How Robust Is the Result That the Cost of "Leaning Against the Wind" Exceeds the Benefit? Response to Adrian and Liang

Lars E.O. Svensson*
Stockholm School of Economics, CEPR, and NBER
www.larseosvensson.se

First draft: October 2016
This version: January 2017

Abstract

The main result in Svensson (2017) and its previous versions is that, given current knowledge and empirical estimates, the cost of using monetary policy to "lean against the wind" for financial-stability purposes exceeds the benefit by a substantial margin. Adrian and Liang (2016a) conduct a sensitivity analysis of this result, state that "the result that costs exceed benefits rely critically on assumptions about the change in unemployment in a recession or crisis, the crisis probability, and the elasticity of crisis probability with respect to the interest rate," and provide alternative assumptions that they assert would overturn the result. This paper shows that Adrian and Liang's alternative assumptions are hardly realistic: they exceed existing empirical estimates by more than 11, 13, and 40 standard errors. Adrian and Liang furthermore do not comment on the extensive sensitivity analysis already done in previous versions of Svensson (2017), which supports the robustness of my result.

JEL Classification: E52, E58, G01

Keywords: Financial crises, financial stability, monetary policy.

* I thank Tobias Adrian, Oscàr Jordà, Nellie Liang, Simone Manganelli, Moritz Schularick, Oreste Tristani, Philip Turner, Skander Van den Heuvel, participants in seminars at ECB's Directorate Monetary Policy and Directorate General Research, and participants in the Annual IJCB Conference hosted by the Federal Reserve Bank of San Francisco in November 2016 for helpful discussions and comments. I also thank the ECB for its hospitality during my visit as a Duisenberg Fellow during September-November 2016.

This paper has been prepared by the author under the Wim Duisenberg Research Fellowship Program sponsored by the ECB. Any views expressed are only that of the author and do not necessarily represent the views of the ECB or the Eurosystem.

1 Introduction

"Leaning against the wind" (LAW for short) here refers to conducting, for financial-stability purposes, a tighter monetary policy (setting a higher policy interest rate) than justified by standard flexible inflation targeting when the possibility of a financial crisis is disregarded. Svensson (2017) (CB for short) and its previous versions show that, given current empirical estimates, the cost of LAW exceeds the benefit by a substantial margin. The cost of LAW consists of higher unemployment and lower inflation, both if no financial crisis occurs and, importantly, *if* a financial crisis occurs. The possible benefit includes a lower probability or magnitude of a crisis.

For an appropriate cost-benefit analysis of LAW, numerical estimates of the cost and benefit are required. CB provides a simple method to combine existing empirical estimates into numerical estimates of the cost and benefit of LAW and shows that the current empirical estimates of the policy-rate effects on the probability and magnitude of a crisis are too small to prevent the cost from exceeding the benefit. The robustness of this result is supported by detailed and extensive sensitivity analysis in the main text and the appendix of CB.

Adrian and Liang (2016a) (AL for short) do not scrutinize the sensitivity analysis in the original IMF Working Paper and later versions of CB. Instead, they conduct their own sensitivity analysis using a simple excel-sheet example that I have used in the slides presenting Svensson (2016c).[1] The excel sheet is a much simplified two-period example to illustrate the mechanisms and orders of magnitude of the relevant effects, but its considerable simplifications and short-cuts make it unsuitable for a serious and reliable sensitivity analysis. For that, the original framework of CB is more appropriate, given that it uses empirically estimated costs and benefits with, in particular, empirical lags and dynamics over a 40-quarter period.

AL state that "the result that costs exceed benefits rely critically on assumptions about the change in unemployment in a recession or crisis, the crisis probability, and the elasticity of crisis probability with respect to the interest rate" and provide alternative assumptions that they assert would overturn the result. In their Voxeu.org summary, Adrian and Liang (2016b), they express this more strongly: "[T]he conclusion that costs exceed benefits is *very sensitive to reasonable alternative assumptions* about three key parameters: the severity of a crisis; the probability of a crisis; and the sensitivity of the probability of a crisis to monetary policy" (italics added).

This paper shows that their alternative assumptions are hardly "reasonable" and realistic,

[1] The simple excel sheet is available at the link
https://larseosvensson.se/2015/10/03/monetary-policy-and-macroprudential-policy-different-and-separate/.

because they differ substantially from and thereby involve large deviations from existing empirical estimates in the literature. Indeed, their alternative assumptions imply an effect of debt on the magnitude of a crisis that is more than 40 standard errors larger than the estimate of Flodén (2014) and more than 11 standard errors larger than an estimate that follows from Jordà, Schularick, and Taylor (2013). They also imply an effect of credit on the probability of a crisis that is more than 13 standard errors larger than the estimate of Schularick and Taylor (2012).

AL question the assumptions about the estimates of the policy-rate effect on the magnitude of a crisis, the probability of a crisis start, and the policy-rate effect on the probability of a crisis as well as the role of the risk-taking channel in the cost-benefit analysis. I will discuss these in turn.

Regarding *the policy-rate effect on the magnitude of a crisis*, AL suggest that the alternative assumption of a larger effect would overturn my result that the cost of LAW exceeds the benefit. In the framework of CB, the main cost of LAW is an increase in the unemployment rate, not only if no financial crisis occurs (a "non-crisis") but also *if* a financial crisis occurs (a "crisis").[2] Assume that a 1 percentage point higher policy rate during 4 quarters increases the non-crisis unemployment gap in 6–8 quarters from 0 to 0.5 percentage point in a non-crisis. This is in line with the standard estimate of Sveriges Riksbank of the policy-rate effect on unemployment. Furthermore, assume at first that the magnitude of a crisis, net of any policy response during the crisis, is given and represented by a benchmark increase in the unemployment rate of 5 percentage points (an assumption used in Sveriges Riksbank (2013)). The higher policy rate during 4 quarters then increases the *crisis* unemployment gap from 5 to 5.5 percentage points.

The cost of a higher unemployment gap in a crisis is the main component of the cost of LAW. However, as AL note, if LAW has the benefit of reducing the magnitude of a crisis, this will reduce the net cost of LAW. In particular, the alternative assumption that the higher policy rate would reduce the crisis increase in the unemployment rate by 0.5 percentage points, from 5 to 4.5 percentage points, would overturn the result that that the cost of LAW exceeds the benefit and make the cost and benefit equal. A larger reduction in the crisis increase in the unemployment rate would then make the cost less than the benefit.

The issue is then whether LAW could realistically cause such reduction of the magnitude of a crisis. In appendix D of CB, I combine the Sveriges Riksbank (2014) estimate of the policy-rate effect on the debt-to-income ratio with the Flodén (2014) estimate of the effect of the debt-to-

[2] More precisely, the loss function is an indirect loss function of the deviation of the actual unemployment rate from the unemployment rate that would be optimal under flexible inflation targeting. This way the loss function incorporates not only the loss from unemployment deviating from its long-run sustainable rate but also the loss of inflation deviating from the inflation target.

income ratio on the increase in the unemployment rate during the Great Recession, in order to assess the effect of LAW on the magnitude of a crisis. I find that Flodén's estimate is so small that the effect on the magnitude can be disregarded. Furthermore, counter to what AL seem to indicate, the estimates of Jordà et al. (2013) (JST) of the effect of the debt-to-GDP ratio on the fall in GDP during a financial crisis are similar to Flodén's estimate. This is also the case for the estimate of Krishnamurthy and Muir (2016).[3]

In addition, I explicitly calculate how much stronger the effect of the debt-to-income ratio on the crisis increase in the unemployment rate must be for break-even, that is, for the cost and benefit of LAW to be equal. It turns out that the required effect must be 17 times as large as Flodén's estimate. This required effect is 40 standard errors larger than Flodén's estimate and 11 standard errors larger than the estimate that follows from JST. Then LAW will indeed have the benefit of making the crisis increase in the unemployment rate about 0.5 percentage points smaller. But such a large deviation from existing estimates is hardly realistic.

Regarding *the probability of a crisis*, AL suggest that a higher probability of a crisis would imply that a smaller reduction of the magnitude of a crisis is sufficient to overturn my result. However, this is not true in the framework of CB. As shown below, a 40 standard errors larger estimate than Flodén's (and about 11 standard errors larger than an estimate that follows from JST) is still required for break-even. The reason is that, for break-even, the policy-rate effect on the magnitude of a crisis still has to offset the policy-rate effect on the non-crisis unemployment rate, regardless of the probability of a crisis.

Regarding *the policy-rate effect on the probability of a crisis*, AL suggest that I underestimate this effect and that an alternative assumption would be that a 1 percentage point increase in the policy rate would reduce the probability of a crisis by as much as 1 percentage point. My estimate is constructed by combining the Sveriges Riksbank (2014) estimate of the policy-rate effect on real debt (and thereby on real debt growth) and the Schularick and Taylor (2012) estimate of the effect of real credit growth on the probability of a crisis. This implies a rather small empirical policy-rate effect on the probability of a crisis. However, in CB I also explicitly examine how much stronger an effect is needed for break-even. I furthermore stack the cards in favor of LAW by assuming that there is monetary non-neutrality and a permanent effect on real debt from a temporary policy-rate increase. Then the required effect is about 6 times as large as the Schularick and Taylor (2012) estimate. This is an effect no less than 13 standard errors larger than their

[3] As explained below, AL fail to translate JST's result into a form comparable to those of Flodén (2014).

estimate. The assumption of such a large effect implies that a 1 percentage point higher policy rate leads to maximum fall in the probability of a crisis of about 1.3 percent, somewhat similar to the alternative assumption of AD. But it is clearly an assumption that deviates too much from existing empirical estimates to be realistic.

Regarding *the risk-taking channel*, AL suggest that it would increase the policy-rate effect on the magnitude and probability of a crisis. However, the estimates of Sveriges Riksbank (2014) and Schularick and Taylor (2012) are reduced-form estimates and may very well pick up any effects through the risk-taking channel. Furthermore, I am not aware on any empirical support for a risk-taking channel as large as likely to matter in this context. A thorough analysis in Dell'Ariccia, Laeven, and Suarez (2013) of bank loans and their risk in the U.S. finds that the risk-taking channel is *statistically* significant but *economically insignificant*. This is because the effect of a 1 percentage point higher increase in the federal funds rate is only 3.6 percent of the standard deviation of the risk-taking measure. Thus, the risk-taking channel is insignificant compared to the effect of other factors on the risk-taking measure and therefore unlikely to matter for the estimate of the policy-rate effect on the probability of a crisis.

In the rest of this paper, section 2 summarizes the main result of CB, section 3 provides intuition for the marginal cost of LAW, and sections 4–7 scrutinize AL's alternative assumptions about the policy-rate effect on the magnitude of a crisis, the probability of a crisis, the policy-rate effect on the probability of a crisis, and their comments on the risk-taking channel. Section 8 notes that the policy-rate effect on real debt and, in particular, debt to GDP, is likely to be small and even of the opposite sign, that is, positive instead of negative. It also reports some recent empirical evidence of a positive policy-rate effect on debt to GDP. Finally, it notes that even if a negative policy-rate effect on credit to GDP is accepted, it is arguably *economically insignificant*, by the same argument as for the risk-taking channel. The estimated effect of a 1 percentage point increase in the policy rate is only about 3.8 percent of the standard deviation of credit-to-GDP, so the effect is insignificant compared to the effect of other factors. Section 9 concludes.

Separately, my cost-benefit analysis of LAW in CB has been criticized in Bank for International Settlements (2016a). I have responded to that criticism in detail in appendix K of CB and argued that the criticism is off the mark.[4]

[4] The main criticism of Bank for International Settlements (2016a, Box IV.B, pp. 77–78) seems to be that I would (1) rely on credit growth rather than a "financial cycle" as a predictor of crises, (2) assume that the magnitude of a crisis is exogenous and independent of the policy rate, (3) just discuss a "one-off" policy-rate increase instead of a systematic and optimal policy of LAW. All three points are apparently off the mark. Regarding criticism (1), the issue is not principal but practical and empirical. Given an estimated effect of a predictor on the probability of a crisis and an estimated effect of the policy rate on the predictor, my approach can be used for any predictor, including

2 The cost and benefit of leaning against the wind

This section summarizes the main result of CB. Consider an intertemporal quadratic loss function for monetary policy,

$$\mathcal{L}_1 = \mathrm{E}_1 \sum_{t=1}^{\infty} \delta^{t-1} L_t = \sum_{t=1}^{\infty} \delta^{t-1} \mathrm{E}_1 L_t,$$

where E_1 denotes expectations conditional on information available in quarter 1, $\delta < 1$ is a discount factor, and L_t denotes the quarter-t loss. The expected quarter-t loss is given by

$$\mathrm{E}_1 L_t = (1 - p_t)\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t\, \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2. \tag{2.1}$$

Here p_t denotes the probability of having a crisis in quarter t, conditional on information available in quarter 1. The variable $\tilde{u}_t^{\mathrm{n}}$ denotes the non-crisis unemployment gap in quarter t, that is, the unemployment gap if there is no crisis in the quarter. More precisely, the unemployment gap is the gap between the actual unemployment rate and the unemployment rate that is optimal under standard flexible inflation targeting when the possibility of a crisis is disregarded (that is, the probability of a crisis is set to zero). Then the first term of the right side of (2.1) is the probability of no crisis times the loss if there is no crisis.[5]

The second term on the right side of (2.1) is the probability of a crisis times the loss in a crisis. Here, Δu denotes the crisis increase in the unemployment rate, net of any policy response during a crisis. Thus, Δu can be interpreted as the unemployment-increase equivalent of the combination of a demand shock and any shock to the to transmission mechanism of monetary policy associated with a crisis, net of the conventional and unconventional policy response at a crisis, including any

a "financial cycle." Then the issue is what is the best predictor of crisis, and what is the policy-rate effect on that predictor. I use credit growth only because Schularick and Taylor (2012) provide relatively precise estimates of how credit growth affects the probability of a crisis. Regarding criticism (2), an endogenous magnitude is thoroughly examined in appendix D of CB. Regarding criticism (3), optimal policy, when the marginal cost and benefit of LAW are equal, is examined in section 3 in CB. (The optimal policy is a small leaning *with* the wind, but too small to bother about.) Furthermore, according to standard "calculus of variations," also a one-off policy-rate change can be used to examine first-order conditions of optimal policy and to infer in what direction policy should be adjusted to be optimal.

The BIS criticism is repeated in Bank for International Settlements (2016b, footnote 21), with a reference to AL: "Studies that find limited benefits of leaning against the wind typically assume – inter alia – that [1] crises do not result in permanent output losses, that [2] leaning affects the probability of a crisis but not its costs and that [3] there are no costs to waiting; see eg Ajello et al. (2016), Svensson (2014, 2016a) and International Monetary Fund (2015). Relaxing some of these assumptions, Adrian and Liang (2016a) find higher benefits from a leaning strategy." (Numbers in brackets added and references adapted to the present style.) Regarding [1], section 5.2 of CB shows that both a larger crisis increase in unemployment and a longer crisis duration increase the cost of LAW more than the benefit. Point [2] is the same mistaken assertion as (2) above. Regarding [3], CB takes into account the empirical lags of the estimated costs and benefits over a 40-quarter period and thereby the full estimated time-profile of the costs and benefits.

[5] As is shown in appendix C of CB, the loss function used is an *indirect* loss function derived from a Phillips curve and a quadratic loss function of both inflation and unemployment. This way it takes into account both the loss both from unemployment deviating from its long-run sustainable rate and inflation deviating from the inflation target.

restriction on the policy response such as the lower bound of the policy rate.[6] Given this, the unemployment gap in a crisis is $\tilde{u}_t^{\mathrm{c}} \equiv \tilde{u}_t^{\mathrm{n}} + \Delta u$, and the loss in a crisis is $\mathrm{E}_1(\tilde{u}_t^{\mathrm{c}})^2 \equiv \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2$.

Equation (2.1) can be written as

$$\mathrm{E}_1 L_t = \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t\,[\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2 - \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2] = \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t\,[(\Delta u)^2 + 2\Delta u\,\mathrm{E}_1\tilde{u}_t^{\mathrm{n}}]. \tag{2.2}$$

Here, the expression in the square bracket in the middle part of (2.2) is the *loss increase* in a crisis, that is, the *cost of a crisis*. The first term within the square brackets can be expanded and the cost of a crisis can be written as the square bracket in the right side of (2.2). Importantly, the cost of a crisis is *increasing* in the non-crisis unemployment gap.[7]

Let LAW be represented by an increase in the policy rate during quarters 1–4, denoted $d\bar{i}_1 > 0$. The effect of LAW can then be represented by the derivative of the intertemporal loss with respect to the policy rate during quarters 1–4,

$$\frac{d\mathcal{L}_1}{d\bar{i}_1} = \frac{d}{d\bar{i}_1}\,\mathrm{E}_1 \sum_{t=1}^{\infty} \delta^{t-1} L_t = \sum_{t=1}^{\infty} \delta^{t-1} \frac{d\mathrm{E}_1 L_t}{d\bar{i}_1}.$$

Furtermore, define the quarter-t net marginal cost of LAW, NMC_t, as $d\mathrm{E}_1 L_t/d\bar{i}_1$, the policy-rate effect on the quarter-t expected less. Taking the derivative of the right side of (2.2) gives

$$\begin{aligned}
\mathrm{NMC}_t &= 2\,(\mathrm{E}_1\tilde{u}_t^{\mathrm{n}} + p_t\Delta u)\frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} \\
&\quad - \Big\{[(\Delta u)^2 + 2\Delta u \mathrm{E}_1\tilde{u}_t^{\mathrm{n}}](-\frac{dp_t}{d\bar{i}_1}) + 2p_t(\Delta u + \mathrm{E}_1\tilde{u}_t^{\mathrm{n}})(-\frac{d\Delta u_t}{d\bar{i}_1})\Big\} \\
&\equiv \mathrm{MC}_t - \{\mathrm{MB}_t\} \equiv \mathrm{MC}_t - \{\mathrm{MB}_t^{p} + \mathrm{MB}_t^{\Delta u}\}.
\end{aligned} \tag{2.3}$$

Here the term outside the curly bracket is defined as the marginal cost of LAW, MC_t, and the sum of the two terms in the curly bracket is defined as the marginal benefit, MB_t. The two components of the marginal benefit are denoted MB_t^{p} and $\mathrm{MB}_t^{\Delta u}$, respectively, and are explained below.

[6] For simplicity, the crisis increase in the unemployment rate, Δu is taken to be deterministic. It could easily be allowed to be time-varying, Δu_t. As shown in appendix G of CB, the analysis can easily be generalized to include the case where the crisis unemployment increase is random with a fixed or time-varying mean and a fixed variance, but this would not affect the results.

[7] CB in addition discusses the consequences of the less realistic assumption that the unemployment rate, instead of *increasing* by Δu, *reaches* Δu, that is, when $\tilde{u}_t^{\mathrm{c}} \equiv \Delta u$. In this case, the loss level in a crisis, $\mathrm{E}_1(\tilde{u}_t^{\mathrm{c}})^2 = \mathrm{E}_1(\Delta u)^2$, is constant. Then the cost of a crisis, the loss increase in a crisis, is $\mathrm{E}_1(\Delta u)^2 - \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2$, and it is *decreasing* in the non-crisis loss, $\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2$. If the non-crisis unemployment gap would then be above Δu, it would be better to be in a crisis than in a non-crisis. In addition, Svensson (2016b), in discussing Filardo and Rungcharoenkitkul (2016), and CB also examines the less realistic assumption that the cost of a crisis, the loss increase in a crisis, is constant and independent of the initial situation, the non-crisis unemployment gap.

As shown in CB and Svensson (2016b), in these less realistic cases, a small but *economically insignificant* amount of LAW is optimal, the result of Ajello, Laubach, Lopez-Salido, and Nakata (2016) that later also appears in Filardo and Rungcharoenkitkul (2016) and Gourio, Kashyap, and Sim (2016).

For a zero (expcected) non-crisis unemployment gap ($\mathrm{E}_1\tilde{u}_t^{\mathrm{n}} = 0$), the net marginal cost, the marginal cost, and the marginal benefit are given by

$$\mathrm{NMC}_t \equiv \mathrm{MC}_t - \{\mathrm{MB}_t^p + \mathrm{MB}_t^{\Delta u}\} = 2p_t\Delta u \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} - \Big\{(\Delta u)^2(-\frac{dp_t}{d\bar{i}_1}) + 2p_t\Delta u(-\frac{d\Delta u_t}{d\bar{i}_1})\Big\}. \quad (2.4)$$

We shall look at these terms more closely below. Here we can note that, for a zero non-crisis unemployment gap, the marginal cost, the first term on the right side of (2.4), is the expected loss increase from a higher non-crisis unemployment under LAW; more precisely, two times the expected unemployment gap at a zero non-crisis unemployment gap, $p_t\Delta u$ (zero plus the expected unemployment gap if there is a crisis), times the policy-rate effect on the (expected) non-crisis unemployment gap, $d\mathrm{E}_1\tilde{u}_t^{\mathrm{n}}/d\bar{i}_1$. The marginal benefit, the term in the curly brackets, consists of two terms. The first, MB_t^p, is the marginal benefit from a fall in the probability of a crisis; more precisely, the cost of a crisis (the loss increase in a crisis) at a zero non-crisis unemployment gap, $(\Delta u)^2$, times the fall in the probability of a crisis, $-dp_t/d\bar{i}_1$. The second, $\mathrm{MB}_t^{\Delta u}$, is the marginal benefit from a fall in the magnitude of a crisis; more precisely, two times the expected unemployment gap in a crisis at a zero non-crisis unemployment gap, $p_t\Delta u$ (the same term as in the marginal cost), times the fall in the crisis increase in the unemployment rate, $-d\Delta u_t/d\bar{i}_1$.

A positive, zero, or negative non-crisis unemployment gap means that the actual non-crisis unemployment rate is, respectively, greater than, equal to, or less than the unemployment rate that is optimal when the probability of a crisis is set to zero. These three possibilities correspond to a situation of, respectively, leaning *against* the wind, *no* leaning, and leaning *with* the wind. Furthermore, a positive (negative) quarter-t net marginal cost indicates that, when quarter t is considered in isolation, leaning with (against) the wind is preferable. In order to assess whether leaning with or against the wind is preferable when all quarters are considered, we then look at the sign of the cumulative discounted net marginal cost,

$$\sum_{t=1}^{\infty}\delta^{t-1}\mathrm{NMC}_t = \sum_{t=1}^{\infty}\delta^{t-1}\mathrm{MC}_t - \sum_{t=1}^{\infty}\delta^{t-1}\mathrm{MB}_t.$$

The main result of CB is illustrated in figure 2.1 (figure 4.1 in CB). The red line shows the benchmark marginal cost, $\mathrm{MC}_t = 2p_t\,\Delta u\, d\mathrm{E}_1 u_t^{\mathrm{n}}/d\bar{i}_1$. Here, p_t, the probability of a crisis in quarter t, is given by the solid green line in figure 6.2. The benchmark probability of a crisis start in a quarter is 0.8 percent, corresponding to on average one crisis in 31 years. The benchmark duration of a crisis is 8 quarters, meaning that the probability of a crisis in a future quarter, approximately

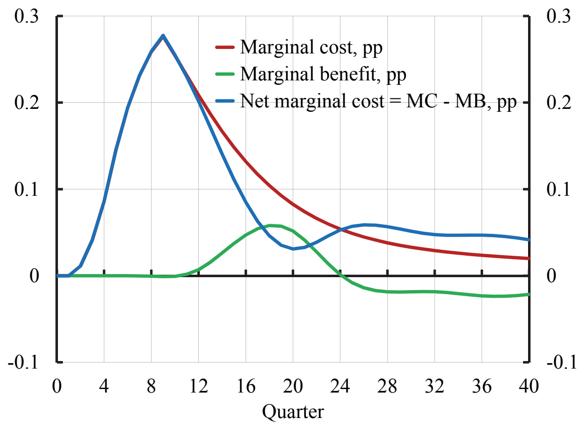

Figure 2.1: (Figure 4.1 in CB) The marginal cost, the marginal benefit, and the net marginal cost of LAW, when the expected non-crisis unemployment gap equals zero. (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

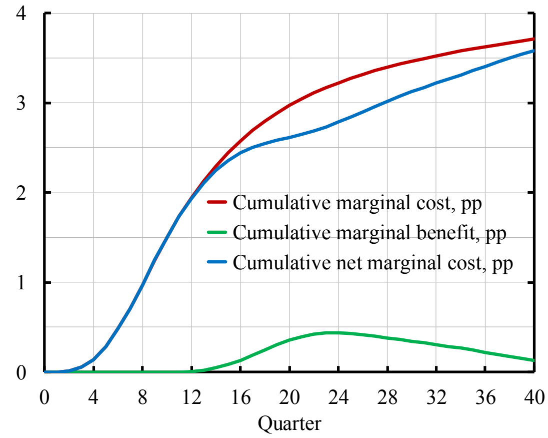

Figure 2.2: (Figure 4.2 in CB) The cumulative marginal cost, marginal benefit, and net marginal cost of LAW, when the expected non-crisis unemployment gap equals zero. (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

equal to the probability of a crisis start during the last 8 quarters, rises up to $0.8 \cdot 8 = 6.4$ percent.[8] Furthermore, Δu, the benchmark crisis increase in the unemployment rate, is set to 5 percentage points, an assumption used in Sveriges Riksbank (2013). Finally, $d\mathrm{E}_1 u_t^{\mathrm{n}}/d\bar{i}_1$, the policy-rate effect on the non-crisisis unemployment rate, is given by the dashed red line in figure 3.1, which shows the Riksbank's benchmark estimate of the effect on the unemployment rate over quarters 1–40 of a temporary policy-rate increase of 1 percentage point during quarters 1–4.

The green line in figure 2.1 shows the benchmark marginal benefit, $\mathrm{MB}_t = \mathrm{MB}_t^p = (\Delta u)^2(-dp_t/d\bar{i}_1)$, where the benchmark benefit from a fall in the magnitude, $\mathrm{MB}_t^{\Delta u}$, is set to zero. (The term $\mathrm{MB}_t^{\Delta u}$ is examined in detail in section 4.) Here, $dp_t/d\bar{i}_1$, the policy-rate effect on the probability of a crisis, is given by the green line in figure 6.1 (and the difference between the dashed and the solid green lines in figure 6.2).

The blue line shows the net marginal cost, $\mathrm{NMC}_t \equiv \mathrm{MC}_t - \mathrm{MB}_t$. The cumulative net marginal cost, the area under the blue line, is positive by a large margin. This is the case also if the negative benefit beyond quarter 24 is disregarded. Figure 2.2 (figure 4.2 in CB) shows the cumulative marginal cost, marginal benefit, and net marginal cost.[9]

The question then is, how robust is this result?

[8] As shown in appendix A of CB, this is a good and convenient linear approximation to an underlying Markov process for crises.

[9] To be precise, it should be cumulative *discounted* marginal cost, marginal benefit, and net marginal cost, but any discounting is for simplicity disregarded here. It would not affect the result.

3 The marginal cost of LAW

In order to better understand the marginal cost of LAW, it is illustrated in figure 3.1. The unemployment gap is measured along the vertical axis. In the right half of the figure, the dashed red line shows the Riksbank's benchmark estimate of the effect on the unemployment rate over quarters 1-40 of a temporary policy-rate increase of 1 percentage point during quarters 1–4 (the solid gray line).[10] The benchmark estimate is that the unemployment rate increases by 0.5 percentage points above the baseline in quarters 6–8 and then slowly falls back to the baseline. This can be seen as an estimate of the derivative $d\mathrm{E}_1 u_t^{\mathrm{n}}/d\bar{i}_1$ of the non-crisis unemployment rate during quarters t = 1, 2, ..., 40 with respect to the policy rate during quarters 1–4. Starting from an unemployment gap of zero in a non-crisis, the unemployment gap will increase from zero by the same amount as the unemployment rate, so the dashed red line then also shows the effect of the policy rate on the non-crisis unemployment gap.

The solid blue line in the left part of the figure shows the quadratic loss, $L_t = (\tilde{u}_t)^2$, from the unemployment gap in quarter t, where the loss is measured along the horizontal line to the left of zero. The loss increase from an increase in the unemployment gap from 0 to 0.5 percentage point is of the second order and small, $\Delta L_t = 0.5^2 - 0^2 = 0.25$ for quarters t = 6, 7, 8. Thus, for a zero initial non-crisis unemployment gap, if there is no crisis, the cost of LAW is small and the marginal cost is zero.

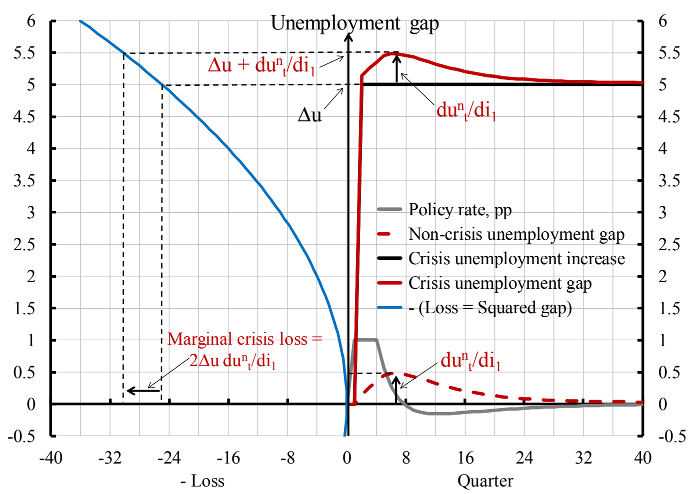

Figure 3.1: The unemployment gap in non-crisis (dashed red line) and crisis (solid red line) from a 1 percentage point higher policy rate during quarters 1–4 (solid gray line) and the quadratic loss (solid blue line). (Source: The Riksbank and own calculations.)

However, if there is a crisis, as mentioned the benchmark assumption is that the unemployment rate increases by $\Delta u = 5$ percentage points (an assumption used by Sveriges Riksbank (2013)).[11] Starting from a zero non-crisis unemployment gap, in a crisis the unemployment gap would then increase to 5 percentage points, illustrated by the solid black horizontal line in the right part of the

[10] See footnote 11 of CB for the precise sources of the Riksbank's estimate.

[11] As mentioned, this crisis increase in the unemployment rate should be interpreted as the unemployment-increase-*equivalent* of the shocks in a financial crisis, net of any policy responses when the crisis occurs.

figure.

Furthermore, if there is LAW, starting from a 0.5 percentage point non-crisis unemployment gap in quarters 6–8, in a crisis the unemployment gap would then increase to 5.5 percentage points, as illustrated by the solid red line in the figure. Thus, in a non-crisis, LAW implies that the unemployment gap would equal 0.5 percentage point instead of 0, but in a crisis, the unemployment gap would equal 5.5 percentage points instead of 5. Whereas, in a non-crisis, the loss increase from LAW is only $\Delta L_t = 0.5^2 - 0^2 = 0.25$, in a crisis, it is $\Delta L_t = 5.5^2 - 5^2 = 5.25$, 21 times as large. This increased cost of a crisis is of the first order. It is the main component of the cost of LAW. The marginal loss is $2\Delta u \, du_t^{\mathrm{n}}/d\bar{i}_t$ in quarter $t = 1, 2, ..., 40$ for an initial zero non-crisis unemployment gap. When it is multiplied by the probability of a crisis, p_t, it is still substantial and equals the marginal cost, MC_t, in (2.4), the red line in figure 2.1.

4 The policy-rate effect on the magnitude of a crisis

If LAW has a negative effect on the magnitude of the crisis, this results in a possible additional marginal benefit of LAW, corresponding to the term $\mathrm{MB}_t^{\Delta u}$ in (2.4). The difference between the marginal cost and this marginal benefit can be written

$$\mathrm{MC}_t - \mathrm{MB}_t^{\Delta u} = 2p_t \, \Delta u \, (\frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} + \frac{d\Delta u_t}{d\bar{i}_1}). \tag{4.1}$$

This makes it clear that any negative policy-rate effect on the crisis increase in the unemployment rate will reduce the marginal loss from the positive policy-rate effect on the non-crisis unemployment rate.[12] In figure 3.1, this would shift down both the solid black horizontal line and the solid red line. Clearly, if the reduction in the magnitude of a crisis would be similar to the increase in the non-crisis unemployment rate, the cost of LAW would be more or less eliminated.

Indeed, AL provide the alternative assumption that LAW would imply a reduction from 5 to 4.5 percentage points of the increase in the unemployment rate in a crisis. Let me assess how realistic such an assumption is.

Appendix D of CB examines the possible effect of LAW on the magnitude in some detail. A possible channel through which the policy rate may affect the magnitude of a crisis is for the policy rate to have an effect on credit and then for credit to have an effect on the magnitude of a crisis. According to Flodén (2014), for the OECD countries, a larger household debt-to-income ratio in 2007 is associated with a larger increase in the unemployment rate during 2007-2012. More

[12] The subindex t of $d\Delta u_t/d\bar{i}_1$ emphasizes that the effect may vary over the quarters.

precisely, a 1 percentage point larger debt-to-income ratio is associated with a 0.023 percentage point larger increase in the unemployment rate.[13] This is in the present context a small effect.

JST, with a dataset for 14 advanced countries 1870–2008, provide an extensive analysis of the effect of credit on the magnitude of "financial recessions" (recessions after a financial crisis).[14] Let me examine their results in some detail, especially because AL refer to JST. Table 8 of JST reports the effect on the GDP downturn in a financial recession of a 1 percentage point higher "excess credit." Here, excess credit denotes the yearly percentage-point excess rate of change of aggregated bank loans relative to GDP in the preceding expansion phase (previous through to peak, where excess is determined relative to the previous mean). The average effect on GDP over 5 years is -0.8 percent (the average of the coefficients in the row "Excess credit $\times$ financial recession" in JST's table 8). Assuming an Okun coefficient of 2, this means an average increase in the unemployment rate of 0.4 percentage point.

Post-WWII, the average duration of an expansion phase is 9.46 years in the sample (JST, table 3).[15] A 1 percentage point higher excess credit over 9.46 years implies that the cumulative bank-loans-to-GDP ratio is about 10 percent higher.[16] This means that a 1 *percent* higher bank-loans-to-GDP ratio is associated with a $0.4/10 = 0.04$ percentage point larger unemployment increase. If the bank-loans-to-GDP ratio is about 100 percent, 1 percent is about 1 percentage point.[17] Then, 1 *percentage point* higher bank loans is associated with about 0.04 percentage point larger unemployment increase, about twice as large as the Flodén estimate but still small.

AL state that "[o]ther empirical studies [than Flodén's] provide strong evidence that higher credit growth results in more severe recessions, suggesting that a smaller [crisis] increase in unemployment from LATW policy is an *alternative reasonable assumption*" (brackets added), refer to JST, and note: "[H]ad credit exceeded average levels by one standard deviation, ... in a financial recession, real GDP per capita would be ... 3 percentage points lower ... in the fourth year after the peak. While these estimates suggest significant effects for excess credit on lost output in the subsequent recession, *it is difficult to convert their estimates to the effects of a 1 percentage point*

[13] Flodén (2014, table 4, column 1) reports the coefficient with only two decimals but the third decimal can be extracted from the data and programs to replicate his estimate, available at `http://martinfloden.net/files/hhdebt_replicate.zip`.

[14] The results of Jordà et al. (2013) are confirmed with new data and more sophisticated econometric techniques in Jordà, Schularick, and Taylor (2016).

[15] JST (table 3) reports an expansion-phase duration of 6.9 years for 30 observations of "Low excess credit" and a duration of 11.8 years for 32 observations of "High excess credit." The average, taking the numbers of observations into account, is then 9.46 years

[16] $1.01^{9.46} - 1 = 0.0987$.

[17] According to Bank for International Settlements (2016c, table F2.3), for advanced economies, bank loans to the private non-financial sector were 83 percent of GDP in 2016Q1.

rise in the level of credit, given their measure of excess credit" (italics added).

However, as I have demonstrated above, it is not too difficult to translate JST's estimate into the effect of a 1 percent or percentage point increase in credit to GDP. AL fail to translate one standard deviation of the measure of excess credit (which is 2.5 percentage points per year) into the corresponding percent higher bank-loans-to-GDP ratio, which is required in order to relate the estimate to Flodén's and make the observation that they are both small. To see this again, we can note that JST (p. 21) summarize their main result in the following way: "Given that the s.d. of the excess credit variable is ... 2.5 ppy in financial recessions (Table 4), these coefficients [in table 8] imply that a +1 s.d. change in excess credit ... would depress output ... by nontrivial amounts: the 5-year postpeak recovery path would be lower on average ... by 2% in financial recessions." ("ppy" denotes rates of change in percentage points per year [of bank loans relative to GDP].) Thus, one standard deviation (2.5 percentage points per year) of excess credit in financial recessions depresses GDP on average over 5 years by 2 percent.[18] This means that 1 percentage point per year excess credit depresses GDP by $2/2.5 = 0.8$ percent in a financial crisis (the average effect in JST's table 8 mentioned above). But, as explained above, 1 percentage point per year higher excess credit corresponds to about 10 percent higher cumulative bank-loans-to-GDP ratio, so 1 percent higher bank-loans-to-GDP ratio depresses GDP by $0.8/10 = 0.08$ percent.

Krishnamurthy and Muir (2016, table 4), with a dataset for 14 countries 1869–2014, find that a 1 percentage point higher 3-year growth in the credit-to-GDP ratio is associated with a (statistically insignificant) 0.05 percentage point larger GDP decline from peak to trough in a financial crisis. With an Okun coefficient of 2, a 0.05 percentage point decline in GDP is associated with a 0.025 percentage point rise in the unemployment rate, a small estimate very similar to Flodén's.

In addition to JST, AL refer to Mian, Sufi, and Verner (2016) and Sutherland, Hoeller, Merola, and Zieman (2012) as implying larger effects of credit on the magnitude of downturns. But, importantly, the estimates that are relevant here are of the possible effect of credit on the magnitude *of a financial crisis*, that is, the effect on the downturn *conditional on a financial crisis*, not the possible effect of credit on the *unconditional* downturn in a general recession, regardless of whether there is a financial crisis or not. The latter is what is examined in Mian et al. (2016) and Sutherland et al. (2012), so those estimates are not the ones that are relevant here.[19]

[18] Furthermore, AL mention the fourth year, for which 1 standard deviation of excess credit has the largest negative effect, about 3 percent. It is arguably more relevant to use the average over the 5 years, 2 percent, as JST do.

[19] Brunnermeier, Palia, Sastry, and Sims (2016) furthermore raise some doubts about the single-equation models used in all these and similar studies, both of the effect of credit on the probability and magnitude of financial crises and on the downturn in a general recessions, because single-equation models may suffer from spurious correlations and exaggerate the effects found.

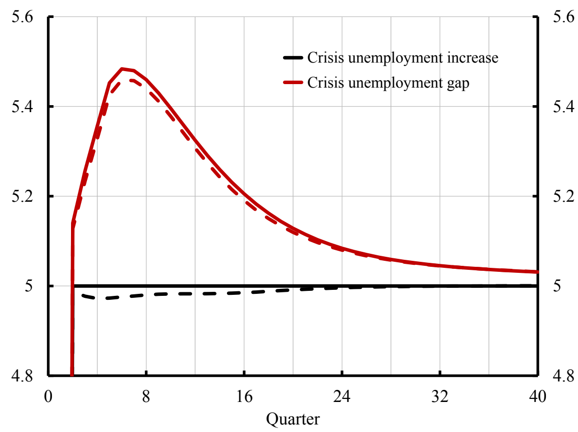

Figure 4.1: The crisis unemployment gap and the crisis increase in unemployment for the benchmark (solid lines) and for a lower magnitude of a crisis due to LAW (dashed lines). (Source: Flodén (2014), the Riksbank, and own calculations.)

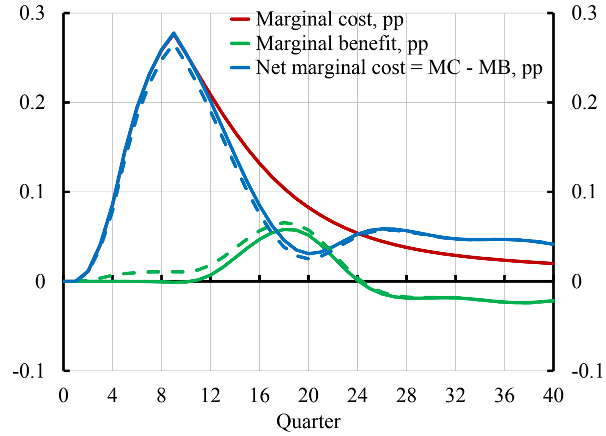

Figure 4.2: (Figure D.2 in CB) The benchmark marginal cost, marginal benefit, and net marginal cost of LAW (solid lines), with the change from including the effect on the crisis magnitude (dashed lines). (Source: Flodén (2014), Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

4.1 The marginal cost and benefit of LAW, taking into account the effect on the magnitude of a crisis

Given Flodén's estimate of the effect of household debt to income on the magnitude of a crisis and the Sveriges Riksbank (2014) estimate of the policy-rate-effect on household debt to income, the effect on the magnitude of a crisis of the policy rate can then be estimated as in appendix D of CB. It is small and hardly visible in a figure like 3.1. If the upper right part of figure 3.1 is enlarged, it can be illustrated by the shift from the solid to the dashed lines in figure 4.1.

Clearly, this effect on the magnitude is too small to materially affect the cost of LAW. This is further illustrated in figure 4.2 (figure D.2 in CB). There, the solid lines show the benchmark case without an effect on the magnitude (when the term $\text{MB}_t^{\Delta u}$ in (2.4) is set to zero), shown above in figure 2.1. The dashed lines show the somewhat larger marginal benefit and lower net marginal cost when the effect of the magnitude, the term $\text{MB}_t^{\Delta u}$, is taken into account. Clearly, it is too small to affect the result. As mentioned, the estimate of JST implies an effect on the magnitude twice as large. This is still too small to affect the result.

4.2 How large an effect on the magnitude is required for break-even?

How large an effect on the magnitude is required to reach the break-even point where the marginal cost and marginal benefit of LAW are equal for an initial non-crisis unemployment gap equal to zero and thus neither leaning *against* nor *with* the wind is desirable? As shown in appendix D of CB, the effect on the magnitude needs to be about 17 times as large as Flodén's estimate. The case with a 17 times as large an effect is illustrated in figure 4.3. The the solid red and black lines would shift down to the dashed red and black lines. The maximum shift is about 0.5 percentage point, in line with AL' assumption. The required effect on the magnitude is a full 40 standard errors larger than Flodén's estimate. It is about 11 standard errors larger than the estimate that follows from JST.[20]

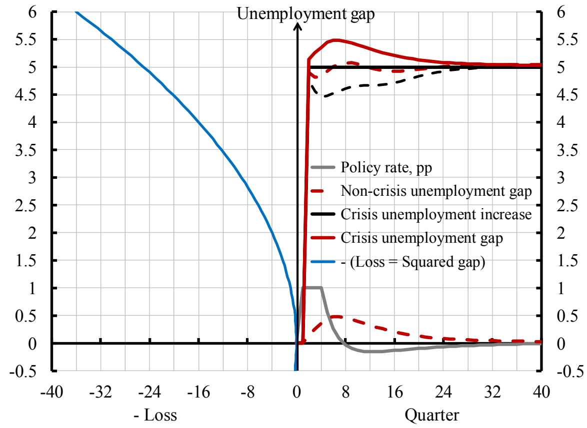

Figure 4.3: The unemployment gap in non-crisis (lower dashed red line) and crisis (solid red line) from a 1 percentage point higher policy rate during quarters 1–4 (solid grey line) for the benchmark and for a 17 times as large an effect on the magnitude of the crises of the policy rate (upper dashed red and black lines), and the quadratic loss (solid blue line). (Source: Flodén (2014), the Riksbank, and own calculations.)

An effect equal to or larger than this required effect on the magnitude is what AL apparently consider to be a reasonable alternative assumption. Clearly, there is no support from existing empirical estimates for such a large effect of LAW on the magnitude of a crisis.

[20] The required effect for break-even is 0.38. (Flodén's estimate of the effect is 0.0230, with a standard error of 0.00897. $0.38/0.0023 = 16.52$. Flodén (2014, table 4, column 1) does not report the standard error and reports the point estimate with only two decimals, but the data and programs to replicate his estimate and extract the standard error are available at `http://martinfloden.net/files/hhdebt_replicate.zip`.) This means that the required effect is $(0.38\text{-}0.023)/0.00897 = 39.8$ standard errors larger than Flodén's estimate.

The estimated effect of credit to GDP on the unemployment increase that follows from JST (table 8) is 0.04, as explained in section 4. The average standard error over years 1–5 for the effect of excess credit on GDP is 0.625 (in the row "Excess credit × financial recession" in table 8). With an Okun coefficient of 2, the average standard error for the effect of excess credit on the crisis increase in the unemployment rate can be considered to be $0.625/2 = 0.313$. Because 1 percentage point excess credit per year corresponds to about a 10 percentage point higher credit-to-GDP ratio, the standard error for the effect of credit to GDP on the crisis increase in unemployment is $0.313/10 = 0.0313$. This means that the required effect for break-even is approximately $(0.38 - 0.04)/0.0313 = 10.86$ standard errors larger than the estimate that follows from JST.

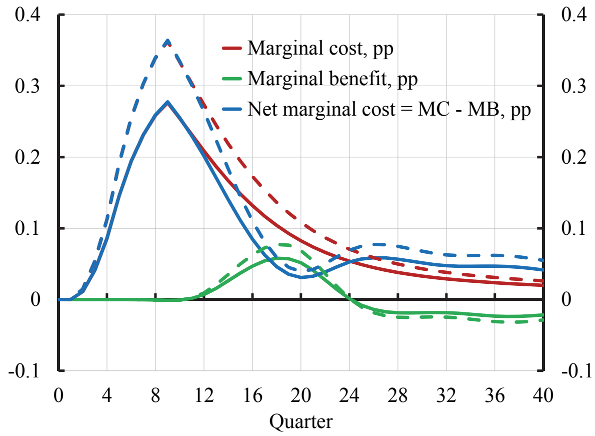

Figure 5.1: (Figure 5.2 in CB) The effect of an increase in the annual probability of a crisis start from 3.2 percent (solid lines) to 4.2 percent (dashed lines) on the marginal cost, the marginal benefit, and the net marginal cost of leaning against the wind. (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

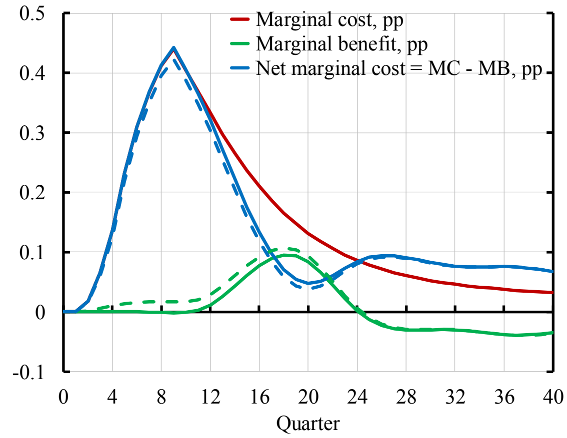

Figure 5.2: The marginal cost, the marginal benefit, and the net marginal cost of LAW for a 5 percent annual probability of a crisis start without (solid lines) and with (dashed lines) the Flodén (2014) effect on the magnitude of a crisis. (Source: Flodén (2014), Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

5 The probability of a crisis

Whereas I use a benchmark probability of an annual crisis start of 3.2 percent (on average one crisis in 31 years), AL prefers a probability of 5 percent (on average on crisis in 20 years): "In the US, since 1975 there have been 5 recession starts (1 in 8 years), in which two (1990 and 2008) involved significant financial sector stress [and have been labeled banking crisis by Laeven and Valencia (2012)]. Based on these estimates of a crisis start of 5%, it is reasonable to evaluate the sensitivity of the costs of LATW policy if the probability of being in a crisis were 10% [given the assumption that a crisis lasts 8 quarters]" (brackets added).

They argue that, for a higher probability of a crisis, "the costs of LATW policy fall below the benefits at *less modest* reductions in unemployment severity from LATW policy" (italics added; obviously, I do not agree that the effect of LAW on the magnitude of financial crisis required for break-even, 17 times larger than Flodén's estimate, is "modest" compared to the empirical estimates discussed above).

However, to begin with, AL do not mention that section 5.1 of my paper already examines the consequences of a higher probability of a crisis. As figure 5.1 (figure 5.2 in CB) shows, an increase in the annual probability of a crisis start from 3.2 percent to 4.2 percent increases the marginal cost of LAW more than the marginal benefit, thus increasing the net marginal cost.[21]

In line with this, the solid lines in figure 5.2 shows that a 5 percent annual probability of a crisis start implies an even higher net marginal cost of LAW than the dashed lines in figure 5.1 that correspond 4.2 percent annual probability. Furthermore, the dashed lines in figure 5.2 show that the empirically estimated effect on the magnitude (the combination of the Sveriges Riksbank (2014) and Flodén (2014) estimates) does not change this result. Counter to what AL suggest, a higher probability of a crisis increases the net marginal cost, also when the effect on the magnitude is taken into account.

5.1 How large an effect on the magnitude is required for break-even?

What about AL's assertion that, for a higher probability of a crisis, "the costs of LATW policy fall below the benefits at less modest reductions in unemployment severity from LATW policy"? The fact is that also for this higher probability of a crisis, the effect of debt on the magnitude of a crisis needs to be about 17 times as large as Flodén's estimate (about 40 standard errors larger) just to reach the break-even point where the marginal cost and benefit of LAW are equal. What is needed is again for LAW to reduce the crisis increase in the unemployment rate by as much as LAW increases the non-crisis unemployment gap, as shown in figure 4.3. This is regardless of what the average probability of a crisis is. This is indeed clear from (4.1), because the probability of a crisis affects both terms MC_t and $\mathrm{MB}_t^{\Delta u}$ equally.

6 The policy-rate effect on the probability of a crisis

Under the heading "Elasticity of crisis probability," AL suggest that I underestimate the effect on credit of the policy rate: "The current literature does not provide much guidance for alternative estimates of this elasticity[, the policy-rate effect on credit]. In fact, changes in credit growth from a change in monetary policy are typically evaluated in models that do not consider time varying pricing of risk or endogenous risk-taking by financial intermediaries, and likely underestimate the sensitivity of credit to monetary policy" (brackets added).

[21] As explained in detail in CB, a higher probability of a crisis is assumed to be the result of a higher steady-state annual real debt growth, 7.9 percent instead of the benchmark 5 percent. A higher probability of a crisis increases the marginal cost, $\mathrm{MC}_t = 2p_t\, \Delta u\, du_t^{\mathrm{n}}/d\bar{i}_1$, because the probability, p_t, of the loss increase in a crisis from LAW, $2\Delta u\, du_t^{\mathrm{n}}/d\bar{i}_1$, is higher. Furthermore, a higher steady-state real debt growth increases the sensitivity of the probability to real debt growth, because the estimated logit function is convex for these levels of real debt growth. This increases the size of the policy-rate effect on the probability, $-dp_t/d\bar{i}_t$, somewhat, but less than the increase in marginal cost.

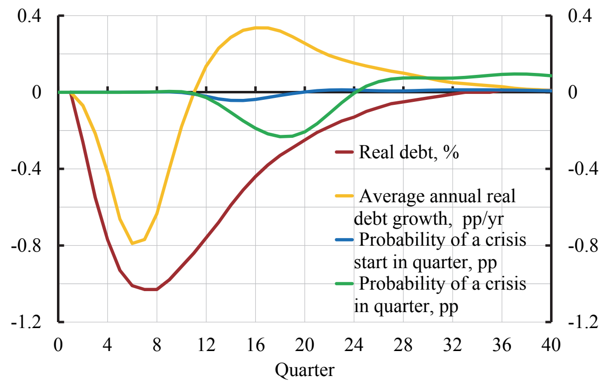

Figure 6.1: (Figure 2.2 in CB) The effect on real debt, the average annual real debt growth, the probability of a crisis start in quarter, and the probability of being in a crisis in quarter of a 1 percentage point higher policy rate during quarters 1–4; deviations from baseline. (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

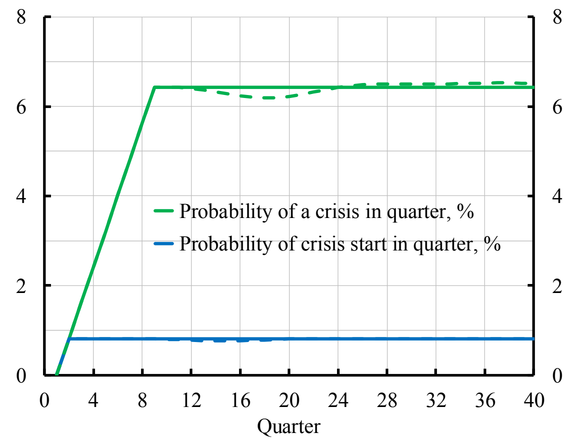

Figure 6.2: (Figure 3.1 in CB) The probabilities of a crisis start and of a crisis for the benchmark (solid lines) and for a 1 percentage point higher policy rate in quarters 1–4 (dashed lines). (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

The Sveriges Riksbank (2014) estimates of the policy-rate effects on real household debt and household debt to GDP are VAR estimates. They are thus reduced-form estimates, not structural estimates, as are the Schularick and Taylor (2012) estimates. In principle, they could pick up any effects through time-varying pricing of risk or endogenous risk-taking and not necessarily underestimate the sensitivity of credit to monetary policy.

I combine the Riksbank estimates with the estimate of Schularick and Taylor (2012) of the effect of real credit and credit to GDP on the probability of a crisis start. The result is illustrated in figure 6.1 (figure 2.2 in CB).[22]

In the figure, the red line shows the Riksbank's estimate of the effect on real household debt of a 1 percentage point higher policy rate during quarters 1–4. The yellow line shows the corresponding average annual real debt growth, which is used as the input in the Schularick and Taylor estimated logit equation for the effect of real debt growth on the probability of a crisis start. The blue line shows the resulting policy-rate effect on the probability of a crisis start. Under the benchmark assumption that a crisis lasts for 8 quarters, the green line shows the probability of a crisis in a given future quarter (the green line is the moving sum of 8 previous probabilities of a crisis start, the blue line).

[22] As a robustness check, in section 7 of CB, I also use IMF staff estimates for International Monetary Fund (2015) on the Laeven and Valencia (2012) dataset, which give a very similar result.

In figure 6.2 (figure 3.1 on CB), the solid blue line shows the benchmark quarterly probability of a crisis start (0.8 percent). The solid green line shows the probability of a crisis in a future quarter, with a steady state of $8 \cdot 0.8 = 6.4$ percent. The dashed lines show the small effects on the probabilities resulting from a 1 percentage point higher policy rate during quarters 1–4. The maximum fall in the probability of a crisis is about 0.2 percentage points in quarter 18 and there is small increase in the probability of a crisis after quarter 24.

The increase in the probability after quarter 24 is due to the fact that monetary neutrality implies that there is no long-run effect on real debt; then lower real debt growth during the first few years must be followed by higher real debt growth in the future (see the yellow line in figure 6.1). The debt growth and the probability of a crisis are simply postponed a few years. However, the assumption of monetary *non-neutrality* and a permanent effect on real debt eliminates the later increase in the probability of a crisis but does not change the small effect on the probability during the first few years, as shown in figure 6.3 (figure 6.1 in CB).

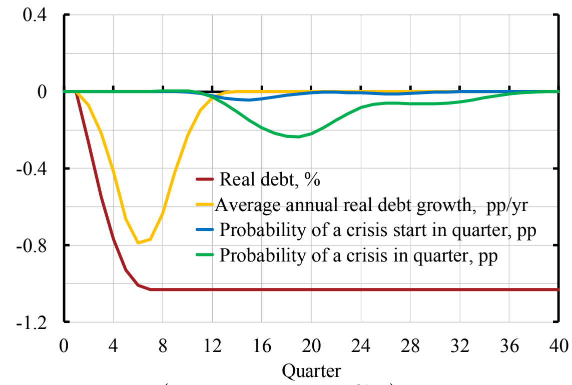

Figure 6.3: (Figure 6.1 in CB) For a permanent effect on real debt, the effect on real debt, the average annual real debt growth, the probability of a crisis start in quarter, and the probability of being in a crisis in quarter of a 1 percentage point higher policy rate during quarters 1–4; deviations from baseline. (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

6.1 What policy-rate effect on the probability of a crisis is needed for break-even?

AL suggest that, "under alternative assumptions for the probability of a crisis and its sensitivity to a rise in the monetary policy rate, even a very small benefit in terms of a smaller rise in unemployment from LATW policy would suggest that LATW policy has net benefits." Is this true?

Above we have noted that, at the benchmark policy-rate effect on the probability, the effect of debt on the magnitude of a crisis has to be 40 standard errors larger than Flodén's estimate to reach the break-even point when marginal cost and benefit of raising the policy rate are equal (and neither leaning against nor leaning with the wind is desirable). We have also noted that, if the probability of a crisis is higher, the effect on the magnitude still has to be 40 standard errors larger than Flodén's estimate and 11 standard errors larger than an estimate that follows from JST. Let us then first examine, for the benchmark case of no effect on the magnitude, how large a policy-rate effect on the probability of a crisis is needed to reach break-even. Then we shall examine what policy-rate effect on the magnitude of a crisis is required for break-even, when both the probability of a crisis and the policy-rate effect on the probability is larger than the benchmark.

But before going further, we need to recall that, under monetary neutrality (when monetary policy does not affect real debt in the long run), lower debt growth and probability for a few years will be followed by a higher debt growth and probability. Thus, the cumulative benefit from the policy-rate effect on the probability of a crisis is zero or close to zero. In order to have a larger benefit from a larger policy-rate effect on the probability, we need to stack the cards in favor of LAW by either disregarding the negative benefit beyond quarter 24 in figures 4.2 and 6.1 or assuming monetary non-neutrality and a permanent policy-rate effect on real debt. Let me do the latter, and assume a permanent effect on real debt, as illustrated in figure 6.3.

Given this, as discussed in in section 6.1 of CB, under monetary non-neutrality, to reach the break-even point when marginal cost and benefit of raising the policy rate are equal, the policy-rate effect on the probability of a crisis needs to be about 5.8 times as large as the benchmark. This requires the coefficients of the logit function estimated by Schularick and Taylor (2012) be about 5.8 times as large as their estimates. The largest and most significant coefficient of their logit equation would have to increase by 13 standard errors.[23]

Thus, given the Sveriges Riksbank (2014) estimate of the policy-rate effect on credit, the credit effect on the probability of a crisis needs to be 13 standard errors larger than the Schularick and Taylor (2012) estimate to reach the break-even point. An assumption of such a large deviation of the policy-rate effect from empirical estimates hardly seems reasonable. Figure 6.4 illustrates this larger policy-rate effect on the probability of a crisis. The maximum fall in the probability of a crisis for a 1 percentage point higher policy rate during quarters 1–4 is

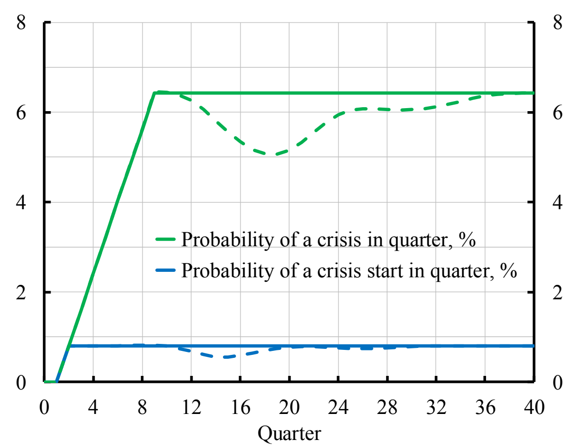

Figure 6.4: The probabilities of a crisis start and of a crisis for the benchmark (solid lines) and for a 5.8 times as large an effect of a 1 percentage point higher policy rate in quarters 1–4 (dashed lines). (Source: Schularick and Taylor (2012), Sveriges Riksbank, and own calculations.)

[23] The largest coefficient and most significant coefficient is 7.138, with a standard error of 2.631 (Schularick and Taylor (2012, table3, specification 6)). In order to be 5.8 times as large, it needs to increase by $(5.8-1)\cdot 7.138 = 34.26$, which equals $34.26/2.631 = 13.0$ standard errors.

then about 1.3 percentage points, for quarter 18, not so different from the 1 percentage point that AL consider a reasonable alternative assumption.

6.2 For a higher probability of a crisis and a higher policy-rate effect on the probability, what is the required effect on the magnitude for break-even

Next, let us assume AL's higher probability of a crisis, 10 percent instead of the benchmark 6.4 percent. Let us assume that this higher probability, as in CB, is caused by higher average real debt growth. Then, because of the convexity of the logit function in the relevant range of debt growth rates, the probability of a crisis is more sensitive to real debt growth. More precisely, the policy-rate effect on the probability of a crisis is 1.6 times as large as the benchmark. In addition, let us assume that the coefficient estimates of Schularick and Taylor are multiplied by 2 (which corresponding to a largest coefficient that is 2.7 standard errors larger than their estimate).[24] This means that the total policy-rate effect is about 3.2 times larger than the benchmark.

As explained above, the probability of a crisis does not affect how much stronger the policy-rate effect on the magnitude must be for break-even. What matters is that the policy-rate effect on the probability of a crisis is larger, which under the assumption of monetary neutrality results in a cumulative benefit from the policy-rate effect on the probability. (Recall that under monetary neutrality, the probability of a crisis is just postponed but there is no cumulative benefit.)

Then, to achieve break-even for this case, the required effect on the magnitude needs to be about 25 standard errors larger than, Flodén's estimate.[25] Because of the larger policy-rate effect on the probability of a crisis and the assumption of monetary non-neutrality, this is less than the required 40 standard errors as large an effect we have found for the benchmark. But, counter to what AL state, it remains implausibly large and is hardly a reasonable assumption. It is hardly the case that, in this situation, "even a very small benefit in terms of a smaller rise in unemployment from LATW policy would suggest that LATW policy has net benefits."

7 The risk-taking channel in cost-benefit analysis

AL suggest that the so-called risk-taking channel would increase the effect of monetary policy on the probability or severity of crises: "when monetary policy conditions affect the risk taking of

[24] The constant in the logit equation is adjusted to keep the probability of a crisis at 10 percent.

[25] The required effect of debt to income on the crisis increase in the unemployment rate for break-even is 0.25, about 11 times as large as Flodén's estimate and implying an effect $(0.25 - 0.023)/0.00897 = 25.3$ standard errors larger than the estimate.

financial institutions, monetary conditions influence current credit conditions, as well as tail risks to the dual mandate." But they do not supply any specific references or detailed arguments. Also, as mentioned above, the reduce-form estimates of Schularick and Taylor (2012) may very well pick up any risk-taking channel, to the extent that it affects the probability of a crisis.

However, there is reason to doubt that any risk-taking channel is economically significant. Dell'Ariccia et al. (2013) provide a thorough examination of the risk-taking channel and the effect of the real federal funds rate on a measure of loan risk for U.S. banks, using extensive confidential Federal Reserve Data. They find that an increase in the real federal funds rate of 1 percentage point is associated with a *statistically* significant fall in the loan-risk measure of 0.031 (table 2, column 6). But the effect is *economically insignificant*. The standard deviation of the loan-risk measure is 0.85, so the effect of a 1 percentage point higher real federal funds rate is only $0.031/0.85 = 3.6$ percent of the standard deviation of the loan-risk measure. This means that the loan-risk measure is influenced mainly by other of factors than the federal funds rate. This is hardly a risk-taking effect that could have any material effect on the probability of crisis.[26]

8 The policy-rate effect on debt

As mentioned, the above analysis uses the Sveriges Riksbank (2014) estimates of the policy-rate effects on household debt and debt to income and combines them with the Schularick and Taylor (2012) and Flodén (2014) estimates of the effect on credit on, respectively, the probability of a crisis and the magnitude of a crisis. However, regarding the policy-rate effect on debt, as discussed Svensson (2013a,b), a priori, the effect on real debt of a higher policy rate is likely to be small and could be of either sign. The stock of nominal debt, in particular the stock of mortgages, has considerable inertia. A higher interest rate may reduce the growth rate of housing prices and, at given loan-to-value ratios, reduce the growth rate of new mortgages. But only a fraction of the stock of mortgages is turned over each year. Furthermore, even if a higher policy rate slows down the rate of growth of nominal mortgages, it also slows down the rate of growth of the price level. Thus, both the numerator and the denominator of real debt are affected in the same direction by the policy rate, making the effect on the ratio smaller. And if the price level is affected more or quicker than the stock of debt, real debt will rise rather than fall. Indeed, the "stock" effect may

[26] Furthermore, as Dell'Ariccia et al. (2013) emphasize, the results should in any case not be interpreted as implying that any the additional risk taking associated with a lower federal funds rate is "excessive."
In the revised version, Dell'Ariccia et al. (2016), the effect of a 1 pp higher federal funds rate is a bit higher, $0.052/0.085 = 6.1\%$ of the standard deviation of the loan-risk measure, but still small and economically not significant.

dominate over the "flow" effect for several years or longer.

Furthermore, as also discussed in Svensson (2013a, 2017), the effect on the debt-to-GDP ratio of a higher policy rate is even more likely to be small or of the opposite sign, because then not only the price level but also real GDP enter in the denominator, and the growth of both are slowed down by a higher policy rate. Several recent papers have indeed found empirical evidence supporting the notion that a higher policy-rate *increases* rather than decreases the debt-to-GDP ratio (Alpanda and Zubairy (2014), Bauer and Granziera (2016), Gelain, Lansing, and Natvik (2015), and Robstad (2014)). Consistent with this, even though the Sveriges Riksbank (2013) point estimates of the policy-rate effects on real debt and debt to GDP are negative, they are not statistically significant from zero and the effect could be of the opposite sign.

Thus, to nevertheless use the point estimates of Sveriges Riksbank (2014), as I have done in CB and here, implies stacking the cards in favor of LAW.

8.1 The policy-rate effect on credit to GDP is economically insignificant

Furthermore, by the same argument as used above for the risk-taking channel, the policy-rate effect on credit-to-GDP is arguably *economically insignificant*. We have noted above that the standard deviation of JST's exc ess credit is 2.5 percentage points per year. Given the average duration of the post-WWII expansion phase of 9.46 years, this corresponds to a standard deviation of the cumulative bank-loans-to-GDP ratio of about 26 percent.[27] According to Sveriges Riksbank (2014) the effect of a 1 percentage point higher policy rate during 4 quarters is a reduction of household debt to GDP by less than 1 percent in 4–8 quarters. The effect then falls back to zero in about 32 quarters. The effect is not statistically significant.[28]

Even if a point estimate of an effect of about 1 percent is accepted, and even if it were permanent, it is arguably not significantly. The effect is only about $1/26 = 3.8$ percent of the standard deviation of the cumulative excess credit. This means that the cumulative excess credit is mainly influenced by other factors than the policy rate.

[27] $1.025^{9.46} - 1 = 0.2631$.

[28] According to Sveriges Riksbank (2014, figure A22), the maximum effect of 1 percentage point higher policy rate during 4 quarters is a fall in the household debt-to-GDP ratio of 1.4 percentage points, which is calculated as the estimated percentage change of the debt ratio times a debt ratio of 173 percent. This means that the percentage change is a fall of $1.4/1.73 = 0.8$ percent.

9 Conclusions

Adrian and Liang (2016a) have not scrutinized the sensitivity analysis done in the first version of Svensson (2017) but have used a much simplified two-period excel-sheet example that I have used to illustrate the mechanism and order of magnitude of the relevant effects. The considerable simplifications and short-cuts make this example unsuitable for a serious and reliable sensitivity analysis. For that, the original framework of Svensson (2017) is more appropriate, given that it uses empirically estimated costs and benefits, in particular including empirical lags over a 40-quarter period.

Adrian and Liang state that "the result that costs exceed benefits rely critically on assumptions about the change in unemployment in a recession or crisis, the crisis probability, and the elasticity of crisis probability with respect to the interest rate" and provide alternative assumptions that they assert would overturn the result. With further sensitivity analysis and more references to existing data and estimates, in this paper I have showed that their alternative assumptions are hardly realistic and reasonable, because they differ substantially from and thereby involve large deviations from existing empirical estimates in the literature. literature

For the marginal cost of leaning against the wind not to exceed but to equal the marginal benefit, that is, to make neither leaning *against* or *with* the wind desirable and in this sense break even, larger effects very different from existing empirical estimates are required. To move beyond break-even and overturn my result, even larger effects are required. Indeed, Adrian and Liang's alternative assumptions required to overturn my result imply an effect of debt on the magnitude of a crisis that is more than 40 standard errors larger than the estimate of Flodén (2014) and more than 11 standard errors larger than an estimate that follows from Jordà et al. (2013), or an effect of credit on the probability of a crisis that is more than 13 standard errors larger than the estimate of Schularick and Taylor (2012).

Given this, and the extensive sensitivity analysis already done in previous versions of Svensson (2017), my result seems so far to stand up to scrutiny and, given current knowledge and existing empirical estimates, to be quite robust and not very sensitive to reasonable alternative assumptions.

References

Adrian, Tobias and Nellie Liang (2016a), "Monetary Policy, Financial Conditions, and Financial Stability," Staff Report No. 690, Revised December 2016, Federal Reserve Bank of New York, www.newyorkfed.org.

Adrian, Tobias and Nellie Liang (2016b), “Monetary Policy, Financial Conditions, and Financial Stability,” Vox Column, August 14, 2016, www.voxeu.org.

Ajello, Andrea, Thomas Laubach, David Lopez-Salido, and Taisuke Nakata (2016), “Financial Stability and Optimal Interest-Rate Policy,” Finance and Economics Discussion Series 2016-067, Federal Reserve Board, www.federalreserve.gov.

Alpanda, Sami and Sarah Zubairy (2014), “Addressing Household Indebtedness: Monetary, Fiscal or Macroprudential Policy?” Working Paper 2014-58, Bank of Canada, www.bankofcanada.ca.

Bank for International Settlements (2016a), *86th Annual Report*, Bank for International Settlements, www.bis.org.

Bank for International Settlements (2016b), “Economic Resilicence: A Financial Perspective,” Note submitted to the G20 on November 7, Bank for International Settlements, www.bis.org.

Bank for International Settlements (2016c), “Statistics Explorer,” Database, Bank for International Settlements, stats.bis.org/statx/.

Bauer, Gregory H. and Eleonora Granziera (2016), “Monetary Policy, Private Debt and Financial Stability Risks,” Working Paper.

Brunnermeier, Markus, Darius Palia, Karthik A. Sastry, and Christopher A. Sims (2016), “Feedbacks: Financial Markets and Economic Activity,” Working Paper.

Dell’Ariccia, Giovanni, Luc Laeven, and Gustavo Suarez (2013), “Bank Leverage and Monetary Policy’s Risk-Taking Channel: Evidence from the United States,” Working Paper WP/13/143, International Monetary Fund, www.imf.org. Forthcoming in *Journal of Finance*.

Dell’Ariccia, Giovanni, Luc Laeven, and Gustavo Suarez (2016), “Bank Leverage and Monetary Policy’s Risk-Taking Channel: Evidence from the United States,” Working Paper 1903, European Central Bank, www.ecb.eu. Forthcoming in *Journal of Finance*.

Filardo, Andrew and Phurichai Rungcharoenkitkul (2016), “Quantitative Case for Leaning-Against-the-Wind,” Working Paper, Bank for International Settlements.

Flodén, Martin (2014), "Did Household Debt Matter in the Great Recession?" Supplement to blog post on Ekonomistas.se, Sveriges Riksbank, www.martinfloden.se.

Gelain, Paolo, Kevin J. Lansing, and Gisle J. Natvik (2015), "Leaning Against the Credit Cycle," Working Paper 04-2015, Norges Bank, www.norges-bank.no.

Gourio, François, Anil K. Kashyap, and Jae Sim (2016), "The Tradeoffs in Leaning Against the Wind," Working Paper.

International Monetary Fund (2015), "Monetary Policy and Financial Stability," Staff Report, International Monetary Fund, www.imf.org.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor (2013), "When Credit Bites Back," *Journal of Money, Credit and Banking*, vol. 45 Supplement, no. 2, pages 3–28.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor (2016), "The Great Mortgaging: Housing Finance, Crises and Business Cycles," *EconomicPolicy*, pages 107–152.

Krishnamurthy, Arvind and Tyler Muir (2016), "How Credit Cycles across a Financial Crises," Working Paper, people.stanford.edu/akris/.

Laeven, Luc and Fabián Valencia (2012), "Systemic Banking Crises Data: An Update," Working Paper WP/12/163, International Monetary Fund, www.imf.org.

Mian, Atif R., Amir Sufi, and Emil Verner (2016), "Household Debt and Business Cycles Worldwide," Working Paper, www.papers.ssrn.com.

Robstad, Ørjan (2014), "House Prices, Credit and the Effect of Monetary Policy in Norway: Evidence from Structural VAR Models," Working paper 05-2015, Norges Bank, www.norges-bank.no.

Schularick, Moritz and Alan M. Taylor (2012), "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008," *American Economic Review*, vol. 102, pages 1029–1061.

Sutherland, Douglas, Peter Hoeller, Rossana Merola, and Volker Zieman (2012), "Debt and Macroeconomic Stability," OECD Economics Department Working Paper No. 1003, OECC, www.oecd.org.

Svensson, Lars E.O. (2013a), "'Leaning Against the Wind' Leads to a Higher (Not Lower) Household Debt-to-GDP Ratio," Working Paper, Stockholm School of Economics, www.larseosvensson.se.

Svensson, Lars E.O. (2013b), "The Riksbank Is Wrong about the Debt: Higher Policy Rates Increase Rather than Decrease the Household-Debt Ratio," *Vox: CEPR's Policy Portal,*, September 4, www.voxeu.org.

Svensson, Lars E.O. (2014), "Inflation Targeting and 'Leaning Against the Wind'," *International Journal of Central Banking*, vol. 10, no. 2, pages 103–114.

Svensson, Lars E.O. (2016a), "Cost-Benefit Analysis of Leaning Against the Wind: Are Costs Larger Also with Less Effective Macroprudential Policy?" IMF Working Paper WP/16/03, International Monetary Fund, www.imf.org.

Svensson, Lars E.O. (2016b), "Discussion (revised) of Filardo and Rungcharoenkitkul, Quantitative Case for Leaning-Against-the-Wind," Research Forum on Macro-Finance, Centre for Central Banking Studies, Bank of England, May 26-27, www.larseosvensson.se.

Svensson, Lars E.O. (2016c), "Monetary Policy and Macroprudential Policy: Different and Separate," Working Paper, www.larseosvensson.se. Forthcoming in *Canadian Journal of Economics*.

Svensson, Lars E.O. (2017), "Cost-Benefit Analysis of Leaning Against the Wind: Are Costs Larger Also with Less Effective Macroprudential Policy?" Revision, January 2017, of IMF Working Paper WP/16/03, January 2016, www.larseosvensson.se.

Sveriges Riksbank (2013), "Financial Imbalances in the Monetary Policy Assessment," *Monetary Policy Report July 2013,*, www.riksbank.se.

Sveriges Riksbank (2014), "The Effects on Monetary Policy on Household Debt," *Monetary Policy Report February 2014,*, www.riksbank.se.