Monetary Policy and Asset Prices:
When Cleaning Up Hits the Zero Lower Bound

by

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Abstract

This study explores the role of the zero lower bound (ZLB) for optimal monetary policy reactions to boom–bust cycles in housing prices. Recently, convincing evidence has been presented that the recession in the wake of the recent financial crisis resulted primarily from an overly levered housing sector that was forced to deleverage and cut consumption spending when faced with collapsing housing prices. Following this interpretation it is argued that, as opposed to the consensus view on monetary policy in the vicinity of the ZLB, optimal monetary policy may involve an interest rate *increase* if the ZLB threatens to become a binding constraint in the aftermath of an asset price bust. This result delivers arguments to advocate a – in the previous literature less favored – pre-emptive tightening policy in an asset price boom. It is also shown that the actual policy decision that central bankers face is not whether to act preemptively when facing a potentially costly asset price boom but rather in which direction interest rates should move.

Keywords: monetary policy, asset price bust, zero lower bound, cleaning-up, pre-emptive tightening

JEL Codes: E52, E58, E44

1 Introduction

The economic costs of a financial crisis can be tremendous, as proven by the crisis that erupted in the late 2000s, after the fall of Lehman Brothers. Until very recently, monetary policy has not been regarded as being able or having the appropriate instruments at its disposal to lean against the wind of an asset price upswing, such as that which preceded and then provoked the recent crisis. Rather, the pre-crisis consensus regarding monetary policy and asset prices has indicated that leaning against the wind created by an asset price boom would be very costly for a central bank while the chances of success are unclear at best. It was usually pointed out that the required interest rate increase would be prohibitively high because it would cause unacceptably severe strains for the real economy. Therefore, monetary policy should simply contain the economic fallout after a bust (i.e., "clean up"). [1]

This pre-crisis consensus has been drastically undermined by the recent financial disaster, which demonstrated some dangerous flaws in the so far consensual approach. The essence of the cleaning-up approach was that a severe shock should be mitigated by a decisive monetary policy reaction. However, there is a natural limit in how much central banks can lower their instrument rates to stimulate the economy. Estimates based on Taylor rule calculations show that the federal funds rate would have needed to be cut by -4% to -6% in 2009. In such severe instances, the ability of the central bank to clean up after the bust can be heavily constrained by the zero lower bound (ZLB). Central banks worldwide, including the U.S. Federal Reserve (Fed), the Bank of England (BoE), the Swiss National Bank (SNB), and the Swedish Riksbank, have been trapped in this situation for some time. The way out that most of them

[1] At the cost of oversimplification we refer to the cleaning-up approach as the pre-crisis or "Jackson-Hole" consensus on the role that asset prices should play in guiding monetary policy (see Bean et al. (2010), Borio (2011)). However, this pre-crisis consensus was not unanimously shared. For example, Cecchetti et al. (2000) and other researchers at the Bank for Internationale Settlements were critical of the cleaning-up approach already several years before the outbreak of the recent financial crisis (see Clarida (2010)).

have chosen is to take recourse to unconventional measures, such as quantitative easing, whose long-term consequences remain largely unclear and much disputed.[2]

In this paper we link the debate on the optimal monetary reaction to asset price boom-and–bust cycles to the discussion about optimal monetary policy in the run-up to a potentially binding ZLB. Our key question can be formulated as follows: What does the ZLB imply for the choice of the optimal monetary policy strategy during an asset price boom-and-bust cycle? We assume that households are levered to settle housing transactions. When house prices drop precipitously, indebted households will be forced not only to deleverage but also to reduce their other spending to repay their loans. Furthermore, if debt exceeds the asset's market value, a levered household may suffer from a credit crunch, because refinancing options become increasingly scarce.[3] In short, the more indebted households are due to purchases on the housing market or equity withdrawals in the course of rising housing prices (i.e., the more levered they are), the higher is the risk that a drop in house prices will lead to a collapse of aggregate demand.[4]

A simple New Keynesian model is presented that explicitly allows the instrument rate to hit the ZLB in the aftermath of an asset price bust–induced recession. We assume that monetary policymakers can influence household leverage by varying the interest rate.[5] Already in a

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[2] Anderson et al. (2010) report that the Fed, the BoE, the SNB as well as the Riksbank all responded to the recent financial crisis with sharp decreases in their policy rate to (nearly) zero, coupled with massive increases in their monetary base, ranging from 147% (Fed) to 204% (BoE).

[3] The access to credit is constrained by the value of the collateral that a leveraged household can offer. The collateral value of houses available to households, however, is influenced by boom-and-bust cycles on the housing market.

[4] See the empirical evidence provided by Mian and Sufi (2010), Glick and Lansing (2010), and the IMF (2012).

[5] Taylor (2009, 2010), the IMF (2008), and Iacoviello and Neri (2010) support the view that the Fed's unusually low interest rate policy was an important factor in the U.S. housing boom prior to the financial crisis. As mentioned above, this housing boom was accompanied by an enormous rise in household indebtedness. The IMF (2008) emphasizes that innovations in the U.S. housing finance system have linked housing prices more closely to the Fed's interest rate policy. Furthermore, rising housing prices, in conjunction with home equity withdrawals have significantly contributed to the rise in U.S. household indebtedness (Dynan and Kohn (2007), Mian and Sufi (2011)). However, it should also be noted that the magnitude of the increase in housing prices in

credit and housing boom, central bankers thus can affect the severity of a potential bust-induced recession in the future and therefore indirectly the likelihood of reaching the ZLB. The mainstream view on monetary policy in the vicinity of the ZLB holds that interest rates should be cut faster and more aggressively than warranted by economic fundamentals if a ZLB threatens to become binding in the near future (see, e.g., Reifschneider and Williams (2000), Gerlach and Lewis (2010)). We argue that, if interest rates reach the ZLB due to disruptions on financial markets, a policy alternative may exist that is diametrically opposed to this mainstream view. The mere possibility that the ZLB could be binding after a financial crisis may render a policy of leaning against the build-up of an asset price boom, which the pre-crisis consensus categorically dismissed as inefficient as discussed above, a reasonable policy option. In spite of the immediate negative effects on output gap, monetary policymakers may optimally choose an aggressive pre-emptive interest rate *hike* during an asset price boom to prevent hitting the ZLB after the bust. We find that central bankers' willingness to adopt a leaning-against-the-wind policy will be even stronger the higher is the relative weight that central bankers place on output gap stabilization relative to inflation stabilization.[6] Thus, while our results support the view that monetary policymakers should move interest rates pre-emptively in the run-up to a potentially binding ZLB, we do not confirm the widespread view that this move has to be an interest rate *cut*.

Although very stylized our model also sheds some light on the actual policy choice that monetary policymakers face in an asset price boom. We argue that optimizing policymakers

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the United States before the recent crisis cannot be ascribed solely to the monetary policy stance. The available mortgage products, for example, have been identified by many observers as another key factor behind the housing price developments (e.g., Bernanke (2010)).

[6] The intuition behind this result is that a pre-emptive interest rate hike not only leads to output gap losses but also gives rise to lower inflation rates during the boom period. Central bankers who place a large relative weight on achieving the inflation target may therefore eschew the threatening deflation that might be associated with a pre-emptive interest rate hike. In other words this "fear of deflation" makes it less likely that stricter inflation targeting central banks will lean against the wind of rising asset prices in the run-up to a potentially binding ZLB. See section 3.3.

may not have the choice between "*Lean(ing) or Clean(ing)*" as White (2009) puts it, but rather between leaning *with* or *against* the wind.[7] Even if policymakers (optimally) refrain from preemptive tightening, they should not remain inactive during the boom phase. Rather, optimal monetary policy calls for a monetary loosening in the boom period, because the risk of a bust-induced binding ZLB gets incorporated into market expectations, driving the policymaker's target variables away from their target values already before the bust.

Perhaps somewhat surprising, implications of the ZLB for central banks' optimal reaction to asset price booms have not been studies extensively so far. However, Robinson and Stone (2005), extending the analysis of Gruen et al. (2005), address this topic. In contrast to our fully forward-looking model, Robinson and Stone employ a backward-looking model in the spirit of Ball (1999) and Svensson (1997). Their results support our view that central bankers face the choice between monetary tightening and monetary loosening during asset price booms if the ZLB threatens to limit policymakers' room to maneuver. However, their study – while emphasizing the role of time lags in monetary policy and the stochastic properties of asset price bubbles – explicitly only considers monetary policy as forward-looking, treating the private sector as backward-looking. The expectations channel that forward-looking expectations by the private sector give rise to is therefore completely absent in Robinson and Stone's work. By contrast, our paper abstracts from time-lags but stresses the importance of both the policymaker's and the private sector's forward-looking behavior.[8]

The remainder of the paper is organized as follows. In Section 2, the model will be presented, the cleaning-up approach will be discussed and the zero lower bound will be introduced as a

[7] See for example the discussion in Berger and Kißmer (2008, 2009).

[8] Berger et al. (2007) and Berger and Kißmer (2008, 2009) also emphasize the importance of this expectations channel for the optimal monetary policy during boom periods. However, these studies abtract from the ZLB and put forward the Phillips-curve-effects of financial shocks.

potentially binding constraint. Sections 3 starts with a discussion of the preemptive tightening policy option followed by a welfare comparison of all policy regimes. We further derive a policy rule to govern the optimal choice of monetary policy strategy in times of boom–bust cycles in asset markets. To gain further intuition, we illustrate our policy rule numerically by applying it to the U.S. economy. Section 4 concludes.

2 Monetary Policy, Asset Price Busts, and the ZLB

2.1 Standard Monetary Policy Model

The model we use in this paper is a standard New Keynesian model, modified to allow for an asset price bust–induced decline in consumption. We begin by following most previous work on this topic and disregard the ZLB as a binding constraint. Then in Section 2.3, we introduce the ZLB to analyse how its binding presence changes the optimal monetary policy strategy if an asset price bust threatens to cause severe economic strains.

The monetary policymaker is assumed to minimize the loss function in equation (1)

(1) $$V = E\left(\sum_{t=1}^{3}\beta^{t-1}L_t\right),$$

where the period losses are quadratic in the inflation rate and output gap,

(2) $$L_t = \pi_t^2 + \lambda x_t^2 .$$

Equations (1) and (2) can be understood as describing an inflation-targeting regime. If policymakers assign a positive (zero) relative weight λ to the output gap stability, a regime of flexible (strict) inflation targeting is said to prevail.

The economy is described by a forward-looking Phillips curve, as in Equation (3), and an IS relationship, as in Equation (4). As is well-known the former relates current inflation π_t to expected next-period inflation $E_t\pi_{t+1}$ and the current output gap x_t while the latter links the current output gap to the expected future output gap E_tx_{t+1} (due to consumption smoothing) and the deviation of the real interest rate ($r_t = i_t - E_t\pi_{t+1}$) from its equilibrium value r*. Thus,

(3) $\pi_t = \beta E_t \pi_{t+1} + \alpha x_t$, $0 \leq \beta \leq 1$, $\alpha > 0$,

(4) $x_t = E_t x_{t+1} - \left(i_t - E_t \pi_{t+1} - r^*\right)/\sigma - v_t$ r*, $\sigma > 0$, t = 1, 2, 3.

The demand shock v_t deserves special attention. In line with the evidence presented by Mian and Sufi (2010), Glick and Lansing (2010), and the IMF (2012) v_t is understood as representing a bust-induced drop in consumption in our model.

The economy exists for three periods. In period 1, asset prices are driven up. The model is sufficiently general that it applies for various assets. However, in light of the recent financial crisis and resultant literature, we will interpret asset prices in our model more specifically as housing prices. In period 2, a bust-induced drop in aggregate demand may or may not occur, depending partly on the monetary policy chosen in period 1. The third period merely serves to represent the new steady state, in which no further shocks can occur.

The distribution of v_t, which can only occur in period 2, is defined as

$$
(5) \qquad v_t = \begin{cases} 0 & \text{in} \quad t \neq 2 \\ 0 & \text{in} \quad t = 2 \quad \text{if} \quad \text{no debt crisis in household sector} \\ \varepsilon > 0 & \text{in} \quad t = 2 \quad \text{if} \quad \text{debt crisis in household sector} \end{cases}
$$

In contrast with conventional models, in this case v_t is not an entirely exogenous shock. Policymakers can affect the probability that a bust-induced drop in consumption will occur by varying the first-period nominal interest rate i_1 and thus affecting household leverage through the real costs associated with a given debt burden ($r_1 = i_1 - E_1\pi_2$).[9] Furthermore, the interest rate policy may affect household indebtedness indirectly through its influence on housing prices, in that low interest rates tend to increase housing prices and encourage home equity withdrawals, because homeowners can borrow additional money against the increased collateral value of their houses.[10]

The more household leverage is contained (i.e., the lower households' debt burden), the lower is the probability that a house price bust will force overly levered households to reduce their leverage abruptly. In addition, the lower household indebtedness, the lower is the probability that a bust in the collateral value of houses will lead to a credit crunch that reduces

[9] In a similar vein, Woodford (2012) assumes that central bankers interest rate policy can influence the probability of a financial crisis through its impact on the output gap. In a New Keynesian model with credit frictions a higher output gap (i.e. a lower real interest rate) is assumed to increase the leverage in the financial sector and thus the probability of a financial crisis.

[10] According to the IMF (2008), the house collateral effect, or "financial accelerator effect", respectively, has become an increasingly important element of the monetary transmission mechanism in economies with well-developed housing finance systems. See also Mian and Sufi (2011) and Dynan and Kohn (2007) on the importance of the home equity–based borrowing channel with respect to the U.S. household leverage crisis. However, not only the financial position of borrowers but also lenders' financial status may be an important variable in the monetary transmission mechanism. Testing the credit channel of monetary policy in four housing markets (Finland, Germany, Norway and the UK) Iacoviello and Minetti (2008) find robust evidence for a bank lending channel in Finland and the UK.

households' refinancing options.[11] For simplicity, we assume that a precipitous drop in consumption that pushes the economy into recession cannot occur if policymakers increase the (real) interest rate (at least) to a certain minimum level during the boom period.

Formally, the probability of the crisis chain of events unfolding in the second period is

$$\mu = \text{prob}(v_2 = \varepsilon \mid i_1 - E_1\pi_2) = \begin{cases} 0 & \text{if} \quad i_1 - E_1\pi_2 \geq \underline{r} > r^* \\ 0 < \mu < 1 & \text{if} \quad i_1 - E_1\pi_2 < \underline{r} \end{cases} \tag{6}$$

where $\underline{r}$ denotes the minimum real interest rate required to completely eliminate the probability of a future household debt crisis.[12] If the real interest rate is set to equal at least $\underline{r}$ in period 1, the debt burden accumulated so far in the household sector will always be low relative to the value of the collateral that households can offer. Household leverage then will not reach the critical level, such that it causes a severe economic slump on the demand side should asset prices collapse.

2.2 The Case for Cleaning Up

The essence of the cleaning-up approach as discussed in the literature so far (see, e.g., White 2009) is that policymakers stabilize the economy optimally when an asset price boom has turned to bust but regard the build-up of a potentially unsustainable boom with benign neglect, such that they refrain from leaning against an upswing on asset markets. Only if and

[11] Also see evidence presented by Glick and Lansing (2009, 2010), Mian and Sufi (2010), and the IMF (2008, 2012).

[12] A similar approach is chosen by Berger et al. (2007) and Berger and Kißmer (2008, 2009) in related models.

when a bust, with its ensuing drop in demand and inflation, occurs do policymakers react by cutting interest rates. Therefore, the cleaning-up approach can be described formally as: [13]

(7) $$i_2^{CU}(v_2 = \varepsilon) = r_2^{CU}(v_2 = \varepsilon) = r^* - \sigma \cdot \varepsilon .$$

It is well-known that monetary policymakers can perfectly stabilize demand shocks in the NKM model through interest rate adjustments.[14] If the interest rate is set according to Equation (7) (and the ZLB does not bind), bust-induced demand insufficiencies are perfectly counterbalanced, and output and inflation move back to their target values. Therefore, irrespective of the occurrence of a financial crisis, the optimal outcome $L_2^{CU} = 0$ prevails in the second period. Given agents' forward-looking behavior, this result gets incorporated into rational agents' expectations. Therefore, also in the first period, the output gap and inflation cannot be driven away from their target values ($L_1^{CU} = 0$), and social losses for the cleaning up strategy must equal zero, $V^{CU} = 0$. Theory thus predicts that the economic costs of a financial crisis that works through the demand side, as proposed by Mian and Sufi (2010) and Glick and Lansing (2010), can be well contained.

Based on these considerations, the decision in favor of the cleaning-up strategy seems a perfectly rational choice.[15] No other policy strategy can improve on this outcome. However, the recent crisis has created economic costs unparalleled by those associated with any financial turmoil since the Great Depression. Although policymakers took decisive

[13] The model is solved by backward induction. Because it is assumed that no further shocks can occur in t > 2, the model's terminal conditions $E_3\pi_4 = \pi_3$ and $E_3x_4 = x_3$ are used to solve for the model's third period. Therefore, $x_3 = \pi_3 = L_3 = 0$, irrespective of the policy chosen in the previous periods. Then the results for the first two periods can be derived.

[14] For example, see the discussion in Berger et al. (2007).

[15] If credibly communicated in advance, the cleaning-up strategy may give rise to moral hazard behavior. Market participants may rely on policymakers to intervene to prevent markets' widespread collapse and, in anticipation, accumulate too much risk from the start ("Greenspan-put") thus deepening a crisis should it occur.

counteractive measures, as prescribed by Equation (7), the output gap and inflation rates dropped on a global scale.[16] The conclusions we have derived thus far hinge critically on the initial assumption, namely, that policymakers have sufficient latitude to adjust their instrument rates as required by economic conditions. However, because there is a natural limit to how far interest rates can be lowered, the next step is to investigate the merits of the cleaning-up approach with this limit.[17]

2.3 Monetary Policy in the Presence of the ZLB: The Cleaning-Up Approach Revisited

Recent experience shows that the ZLB can constitute a binding constraint that, arguably, has been severely underestimated by policymakers and academics alike in most pre-crisis discussions about how to cope with a potentially dangerous asset price boom.[18] As noted previously, central banks worldwide have reached the ZLB or are hovering around it. To take the ZLB explicitly into account, we require formally.

(8) $$i_t \geq 0 \, .$$

The value of the shock ε is assumed to be either $\bar{\varepsilon} > r^*/\sigma$ or $\underline{\varepsilon} \leq r^*/\sigma$. From Equation (7), we know the ZLB would bind for $\bar{\varepsilon}$, while the optimal (nominal) interest rate for the

[16] See Woodford (2012). One could object to the preceding line of argumentation that the recent global financial crisis not only worked as a demand shock but also had effects on the supply side. The perfect stabilization outcome generally is not achievable if the supply-side effects of a financial shock are considered as well (Adrian et al. (2010), Bordo and Jeanne (2002) and Berger and Kißmer (2008, 2009)). Gruen et al (2005) provide another explanation without resorting to supply-side effects. In their backward-looking model along the lines of Ball (1999) and Svensson (1997) central bankers might be unable to fully stabilize aggregate demand should a bubble burst because the impact of monetary policy on the real economy unfolds with a lag.

[17] The interaction between the demand-side and supply-side effects of a financial crisis and the optimal reaction of monetary policy is left to future research in order to single out the effect of the ZLB on the merits of the cleaning-up approach. Filardo (2009) allows for both supply and demand side effects of asset price bubbles while analyzing the nexus between household debt, monetary policy and financial stability. However, he abstracts from the ZLB.

[18] Chung et al. (2011) provide evidence that the magnitude and duration of the ZLB constraint encountered in the recent crisis in the United States and other countries came as a surprise to both policymakers and academics.

cleaning-up strategy would remain positive if the value $\underline{\varepsilon}$ were realized. For simplicity, we assume the (contingent) probability of both specific values for ε is exogenous. Thus,

$$(9) \qquad \eta = \text{prob}\left[\varepsilon = \bar{\varepsilon} \mid v_2 = \varepsilon\right] \qquad \text{and} \qquad 1-\eta = \text{prob}\left[\varepsilon = \underline{\varepsilon} \mid v_2 = \varepsilon\right].$$

Taking the possibility of a ZLB explicitly into consideration fundamentally changes the efficiency of monetary policy. If the bust-induced drop in demand is sufficiently large ($\bar{\varepsilon} > r^*/\sigma$), a policymaker that adopts a cleaning-up approach cannot fully balance the impact of the shock on the output gap and inflation any more. If the instrument rate hits the ZLB, the country slips into a recession with deflation. That is,

$$(10) \qquad x_2^{CU}(\varepsilon = \bar{\varepsilon}) = -\Omega, \qquad \text{and} \qquad (11) \qquad \pi_2^{CU}(\varepsilon = \bar{\varepsilon}) = -\alpha \cdot \Omega, \quad \text{where} \quad \Omega = \bar{\varepsilon} - r^*/\sigma > 0.$$

Although our model is based on a relatively simple structure, Equations (10) and (11) offer an accurate description of the macroeconomic dilemma in which many countries were (or remain) trapped after the arrival of the recent crisis.

If the debt crisis is less severe ($\underline{\varepsilon} \le r^*/\sigma$), the output gap and inflation can be moved back to their target values. The expected second-period losses then can be written as:

$$(12) \qquad E(L_2) = \mu \cdot \eta \cdot \Delta \cdot \Omega^2, \qquad \text{where} \quad \Delta = \lambda + \alpha^2.$$

However, the ZLB does not just give rise to economic costs in the bust period during which it may be reached. The mere possibility of reaching the ZLB, should a crisis unfold, also affects social losses in the first period if agents display forward-looking behavior. This point marks another consideration that thus far has often been overlooked in the debate about optimal monetary policy reactions in the wake of a financial crisis. The economic outcome therefore changes not only if and when a crisis hits but also in the periods preceding that crisis. Agents already start to incorporate the possibility of output losses and deflation in their expectations if they observe rapidly rising asset prices, ($E_1 x_2 = -\mu \cdot \eta \cdot \Omega$ and $E_1 \pi_2 = -\mu \cdot \eta \cdot \alpha \cdot \Omega$).

Because the current values of the output gap and inflation depend on market expectations, the possibility of a future crisis causes immediate downward pressure on (period – 1) inflation and output. The output gap and inflation are driven away from their target values, such that the central bank must adapt its monetary policy stance already in period 1. Therefore,

(13) $$i_1^{CU} = r^* - \frac{q}{\Delta}\left[(\sigma + \alpha) \cdot \Delta + \alpha^2 \cdot \beta \cdot \sigma\right]$$

(14) $$r_1^{CU} = r^* - \frac{q \cdot \sigma}{\Delta}\left[\Delta + \alpha^2 \cdot \beta\right], \qquad \text{where } q = \mu \cdot \eta \cdot \Omega.$$

The policymaker then should allow both the nominal and the real interest rate to fall below their flex-price equilibrium values to contain the expectation-induced decrease in inflation and output.[19] In contrast to the vast majority of the literature on the optimal monetary policy reaction to asset price boom-bust-cycles our model demonstrates that the policymaker should turn to an expansionary monetary policy even before the bust. Such a policy during the growth phase of the boom is simply a consequence of changes in (forward-looking)

[19] For simplicity, we solve the model with the assumption that the nominal interest rate does not hit the ZLB already in period 1. This assumption requires that the maximum value of ε fulfils the following condition: $\frac{r^*}{\sigma} < \bar{\varepsilon} < \frac{r^*}{\sigma}\left[1 + \frac{\Delta}{\mu \cdot \eta \cdot (\Delta + \alpha^2 \cdot \beta)}\right]$.

expectations that a looming asset price bust gives rise to, but not an attempt to influence the growth of the boom itself.[20] We thus obtain

(15) $\pi_1^{CU} = -\frac{\alpha \cdot \beta \cdot \lambda}{\Delta} \cdot q$, and (16) $x_1^{CU} = \frac{\alpha^2 \cdot \beta}{\Delta} \cdot q$.

Equation (15) shows that the optimal outcome cannot be replicated anymore, so that losses in the first period amount to

$$(17) \quad L_1^{CU} = \frac{\lambda}{\Delta} \cdot (\alpha \cdot \beta \cdot q)^2 = \frac{\lambda}{\Delta} \cdot [\alpha \cdot \beta \cdot \mu \cdot \eta \cdot \Omega]^2,$$

and the intertemporal losses of the cleaning-up approach are

$$(18) \quad V^{CU} = \frac{\mu \cdot \eta \cdot \beta}{\Delta} \cdot \Omega^2 \cdot \left[\alpha^2 \cdot \beta \cdot \lambda \cdot \mu \cdot \eta + \Delta^2\right].$$

Several implications concerning the optimal cleaning-up approach are worth noting. First, relying on monetary policymakers to mitigate the economic costs of an asset price collapse may mean overestimating the central banks' power, even for a purely demand-side financial crisis.

Second, the model lends support to the conclusion drawn in large part of the literature about how to react in the run-up to a ZLB. Interest rates should be decreased drastically, possibly

[20] Our interpretation of the optimal cleaning-up strategy is more in line with the conventional wisdom that inflation targeting should involve a timely adjustment of monetary policy if an asset price boom signals current or future changes in the target variables, inflation, and output gap. Detken and Smets (2004) provide empirical evidence that monetary policy during asset price booms followed by severe recessions is typically quite expansionary. Our interpretation also corresponds with central bankers' rhetoric. Prior to the recent financial crisis, central bankers often expressed their scepticism of the (alternative) leaning against the wind strategy.

even more than warranted by economic fundamentals, prior to reaching the ZLB (see also, e.g., Reifschneider and Williams (2000) and Adam and Billi (2006, 2007)). If the ZLB might become a binding constraint, optimal monetary policy dictates lowering the nominal interest rate i_1 immediately below the level r* that would be optimal in the absence of a looming ZLB (see Equation (13)). Conserving some ammunition and cutting interest rates in the run-up to a ZLB rather cautiously, to reserve scope for further cuts in the future as advised by Bini Smaghi (2008) is therefore clearly rejected by our model.[21]

Third, not interfering with the boom itself but focusing on cleaning up after the bust implies, correctly understood, that policymakers should start to loosen the monetary policy stance, before the bust actually occurs. Therefore, we prefer to characterize this policy as a "preemptive loosening" or "leaning with the wind strategy" which differs profoundly from a benign neglect policy as commonly understood.[22] Furthermore, as can be seen from equations (15) and (16) central bankers who place a large relative weight on inflation stability relative to output gap stability (i.e., a small λ) will behave even more aggressively in order to reduce the extent of deflation, thereby boosting output in the run-up to a potentially binding ZLB. For example, under a regime of strict inflation targeting ($\lambda = 0$) central bankers will cut the interest rate to such a low level that inflation will be brought back on target while the output boom *ceteris paribus* reaches its maximum strength..

Our results are somewhat complementary to that of Robinson and Stone (2005). Relying on the purely backward looking model by Gruen et al. (2005) that imbeds time-lags in the impact of monetary policy on real activity and inflation as a key feature, they show that in the final stages of an unsustainable asset price boom pre-emptive interest cuts must be more aggressive

[21] See, e.g., the discussion in Gerlach and Lewis (2010).
[22] For example, see Greenspan (2002) and Posen (2006) and the discussion in Berger and Kißmer (2009).

than without a possibly binding ZLB. However, as time-lags in monetary policy render a pre-emptive interest rate cut shortly before the bubble bursts optimal even in the absence of a looming ZLB, the main impact of the ZLB on the optimal policy during an asset price boom consists in the amplification of the required interest rate move. In stark contrast to that, we argue that a potentially binding ZLB changes the set of policy options fundamentally. The mere possibility that the ZLB could be reached forces the central bank in our model to consider a pre-emptive interest rate cut, which would not be necessary otherwise.

Our results so far come with an important qualification though. We have simply assumed that policymakers choose the cleaning-up approach when they confront a potentially unsustainable asset price boom. In the next section, we turn to a question that has remained thus far unanswered: What are the implications of the ZLB on the choice of the optimal monetary policy strategy in the presence of an asset price boom?

3 How to React to an Asset Price Boom

3.1 A Policy Alternative: Preemptive Tightening

In principle, policymakers who observe rapidly rising asset prices have the choice between the (so far dominant) cleaning-up strategy and a policy of preemptive monetary tightening to contain debt accumulation in the private sector and thus the build-up of a crisis scenario. The latter strategy may be described as a policy of an early "leaning against the wind" of a boom expansion. This idea is captured in Equation (6) above. If policymakers decide to lean against the wind, they must set the interest rate in period 1 so high that it prevents the accumulation of a household debt burden that could jeopardize financial stability in the future. In this case, no bust-induced drop in aggregate demand can occur in period 2.[23] Hence, preemptive tightening enables policymakers to mimic the favorable steady-state solution in period 2:

(19) $i_2^{PT} = r_2^{PT} = r^*$. (20) $\pi_2^{PT} = x_2^{PT} = L_2^{PT} = 0$.

However, this outcome in period 2 does not arrive without costs. In period 1, interest rates must be raised high enough to keep leverage in the household sector within sustainable limits, notwithstanding the economic costs of such a policy. More formally, interest rates must rise to $\underline{r}$ (see Equation (6)), which implies that both inflation and the output gap fall below their targets during the boom period. That is,

(21) $i_1^{PT} = r_1^{PT} = \underline{r}$, (22) $\pi_1^{PT} = -\alpha z / \sigma$,

(23) $x_1^{PT} = -z / \sigma$, (24) $L_1^{PT} = \Delta(z / \sigma)^2$,

where $z = \underline{r} - r^* > 0$, and $\Delta = \lambda + \alpha^2$. Intertemporal losses then amount to

(25) $V^{PT} = \Delta(z / \sigma)^2$.

The ZLB has no impact on the welfare outcome under a policy of preemptive tightening, because a household leverage crisis will be avoided.

[23] As explained above, interest rate moves can affect both household leverage and consumption directly, through the change in cost and availability of credit, and indirectly, by influencing house prices (see, e.g., IMF 2008). In contrast with our focus on household indebtedness, Bordo and Jeanne (2002), Berger et al. (2007) and Berger and Kißmer (2008, 2009) analyze the optimal monetary reaction to asset price booms by incorporating the idea that policymakers' interest rate policy may affect non-financial corporate indebtedness, while Woodford (2012) focuses on the nexus between interest rate policy and the leverage of the financial sector.

3.2 Optimal Strategy Choice

The ZLB can be a major impediment to the efficient stabilization of the economy after an asset price bust. The necessary policy adjustments prescribed by the cleaning-up approach therefore may become impossible to implement. A policy of preemptive monetary tightening as the alternative policy strategy instead forces policymakers to incur immediate, possibly high economic costs to eliminate the risk of a bust-induced macroeconomic crisis in the future.

The next step in our analysis therefore is to examine whether and in which conditions central banks should be ready to reject the traditional approach in favor of a preemptively tight monetary policy. A comparison of the welfare results (see Equations (18) and (25)) shows that the optimal policy choice is governed by

$$(26) \qquad \underline{r} < r^* + \sigma \cdot \Omega \cdot \sqrt{\mu \cdot \eta \cdot \beta \cdot \left(\alpha^2 \cdot \beta \cdot \lambda \cdot \mu \cdot \eta + \Delta^2\right)}, \qquad \Omega = \bar{\varepsilon} - r^*/\sigma > 0,\ \Delta = \lambda + \alpha^2,$$

where, as defined above, $\underline{r}$ is the minimum level of the real interest rate required to forestall a financial crisis. If this interest rate is smaller than the maximum level of the real interest rate that central bankers are willing to endure to avoid a financial crisis (i.e., the right hand side of inequality (26)), then adopting a preemptive leaning against the wind strategy leads to comparatively smaller welfare losses, such that the condition $V^{PT} < V^{CU}$ is fulfilled. If however we ignore the possibility of a ZLB, the cleaning-up approach is always the welfare-superior policy. Because $V^{CU} = 0$ in this case, considering any other policy is pointless.

The model shows that even a financial crisis that works like a demand shock may give rise to substantial economic costs and necessitate an explicit cost–benefit comparison of available policy alternatives. Intuitively, policymakers' willingness to lean against the wind increases with the probability of a binding ZLB ($\mu \cdot \eta$), the maximum drop in consumption ($\bar{\varepsilon}$), and the relative weight policymakers assign to output gap stability (λ), and decreases with the degree of time preference (i.e., fall in β) and the sensitivity with which the output gap reacts to interest rate changes ($1/\sigma$).

3.3 Numerical Example

Inequality (26) demonstrates our key result. Taking the possibility of hitting the ZLB seriously may render a preemptive interest rate *hike* welfare-superior to a preemptive interest rate *cut* cum cleaning-up.[24] The welfare-maximizing policymaker thus must make deliberate policy choices between two options. Our model suggests that merely asking how aggressive and how fast interest rates should be cut if a ZLB threatens to bind in the aftermath of a financial crisis is too short-sighted. The first point to determine instead should be in *which direction* interest rates should be adjusted if the ZLB may become binding in the future. Our results show that a pre-emptive interest rate hike that reduces the likelihood of hitting the ZLB may indeed be a better policy option than the usually recommended pre-emptive interest rate cut in the run-up to the ZLB.

To gain further intuition on the deliberate policy choice that central bankers have to make during a potentially unsustainable asset price boom we calibrate the r.h.s of inequality (26). Thus we analyze the threshold value for the real interest rate central bankers are ready to endure to avoid a future financial crisis. In doing that special attention is paid to the flexibility of the inflation targeting regime.

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[24] Complementary to our result Adam and Billi (2007) stress that expectations of a possibly binding ZLB amplify adverse economic shocks through an adjustment of forward-looking expectations. This makes a pre-emptive policy action optimal.

Table 1 Parameterization of the model

α	β	σ	r*/r* p.a.	λ	$\mu \cdot \eta$	$\bar{\varepsilon}$
0.024	0.99	1	1% ≈ 4% p.a.	0…0.25	0.002/ 0.02	0.01…0.3

The values of the parameters α, β, and σ are derived from Billi (2011) and correspond to those of Woodford (2003) for U.S. data with the nowadays conventional exception that the value of $1/\sigma$ represents a lower degree of interest-sensitivity of aggregate expenditure than originally employed by Woodford. The value of the quarterly discount factor ($\beta = 0.99$) implies that the steady state real interest rate is 4% annually. We let the value of the IS-shock $\bar{\varepsilon}$ in the bad scenario (i.e. when the ZLB becomes binding) run from 0.01 to 0.3 and consider two alternative values of the conditional probability of hitting the ZLB ($\mu \cdot \eta$).[25] Furthermore, we allow for alternative values of the relative weight central bankers place on output relative to inflation stability (λ) in the range between 0 and 0.25.

[25] Since we wish to avoid an overestimation of the importance of ZLB events, we choose relatively low values of these parameters from Chung et al. (2011), Table 2. The authors estimate the likelihood and severity of ZLB events in various macroeconomic models.

Figure 1 Threshold Value of Real Interest Rate

a) $\mu \cdot \eta = 0.002$ b) $\mu \cdot \eta = 0.02$

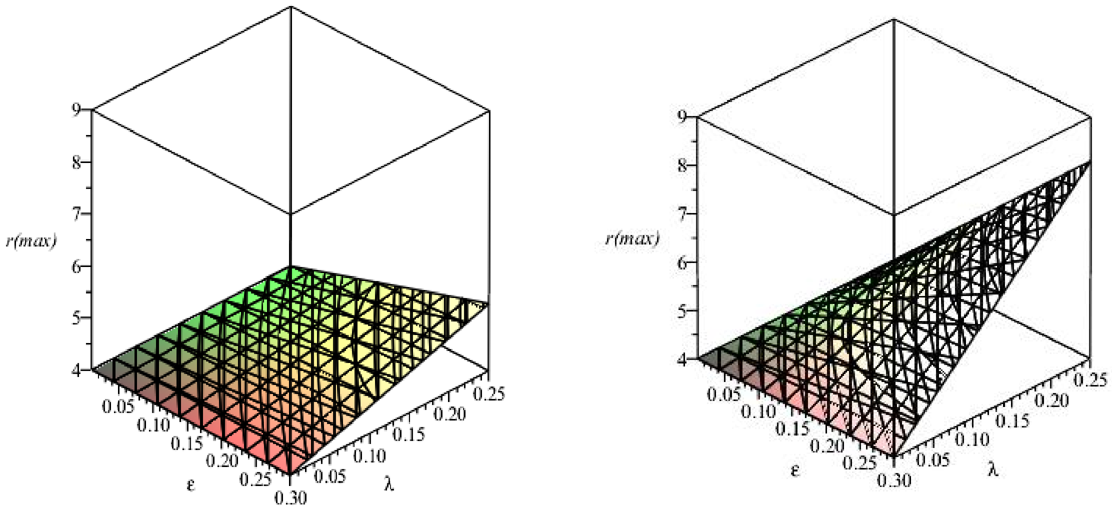

Figure 1 shows that under a rather strict inflation targeting regime the threshold value of the real interest rate r(max) (i.e. the r.h.s. term of inequality (26)) remains in the neighborhood of the assumed steady interest rate of 4% p.a. even if the absolute value of the negative IS-shock increases and the likelihood of hitting the ZLB is decupled.[26] That is, given a stricter inflation targeting regime, central bankers will prefer the cleaning-up strategy in most instances. As already explained above a pre-emptive interest rate hike not only leads to output gap losses but also gives rise to lower inflation rates during the boom period. Central bankers who place a large relative weight on achieving the inflation target (i.e., a small λ) may therefore eschew the threatening deflation associated with a pre-emptive interest rate hike.[27] By adopting the cleaning up policy, stricter inflation targeting central banks can avoid strong direct deflationary effects through aggressive and pre-emptive interest rate cuts. However, under

[26] In Figure 1, r(max) has been normalized to annual values.

[27] Arguably, this "fear of deflation" was an important element in the Fed's decision during the mid-2000s not to increase interest rates more rapidly despite an excessive housing price boom (see Bernanke (2010), Woodford (2012), Taylor (2010) and Berger and Kißmer (2013)). Note, that Woodford (2003, Table 6.1), by analyzing U.S. data, obtained a theoretical quarterly value of λ = 0,003 or λ = 0,048 when inflation and interest rates are measured as annualized percentage rates, respectively. Hence, our interpretation suggests that the period of "monetary excesses", as Taylor (2010) describes the time from 2000 to 2007, should not necessarily be regarded as a period where the Fed attached too much attention to output gap stability relative to inflation stability.

more flexible inflation targeting regimes the threshold value for the real interest rate significantly increases in the absolute value of the shock and this might even hold when hitting the ZLB is a low probability event (Figure 1a). Thus, our numerical example suggests that under flexible inflation targeting a pre-emptive interest rate hike during an asset price boom indeed is a reasonable policy option when central bankers face a potentially binding ZLB. The smaller the relative weight central bankers put on inflation stabilization (versus output stabilization) the more likely it is that they will adopt a leaning against the wind strategy to avoid a future financial crisis scenario. In this sense, inflation targeting central banks face a trade-off between price stability and "financial stability".[28]

Another strategy to deal with a financial crisis–induced demand contraction and the risk of hitting the ZLB also has been suggested recently. Blanchard et al. (2010) point out that central banks would have more latitude to lower (real) interest rates after a bust if their inflation target was sufficiently high. Pointing to the costs of a higher average inflation rate, Walsh (2010) argues that reducing the risk of a negative shock to aggregate demand is a better strategy to avoid the ZLB than is raising the inflation target. This could be achieved through better financial market regulation or a more active response to emerging financial imbalances. Our paper can be interpreted as being in line with Walsh's argumentation, in that we show that an early and aggressive monetary policy reaction may be called for before financial imbalances build up to the point that they turn out to be unsustainable.

[28] This result corresponds somewhat to the view taken in Berger and Kißmer (2013) that central bankers' willingness to implement a pre-emptive leaning against the wind policy during an asset price boom is lesser the stronger is the degree of central bank independence.

4 Conclusion

Recently, overwhelming evidence has been presented that deleveraging in the household sector and the ensuing drop in consumption spending constituted the heart of the recent economic slump in the United States. After a steep increase in household leverage in the years prior to the crisis, an over-levered household sector was forced to reduce its spending sharply when housing prices dropped precipitously, thus pushing the economy into a severe recession.

Adopting this interpretation of the recent crisis the policy strategies available to monetary policymakers are investigated in this paper. Basically, monetary policymakers have the choice between dealing with the economic consequences of an asset price bust if and when it occurs ("cleaning up"), or preventing the crisis in the first place through pre-emptive monetary tightening. The notion that policymakers could be constrained by the zero lower bound is a factor we take explicitly into consideration. Given the recent experiences, this consideration seems highly relevant, though the previous financial crisis literature has thus far widely disregarded this point (recent work suggests that both researchers and politicians were taken by surprise that many central banks encountered the ZLB in the wake of the recent crisis).

Several results of our study stand out particularly. Optimal monetary policy in the run-up to the ZLB may not involve a timely interest rate cut ("clean-up") as commonly argued but the exact opposite, i.e. render a pre-emptive interest rate hike preferable. We argue that the costs of relying on the cleaning-up approach after a financial crisis can be prohibitively high if hitting the ZLB in the course of the cleaning-up process cannot be excluded. Therefore, it may be optimal for policymakers, in particular under a flexible inflation targeting regime, to increase interest rates in order to prevent a financial crisis if the ZLB threatens to become a binding constraint in the future. If, however, the cleaning-up approach is chosen over a preemptive tightening policy, our results endorse the recommendation that interest rates should be cut aggressively in the run-up to the ZLB. The policy problem is therefore not *whether* but *in which direction* to adapt interest rates during an asset price boom if the ZLB threatens to limit the scope for stabilizing interventions by the central bank after the collapse. Hence, our model cautions policymakers against viewing asset prices with "benign neglect" during the boom phase, i.e. refraining from all monetary policy interventions, if agents display forward-looking behavior.

Our model largely ignores the other instruments that central bankers have at their disposal, beyond the interest rate. For example, some central banks have adopted a quantitative easing policy recently. In particular central banks that enjoy a high degree of credibility can commit to policies that would result in higher inflation in the future, thus raising inflation expectations immediately. Therefore, it is possible to argue that the costs of the cleaning-up approach may actually be lower than those derived in our model. On the other hand, it is assumed that the ZLB is binding only in one period. This assumption clearly contributes to a possible underestimation of the costs associated with the cleaning-up policy. We leave the questions of how additional instruments and a more prolonged ZLB impact the optimal policy choice for further research.

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