over-estimate the long-run pass-through coefficients. Following the fully asymmetric specifications, the degree of pass-through is similar to the U.S. case, with estimated long-run coefficients ranging between 0.2 and 0.5. Once again, we find evidence of short- and long-run asymmetries acting in opposite directions. Lending rates tend to overshoot following an interest rate hike, but react more sluggishly in response to a monetary loosening. In the longer-run, however, we find rather strong evidence of negative asymmetry. The Wald tests and bootstrapped confidence intervals indicate that both short- and long-run asymmetries are statistically significant for all interest rates. The most notable difference is that the short-run positive asymmetry is typically somewhat more persistent in Germany than in the U.S. The otherwise striking similarities between our results for the U.S. and Germany suggest that the widely discussed differences between market- and bank-based financial systems may have become less significant at the level of the end-user in recent years.

TABLE 3 AND FIGURE 3 ABOUT HERE

5 Has there been a decoupling in the U.S.?

We now examine the increasingly pervasive argument that the Fed lost control over longer-term interest rates in the years leading up to the housing price bubble and the subsequent financial crisis. As Greenspan (2009) famously complained, "between 1971 and 2002, the fed-funds rate and the (long-term fixed) mortgage rate moved in lockstep. The correlation between them was tight at 0.85. Between 2002 and 2005, however, the correlation diminished to insignificance." The estimation results reported above indicate unambiguously that this view is excessively simplistic. Rather, our sub-sample analysis in Section 4.2 suggests that the nature of the monetary transmission mechanism appears to have fundamentally changed considerably earlier.

Simple visual inspection of Figure 4 further substantiates this contention: it appears that the decoupling of the long-term fixed mortgage rate from policy-controlled rates has been a common phenomenon in the U.S. during phases of monetary tightening since the mid-1980s. During this time, there have been four periods in which the Fed has raised interest rates over an extended period of time. Between 1988 and 1989, the mortgage rate remained almost completely flat despite pronounced gradual increases in the federal funds rate. Between February and April 1994, while we observe pronounced short-run overshooting of the mortgage rate in reaction to the Fed's tightening, by early 1995 the mortgage rate had almost returned to its early 1994 level despite continued interest rate hikes administered by the Fed.[11] In 1999 and 2000, we again observe an apparent disconnect between the mortgage rate and the policy rate during a monetary tightening: while the short-term rate increased by about 2 percentage points between mid-1999 and late 2000, the long-term mortgage rate returned to its initial level after a temporary, but subdued, increase in early 2000. In light of these observations, it is clearly incorrect to argue that the decoupling observed in the mid-2000s was a new phenomenon.

FIGURE 4 ABOUT HERE

Further support for this view can be derived from our NARDL model. When we re-estimate the model for the mortgage rate for the period 1984:1-2009:6 and control for the alleged conundrum period by including a dummy variable taking the value of unity during 2003:1-2005:12, we obtain a point estimate of 0.002 with a standard error of 0.04. Furthermore, when we estimate the model for the sub-period 1984:1-2001:12, or for a range of arbitrarily chosen sample periods ending prior to the so-called conundrum period, the long-run coefficients do not change materially. We obtain estimated long-run coefficients of 0.413 (positive) and 0.590 (negative) with standard errors of 0.101 and 0.079, respectively.[12] On the basis of these results, and in conjunction with Figure 4, we are unable to discern any difference between Greenspan's conundrum period and the earlier episodes of monetary tightening described above save for the fact that the short-run overshooting of the mortgage rate may have been slightly weaker following the monetary tightening in 2004 than in earlier periods. This observation stands in stark contrast to Rudebusch *et al.* (2006), who argue that the inability of their pair of macro-financial models to explain the behaviour of long yields in the proposed conundrum period substantiates Greenspan's claim. However, their conclusion that a reduction in the volatility of long-term bond yields underlies the apparently strange behaviour of the bond market is acutely vulnerable to criticisms surrounding the direction of causality.

In Figure 5, we conduct a counterfactual simulation in order to assess the hypothetical effects that an earlier monetary tightening would have had on selected bond yields and lending rates, given our estimation results. Figure 5(a) is reproduced from Taylor (2007, p. 3, Figure 1) who also conducts a counterfactual exercise, in which the actual and the alternative paths of the federal funds rate depart in the second quarter of 2002 and merge again in the third quarter of 2006, as in our Figure 5. The simulations in Figures 5(b) to 5(c) are based on the three different specifications of the pass-through equations reported in Table 2. We note that the increase in the AAA corporate bond yields and the mortgage rate would have been rather limited had the Fed followed the policy stance recommended by the Taylor rule.[13] In 2004, the point at which the deviation of the Fed's policy from the Taylor rule was most pronounced, the AAA bond yields and mortgage rates would have been less than 0.75 and

[11] Campbell (1995, p. 145) attributes this overshooting to a temporary increase in excess returns on long-term bonds, which may have been due to a higher effective risk aversion of market participants linked to increased losses incurred by highly leveraged bond traders.

[12] Note that the overshooting of the mortgage rate is somewhat more pronounced for this reduced sample, with the short-run multiplier exceeding unity. This effect is not apparent in relation to any other long-term rates.

[13] Of course, the results from such a counterfactual experiment must be treated with caution because we do not account for potential feedback effects between long rates and other macroeconomic factors and the decisions of the monetary authority.

1.2 percentage points higher, respectively, than in the baseline scenario according to our preferred, fully asymmetric model. It is difficult to imagine how such a limited increase in long-term rates could have prevented the housing bubble, fuelled as it was by expectations of two-digit growth rates in housing prices. Hence, we conclude that Taylor's (2009) belief that the housing boom is primarily attributable to the Fed's interest rate policies is mistaken.

Again, it is important to note that both the size of the pass-through coefficient and the dynamic pattern of the adjustment process differ substantially depending on the nature of the asymmetries that we allow for in the underlying estimations. In particular, when we account for short- and long-run asymmetries, we observe substantial overshooting and persistent deviations from the baseline scenarios considerably beyond 2006. This is yet another manifestation of our earlier argument that the results of existing linear models must be treated with extreme caution, if not scepticism, given their pronounced bias in the presence of an asymmetric data generating process.

FIGURE 5 ABOUT HERE

Finally, we note that the difference between the paths followed by the bond rates and the bank lending rates substantiates our earlier claim that the impact of monetary policy will vary considerably between different sectors of the economy, with large firms relying on bond issuance and small firms and consumers relying on bank loans to raise funds.[14] Moreover, as is readily apparent in Figures 2(a) and 2(b), since the Great Moderation BAA bond yields have responded more strongly to contractionary monetary policies than AAA yields, both in the long-run and also in terms of the persistence of the short-run impact of the rate hike. This further suggests that smaller (and perhaps less financially robust) firms tend to bear a disproportionate share of the burden of higher interest rates.[15]

6 Policy Implications

Our empirical analysis indicates unequivocally that the pass-through from the policy-administered interest rate to various longer-term market rates exhibits widespread, pervasive and complex asymmetries of a time-varying nature. This finding offers an intuitive explanation of the divergent evidence adduced in the existing empirical and theoretical literature. Moreover, our results pose a fundamental challenge to established macroeconomic theory, which maintains that setting the policy-controlled short-term interest rate appropriately is the essence of good monetary policy, with relatively little attention being afforded to the long-term rates to which we may expect leveraged agents to react more strongly and/or directly.[16]

The reduction in the long-term pass-through since the mid-1980s is not necessarily inconsistent with the view that monetary policy has become more efficient in fighting inflation during the Great Moderation. In fact, initial signs of inflationary pressures repeatedly turned out to be short-lived throughout

[14]The prime bank lending rate tracks the policy-controlled rate very closely. The impact of monetary policy on borrowers that depend largely on bank finance will, therefore, be quite different to the case of borrowers with ready access to market finance (*e.g.* Greenwald and Stiglitz, 2003, p. 197).

[15]See Čihák *et al.* (2009) for a similar finding that the pass-through to higher-grade bond yields is smaller than to lower-grade bond yields in the EU. This effect may derive from the behaviour of investors, who demand higher excess returns on financially fragile firms in the uncertain environment of an overheating economy faced with a monetary tightening (Campbell, 1995).

[16]For example, Woodford (2003, p. 15) emphasises: "Not only do expectations about policy matter, but, at least under current conditions, very little else matters. Few central banks of major industrial nations still make much use of credit controls or other attempts to directly regulate the flow of funds through financial markets and institutions. [...] Instead, banks restrict themselves to interventions that seek to control the overnight interest rate in an interbank market for central-bank balances." Further, Clarida *et al.* (2001, p. 1664) famously claimed that "(u)nder Volcker and Greenspan [...] U.S. monetary policy adopted the kind of implicit inflation targeting that we argue is consistent with good policy management".

this period. By contrast, in the late 1960s and 1970s, inflation expectations were less well anchored and inflationary spirals were much more persistent, leading to stronger long-run responses of longer-term rates to policy innovations. Many commentators have attributed this regime shift to stronger reaction coefficients on the output gap and inflation in the (implicit) interest rate reaction function of the Fed, which helped to anchor inflation expectations more effectively (Taylor, 2007). Indeed, central banks can credibly commit to set an end to a boom by raising interest rates should inflationary pressures arise. In this environment, the first signs of inflationary pressures are rapidly alleviated and long-term rates are quickly brought down again after an initial increase. In this sense, the overshooting observed in our estimation results may reflect the efficiency and credibility of the central bank's policy. In a similar vein, Blinder *et al.* (2001, p. 8) have argued that, in the second half of the 1990s, small changes in the federal funds rate were sufficient to stabilise the economy. They suggest that this reflects an improvement in the ability of the bond market to forecast the future path of the Fed's interest rate policies. Therefore, until very recently, many authors attributed the smooth functioning of monetary policy to "greater sophistication on the part of financial markets and greater transparency on the part of central banks, the two developing in a sort of symbiosis with one another" (Woodford, 2003, p. 16).

An alternative explanation is that other factors such as the weakening of the bargaining position of workers and trade unions brought about by globalisation and the deregulation of the labour market has constrained upward wage pressures and hence inflationary tendencies during booms. Estimates of the NAIRU have repeatedly transpired to be exaggerated in retrospect and, despite initial fears, persistent inflationary pressures have generally not been observed in spite of very low levels of unemployment. Clearly, these phenomena may help to explain the temporary over-reaction of long-term rates to contractionary monetary policies, as well as the weak long-run influence of the latter.[17] Moreover, this effect is clearly not limited to the period of monetary tightening starting in 2004. Therefore, the argument by Smith and Taylor (2007) according to which the decoupling of monetary policy from long-term rates in this period may have been caused by the expectation of a new structural break in the Fed's interest rate reaction function and a smaller response coefficient on inflation seems misplaced (despite the somewhat reduced overshooting in mortgage rates in 2004). Rather, it seems that the weak inflationary pressures throughout the entire period of the Great Moderation have fuelled the expectation that even long periods of sustained output growth and low unemployment will not require higher interest rates in the longer-run.

One may even go so far as to invoke the 'stability begets instability' view popularised by Minsky (1975, 1982, 1986) and argue that the enduring tranquility in the labour and financial markets, in conjunction with contained inflationary expectations, created the macroeconomic climate in which financial speculation and the massive expansion of credit, together with the continued downward pressure on long-term yields, could develop. The ongoing deregulation and globalisation of financial markets has led to reduced refinancing costs, a higher degree of competition in the banking system and more rapid financial innovation, all of which are certainly consistent with this view. However, in this context, given the expectation of continuously rising asset prices and low goods market inflation, it seems highly improbable that merely slightly tighter interest rate policies after 2002/3 (as recommended by Taylor, 2009) could have combated these powerful trends. By contrast, had the Fed attempted to significantly raise longer-term interest rates via a very strong and continual monetary tightening in an attempt to

[17] An excellent example is the period 1994-1996, when unemployment fell considerably below accepted NAIRU estimates without triggering persistent inflationary pressures and when the overshooting of long-term rates following the Fed's temporary monetary tightening was also very strong, as discussed in Section 5. See Stiglitz (1997, p. 6) for a detailed discussion of this episode.

effectively fight the housing price bubble, this would almost certainly have led to lower than optimal real output growth and possibly persistent downward deviation from the Fed's inflation target.

In general, if our experience of the global financial crisis has led us to doubt that the Great Moderation was brought about by good policy management,[18] then the alternative explanation is that it was rather the calm before the storm: it created the illusion that monetary policy had become highly efficient, leading to low output volatility, low inflation and low long-term interest rates. While conventional monetary policy could not have prevented the recent crisis, the latter has clearly revealed the limitations of interest rate policies.[19] In particular, it seems to confirm the well-known dictum that monetary policy is like a string that can be pulled but not pushed. Rather than working symbiotically, the financial markets and the banking system have failed to transmit the expansionary interest rate policies of the Fed into lower long-term rates (this is readily apparent in Figure 4 above).

However, it is important to note that the sluggish reaction of long-term rates to cuts in policy-controlled rates is a phenomenon that precedes the financial crisis. From Figure 4, it is clear that during previous phases of extended interest rate cuts (such as 1989-91 or 2001-2) the reaction of the mortgage rate and other lending rates was highly inertial. As can be seen in Figures 2 and 3, for some interest rates, including long-term bond yields in the U.S. and most interest rates in Germany, we do not observe any significant impact of lower short-term rates even one year after the initial shock. These results indicate that the interest rate channel of monetary policy may generally be a weak tool for stimulating aggregate demand, especially in the short-run.

This diagnosis, together with the build-up of financial fragility despite the 'efficient' containment of inflationary pressures throughout the Great Moderation, clearly suggests that good policy management requires more than a narrow focus on short-term interest rates.[20] Given the increasingly widespread realisation that central banks have repeatedly failed to adapt their policies to changes in the structure of the financial system, the need for regulatory innovation is apparent. Such innovation could take the form of the re-regulation of financial institutions in order to strengthen and simplify the pass-through of monetary policy or the development of alternative tools of demand management such as countercyclical reserve requirements. In the absence of such reform, the likelihood of further painful crises in the near future seems unacceptably high.

7 Conclusion

We propose a new approach to the analysis of the pass-through from short-term policy administered interest rates to longer-term loan rates and bond yields. The novelty of our methodology lies in its ability to model both short- and long-run asymmetries in an easily estimable manner. While the necessity to distinguish between the short- and the long-run influences on the interest rate pass-through was

[18] A number of studies have investigated the sources of the Great Moderation in an attempt to disentangle the relative contributions of two main factors: good policy and good luck. For instance, using simulations based on a New Keynesian model, Benati and Surico (2009) show that the good policy and good luck explanations are almost observationally equivalent. However, their results are likely to be biased in favour of the good policy explanation since the only sources of change are the move from passive to active monetary policy, and the presence of sunspots under indeterminacy.

[19] In it's 2008 *Global Financial Stability Report*, the IMF argues that the the ongoing financial crisis has disrupted interest rate pass-through in both the U.S. and the Euro Area, particularly in the case of long-term rates (IMF, 2008). Čihák *et al.* (2009) find further evidence of this effect in the EU.

[20] For example, Kobayashi (2008) investigates optimal monetary policy in the presence of incomplete interest rate pass-through. He argues that the central bank may face a policy dilemma in terms of stabilising changes in the average loan rate in addition to inflation and the output gap. Incorporating a loan rate stabilisation term in the loss function of the central bank causes optimal monetary policy to be more inertial, and thus calls for a more drastic but infeasible policy reaction in the face of an exogenous shock such as a shift in the loan rate premium.

recognised conceptually by de Bondt (2002), we are unaware of any existing empirical studies that have deployed a rigorous econometric framework to explore these effects.

Importantly, the existing literature has so far failed to establish a consensus regarding the nature of the asymmetries characterising the transmission from policy-controlled to bank-lending rates and bond yields. On the contrary, previous theoretical and empirical studies have come to opposite conclusions. Our results for both the U.S. and Germany suggest that these apparently contradictory findings are not necessarily mutually exclusive in our general framework: the importance of various asymmetry generating mechanisms may simply depend upon the time horizon. Furthermore, our results demonstrate that accounting for both short- and long-run asymmetries improves the accuracy of estimation considerably and reveals complex dynamics that conventional linear models fail to address. In this regard, the pass-through coefficients estimated using linear models are largely misleading. By contrast, our NARDL models can successfully capture the underlying dynamics of the pass-through mechanism and can shed new light on the alleged decoupling of longer-term rates from policy-controlled rates since the mid-1980s for the U.S. and since the mid-1990s for Germany. The evidence adduced on this basis suggests that the interest rate channel of monetary policy is much more complex than is commonly assumed in stylised theoretical models and that a narrow focus on the interest rate channel of monetary transmission may be insufficient to achieve truly optimal policy management. Our experience of the global economic and financial crisis certainly lends support to this claim.

Finally, we should note two obvious avenues for continuing research. Firstly, despite the rich dynamics embedded in our model, it nevertheless remains simple in the sense that it does not allow for feedback effects in the way that a system model would. The modelling of asymmetric cointegration in a system context remains a challenge for future research. Secondly, although we refer to the potential relevance of business cycle factors for our estimation results, we do not elaborate on the mechanisms at work. This is an interesting issue which must be addressed before firm policy recommendations can be deduced on the basis of asymmetric pass-through models.

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	short-run	medium-run	long-run
Switching costs	+	+	
Information costs		+	+
Imperfect competition	+	+	+
Business cycle	+	+	
Liquidity preference	+	+	
Asymmetric information		-	-
Financial innovation	-	-	-
Globalised markets	-	-	-
Deregulated labour market		-	-
Refinancing		-	-

Note: '+' and '-' denote positive and negative asymmetry, respectively.

Table 1: Alternative explanations of asymmetric interest rate pass-through

	1965:1-1979:12						1984:1-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym		LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	1.327	0.194	1.082	0.196			0.601	0.170	0.739	0.132		
β^+					0.854	0.253					0.110	0.084
β^-					0.809	0.288					0.295	0.064
Adj. R2	0.470		0.466		0.465		0.214		0.260		0.261	
F_{PSS}	19.358		12.150		8.313		4.363		6.921		12.012	
χ^2_{SC}	2.276 [0.685]		7.330 [0.119]		7.024 [0.135]		4.916 [0.296]		2.084 [0.720]		4.136 [0.388]	
W_{LR}					1.109 [0.294]						54.228 [0.000]	
SR asym			POS [1-12]		POS [1-11]				POS [1]		POS [0-4]	

(a) AAA corporate bond yield

	1965:1-1979:12						1984:1-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym		LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	1.641	0.193	1.389	0.161			0.684	0.169	0.685	0.131		
β^+					1.241	0.253					0.509	0.252
β^-					1.215	0.285					0.568	0.188
Adj. R2	0.576		0.620		0.617		0.215		0.256		0.254	
F_{PSS}	30.106		24.333		16.291		5.778		9.528		6.494	
χ^2_{SC}	6.878 [0.143]		2.083 [0.721]		1.978 [0.740]		1.287 [0.864]		2.371 [0.668]		2.682 [0.612]	
W_{LR}					0.476 [0.491]						0.610 [0.435]	
SR asym			POS [2, 5-14]		POS [2, 4-14]				POS [0-4]		POS [0-4]	

(b) BAA corporate bond yield

continued overleaf...

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	1965:1-1979:12						1984:1-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym		LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	1.124	0.276	1.168	0.238			0.785	0.162	0.785	0.176		
β^+					0.772	0.176					0.222	0.101
β^-					0.703	0.196					0.424	0.079
Adj. R2	0.471		0.482		0.509		0.346		0.344		0.395	
F_{PSS}	6.013		8.789		6.694		4.760		4.489		9.604	
χ^2_{SC}	4.076 [0.396]		2.742 [0.602]		3.990 [0.407]		9.906 [0.042]		8.001 [0.092]		10.067 [0.039]	
W_{LR}					6.307 [0.013]						53.553 [0.000]	
SR asym			NEG [0-3]		NEG [insig]				POS [1-4]		POS [1, 4]	

(c) 10-year T-bill rate

	1965:1-1979:12						1984:1-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym		LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	7.624	40.966	2.876	3.101			0.679	0.202	0.906	0.134		
β^+					0.501	0.073					0.351	0.128
β^+					0.353	0.082					0.512	0.099
Adj. R2	0.590		0.619		0.643		0.310		0.339		0.349	
F_{PSS}	4.917		7.735		4.650		3.363		7.194		6.902	
χ^2_{SC}	1.855 [0.762]		3.984 [0.408]		5.818 [0.213]		2.092 [0.719]		1.524 [0.822]		8.161 [0.086]	
W_{LR}					43.115 [0.000]						19.659 [0.000]	
SR asym					POS [1]				POS [3]		POS [1-4]	

(d) Mortgage rate

Note: *The tabulated results do not include the estimated short-run dynamics in order to conserve space (see footnote 9 on page 13 for further details). Full estimation results are available on request. β, β^+ and β^- are the estimated long-run coefficients from regressions of long-term interest rates on the (partial sum processes of the) 3-month T-bill rate. F_{PSS} denotes the test statistic of the F-test proposed by Pesaran* et al. *(2001). The relevant 5% upper bound critical value is 5.73 for k=1 and 4.85 for k=2, where k is the number of regressors. χ^2_{SC} is the test statistic of the Breusch-Godfrey Serial Correlation LM Test, followed by the p-value. W_{LR} is the Wald test for the null hypothesis of long-run symmetry, followed by the p-value. SR asym indicates whether positive (POS) or negative (NEG) short-run asymmetry is present while the figure in square parentheses denotes the quarters after the simulated shock during which the asymmetry is statistically significant, based on bootstrapped confidence intervals using Eviews 6.*

Table 2: Estimation results, U.S.

	1996:11-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	0.602	0.202	0.374	0.185		
β^+					0.241	0.115
β^-					0.414	0.112
Adj. R2	0.330		0.329		0.379	
F_{PSS}	4.749		5.298		7.445	
χ^2_{SC}	2.545 [0.637]		1.378 [0.848]		0.769 [0.943]	
W_{LR}					18.900 [0.000]	
SR asym			POS [2-7]		POS [3-7]	

(a) Composite bond yield

	1996:11-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	0.620	0.327	0.483	0.400		
β^+					0.227	0.111
β^-					0.463	0.111
Adj. R2	0.352		0.373		0.355	
F_{PSS}	3.180		2.055		6.091	
χ^2_{SC}	8.390 [0.078]		2.507 [0.643]		5.194 [0.268]	
W_{LR}					23.884 [0.000]	
SR asym			POS [0, 2]		POS [0, 3]	

(b) Long-term mortgage rate

continued overleaf...

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	1996:11-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	0.484	0.187	0.295	0.238		
β^+					0.196	0.098
β^-					0.340	0.093
Adj. R2	0.284		0.345		0.358	
F_{PSS}	3.549		2.290		6.519	
χ^2_{SC}	2.646 [0.619]		0.539 [0.970]		2.500 [0.645]	
W_{LR}					13.165 [0.000]	
SR asym			POS [0, 2-6]		POS [0, 2-5]	

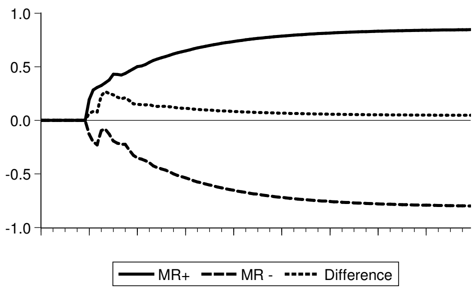
(c) Bank lending rate, small long-term business loans

	1996:11-2009:6					
	LR & SR sym		LR sym & SR asym		LR & SR asym	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
β	0.532	0.107	0.346	0.117		
β^+					0.348	0.067
β^-					0.404	0.064
Adj. R2	0.350		0.334		0.371	
F_{PSS}	5.464		5.700		8.589	
χ^2_{SC}	2.339 [0.674]		0.528 [0.971]		5.394 [0.249]	
W_{LR}					4.005 [0.048]	
SR asym			POS [2-6]		POS [2-6]	

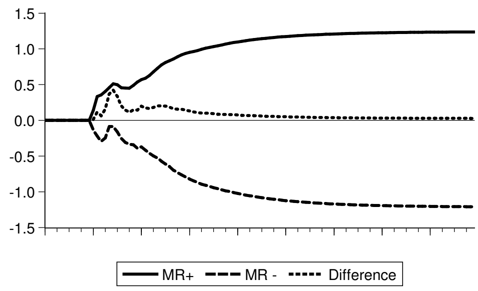
(d) Bank lending rate, large long-term business loans

Note: *The tabulated results do not include the estimated short-run dynamics in order to conserve space (see footnote 9 on page 13 for further details). Full estimation results are available on request.* β, β^+ *and* β^- *are the estimated long-run coefficients from regressions of long-term interest rates on the (partial sum processes of the) 3-month money market rate. See the notes to Table 2 for further details of our notational conventions.*

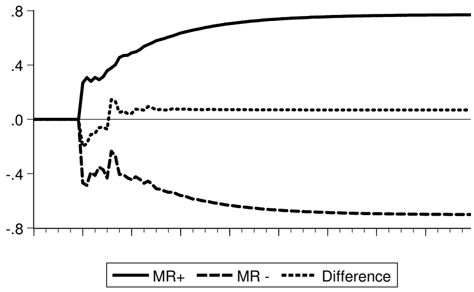
Table 3: Estimation results, Germany.



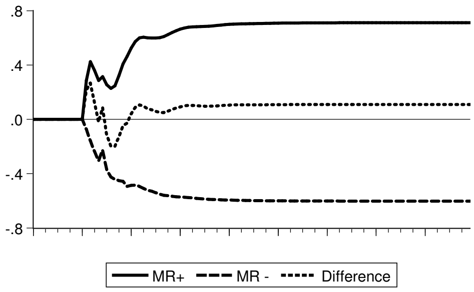
(a) AAA corporate bond yield



(b) BAA corporate bond yield

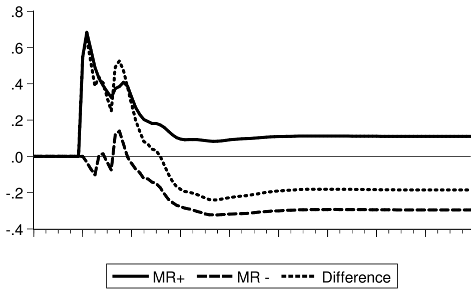


(c) 10-year T-bill rate

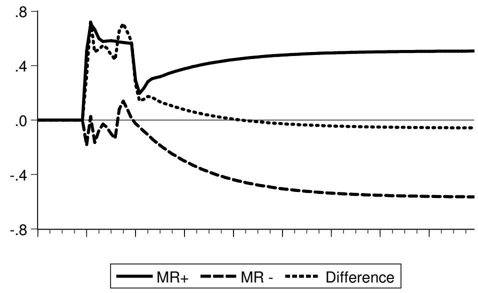


(d) Mortgage rate

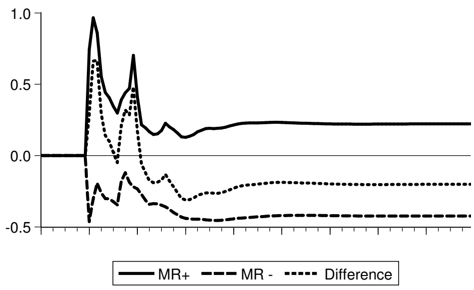
Figure 1: Dynamic multipliers: U.S., first sub-period



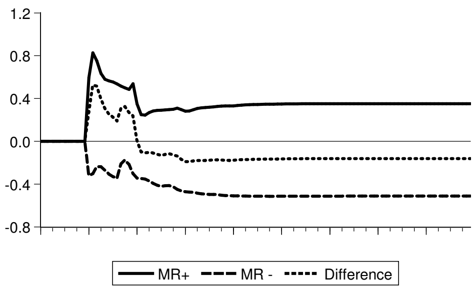
(a) AAA corporate bond yield



(b) BAA corporate bond yield

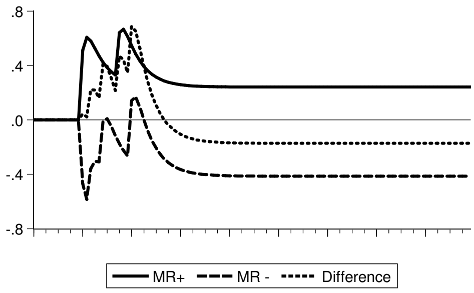


(c) 10-year T-bill rate

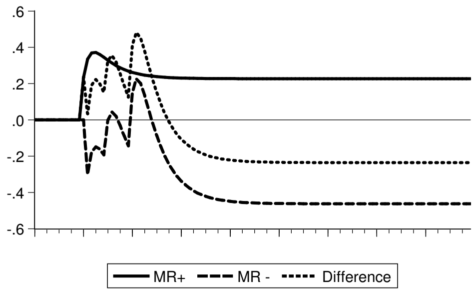


(d) Mortgage rate

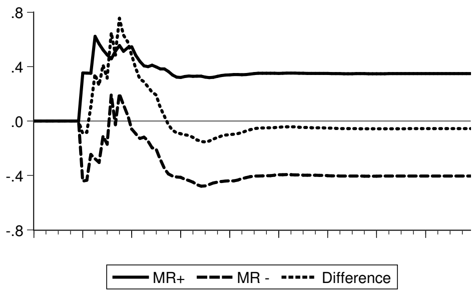
Figure 2: Dynamic multipliers: U.S., second sub-period



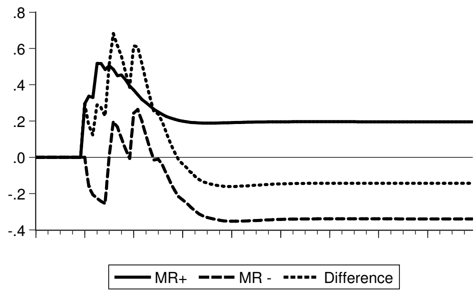
(a) Composite bond yield



(b) Long-term mortgage rate



(c) Bank lending rate, large long-term business loans



(d) Bank lending rate, small long-term business loans

Figure 3: Dynamic multipliers: Germany

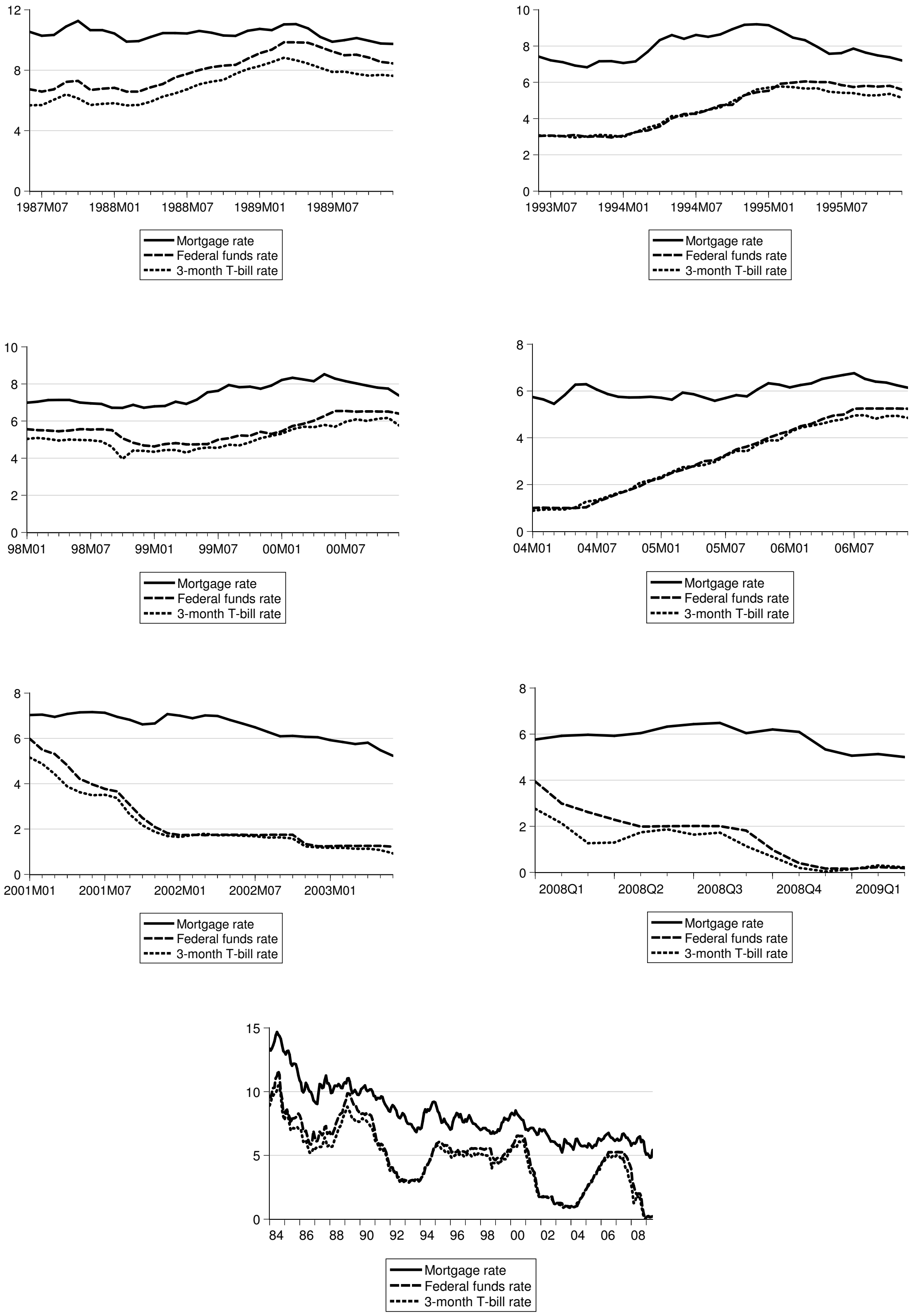
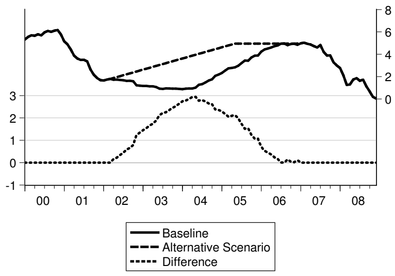
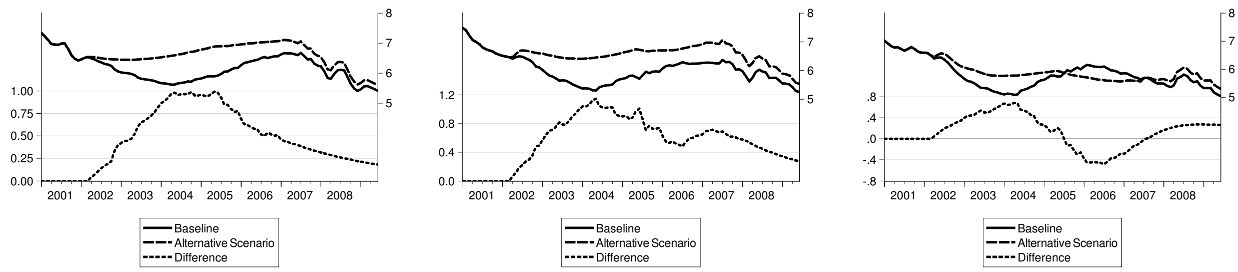


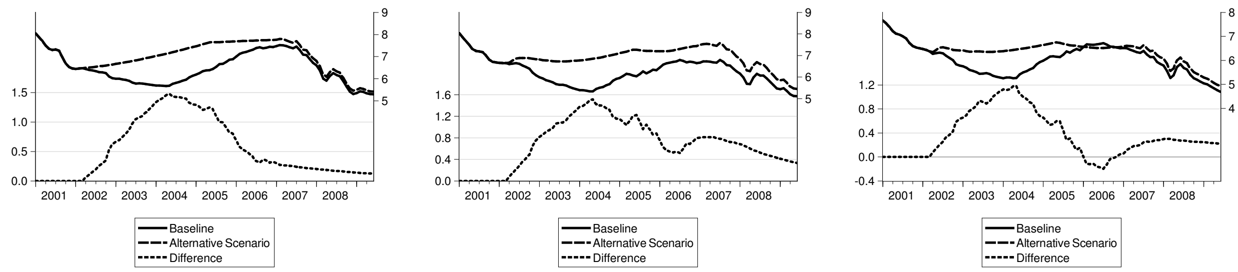
Figure 4: The relationship between policy-controlled rates and the mortgage rate



(a) 3-month T-bill rate



(b) AAA corporate bond yield



(c) Mortgage rate

Note: Panel (a) shows what the 3-month T-bill rate would have been, if the Fed had followed Taylor's rule (Taylor 2007). The simulations in panels (b) and (c) are based on the three different specifications of the estimated pass-through equations from Table 2 (left: symmetric SR & LR; middle: asymmetric SR, symmetric LR; right: asymmetric SR & LR).

Figure 5: If Greenspan had followed Taylor's rule...

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