Cost-Benefit Analysis of Leaning Against the Wind: Are Costs Larger Also with Less Effective Macroprudential Policy?

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1The views expressed in this paper are those of the author and do not necessarily represent those of the IMF or IMF policy.
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Requires a cost-benefit analysis
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- Multiperiod quarterly model (as in Diaz Kalan et al.)

- New: Cost of crisis higher if initial unemployment higher (previous papers: constant cost of a crisis)

- Monetary neutrality implies no accumulated effect on probability of crisis

- Has strong implications for the cost and benefit of LAW

- Less effective macroprudential policy: Effects on relative marginal cost and benefit?
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Conclusions 1

- For existing empirical estimates, marginal cost of LAW much higher than marginal benefit.
- Thus, LAW not justified. If anything, modest leaning with the wind justified.
- LAW increases not only non-crisis unemployment gap but also crisis unemployment gap; the latter is main component of marginal cost.
- Lower probability of a crisis is main component of possible marginal benefit of LAW.
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Thus, LAW not justified. If anything, modest leaning with the wind justified.

LAW increases not only non-crisis unemployment gap but also crisis unemployment gap; the latter is main component of marginal cost

Lower probability of a crisis is main component of possible marginal benefit of LAW

For empirical estimates and channels, effect of LAW on probability of a crisis too small to make marginal benefit exceed marginal cost
Empirically, probability of a crisis depends on real debt growth
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If monetary policy neutral in long run, no long-run effect on real debt and accumulated real debt growth.

Even if monetary policy non-neutral and lowers real debt in the long run, empirically marginal benefit still much smaller than marginal cost.

Less effective macroprudential policy might increase the probability, severity, or duration of a crisis; however, each of these increases marginal cost more than marginal benefit and strengthens the case against LAW.
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Then, if real debt growth and probability of a crisis lower for a few years, they must be higher in later years; no effect on long-run average probability of a crisis.

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Unemployment rates, crises, and probabilities

- $u_t$ unemployment rate in quarter $t$
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- $\Delta u > 0$ fixed crisis *increase* in the unemployment rate, ($\Delta u = 5$ pp (Riksbank assumption) (6 pp))
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$$p_t = \sum_{\tau=0}^{n-1} q_t$$
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  \[
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  \]

- Acceptable linear approximation to Markov process for relevant range of parameters (appendix)
Exogenous probability: Lean *with* the wind (!)

- Exogenous crisis probabilities $\bar{p}_t, t \geq 1$
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- Exogenous crisis probabilities $\tilde{p}_t, t \geq 1$
- Optimal policy: Set expected unemployment gap equal to zero
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$$E_1 \tilde{u}_t = (1 - \bar{p}_t)E_1 \tilde{u}_t^n + \bar{p}_t E_1 \tilde{u}_t^c$$
$$= (1 - \bar{p}_t)E_1 \tilde{u}_t^n + \bar{p}_t (E_1 \tilde{u}_t^n + \Delta u)$$
$$= E_1 \tilde{u}_t^n + \bar{p}_t \Delta u$$
$$= 0$$

Negative non-crisis unemployment gap: 
Modest leaning *with* the wind

Can a higher policy rate reduce the probability or severity of a crisis so much so as to counter this strong incentive toward leaning with the wind?

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\[
E_1 \hat{\mu}_t = (1 - \bar{p}_t)E_1 \hat{\mu}_t^n + \bar{p}_t E_1 \hat{\mu}_t^c
\]
\[
= (1 - \bar{p}_t)E_1 \hat{\mu}_t^n + \bar{p}_t (E_1 \hat{\mu}_t^n + \Delta u)
\]
\[
= E_1 \hat{\mu}_t^n + \bar{p}_t \Delta u
\]
\[
= 0
\]

\[
E_1 \hat{\mu}_t^n = - \bar{p}_t \Delta u \ (= - 0.064 \cdot 5 = - 0.32 \text{pp}) < 0
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\[
E_1 \tilde{u}_t = (1 - \bar{p}_t)E_1 \tilde{u}^n_t + \bar{p}_t E_1 \tilde{u}^c_t \\
= (1 - \bar{p}_t)E_1 \tilde{u}^n_t + \bar{p}_t (E_1 \tilde{u}^n_t + \Delta u) \\
= E_1 \tilde{u}^n_t + \bar{p}_t \Delta u \\
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- Negative non-crisis unemployment gap: Modest leaning *with the wind*
- Can a higher policy rate reduce the probability or severity of a crisis so much so as to counter this strong incentive toward leaning with the wind?
Expected future unemployment rate:

$$E_1 u_t = (1 - p_t)E_1 u_t^n + p_t E_1 u_t^c = E_1 u_t^n + p_t \Delta u$$

- $i_t$, policy rate, constant during qtrs 1–4: $i_t = i_1$, $1 \leq t \leq 4$
- Leaning against the wind (LAW): $d i_1 > 0$
- Effect on expected future unemployment rate:

$$\frac{d E_1 u_t}{d i_1} = \frac{d E_1 u_t^n}{d i_1} + \frac{dp_t}{d i_1} \Delta u \left( + p_t \frac{d \Delta u}{d i_1} \right)$$

- Need to determine $\frac{d E_1 u_t^n}{d i_1}$ and $\frac{dp_t}{d i_1}$, $t \geq 1$
- Disregard $\frac{d \Delta u}{d i_1}$ (appendix: negligible, uncertain sign)
Effect on the expected non-crisis unemployment rate

\[ \frac{dE_1 u^n_t}{di_1}, \quad t \geq 1, \text{ example and benchmark: Riksbank estimate} \]
If a crisis happens: $\Delta i_1 = 1$, $E_1 u^c_t = E_1 u^n_t + \Delta u$
If a crisis happens in quarter 12: $\Delta \tilde{i}_1 = 1$, $E_t^c \equiv E_t^n + \Delta u$
Schularick and Taylor (2012):
The probability of a crisis start in quarter $t$ ($q_t$) depends on real debt growth (annual data, 14 countries, 1870–2008)

\[
q_t = \frac{1}{4} \exp(X_t) + \exp(X_t) g_t - 4 + 7.138 g_t - 8 + 0.888 g_t - 12 + 1.867 g_t - 20 g_t \equiv \left( \sum_{3 \tau = 0} d_t - \tau / 4 \right) / \left( \sum_{3 \tau = 0} d_t - 4 - \tau / 4 \right) - 1
\]

Real debt, $g_t$ annual growth rate of average annual debt
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The probability of a crisis start in quarter $t$ ($q_t$) depends on real
debt growth (annual data, 14 countries, 1870–2008)

Main logit equation, adapted to quarterly data

$$q_t = \frac{1}{4} \frac{\exp(X_t)}{1 + \exp(X_t)}$$

$$X_t = \begin{bmatrix} -3.89 \end{bmatrix} - 0.398 g_{t-4} + 7.138^{***} g_{t-8}$$
$$+ 0.888 g_{t-12} + 0.203 g_{t-16} + 1.867 g_{t-20}$$

$$g_t \equiv \left( \sum_{\tau=0}^{3} d_{t-\tau} / 4 \right) / \left( \sum_{\tau=0}^{3} d_{t-4-\tau} / 4 \right) - 1$$

d_t real debt, $g_t$ annual growth rate of average annual debt
Effect on probability of a crisis 2

\[ \frac{d(d_t)}{di_1}, \; t \geq 1, \text{ example and benchmark: Riksbank estimate} \]

- Determines effects on real debt growth, \( \frac{dg_t}{di_1} \),
- on the probability of a crisis start, \( \frac{dq_t}{di_1} \), and
- on the probability of a crisis, \( \frac{dp_t}{di_1} = \sum_{\tau=0}^{n-1} \frac{dq_t}{di_1} \)
An intertemporal quadratic loss function

- $u_t^*$ benchmark unemployment rate: (optimal for flexible inflation targeting when $p_t \equiv 0, \ t \geq 1$ (appendix))
- $\tilde{u}_t \equiv u_t - u_t^*$ unemployment gap ($\tilde{u}^n_t \equiv u^n_t - u_t^*, \ \tilde{u}^c_t \equiv u^c_t - u_t^*$)
- Intertemporal (indirect) loss function (relevant loss for $p_t \geq 0, \ t \geq 1$):
  \[ \sum_{t=1}^{\infty} \delta^{t-1} E_1 L_t \]
  \[ L_t = (\tilde{u}_t)^2 \]

- Expected quarter-$t$ loss:
  \[ E_1 L_t = (1 - p_t)E_1 (\tilde{u}_t^n)^2 + p_t E_1 (\tilde{u}_t^c)^2 \]
  \[ = (1 - p_t)E_1 (\tilde{u}_t^n)^2 + p_t E_1 (\tilde{u}_t^n + \Delta u)^2 \]

- Need to know the probability of a crisis, $p_t, \ t \geq 1$
The probability of a crisis

- Annual benchmark steady state probability of crisis start
  \[ 4q = 3.2\%: \]
  A crisis start on average every 31 years
- Quarterly probability of crisis start \( q = 0.8\% \)
- Conditional on no crisis in qtr 1, benchmark probability of crisis in qtr \( t \) (\( n = 8 \)):
  \[
  p_t = \begin{cases} 
  0 & \text{for } t = 1, \\
  (t - 1)q = (t - 1) 0.8\% > 0 & \text{for } 1 \leq t \leq 8, \\
  nq = 6.4\% > 0 & \text{for } t \geq 9.
  \end{cases}
  \]
The expected quarter-\(t\) loss

\[
E_1 L_t = (1 - p_t)E_1 (\tilde{\nu}_t^n)^2 + p_t E_1 (\tilde{\nu}_t^n + \Delta u)^2
\]

\[
E_1 (\tilde{\nu}_t^n)^2 = (E_1 \tilde{\nu}_t^n)^2 + \text{Var}_1 \tilde{\nu}_t^n
\]

\[
E_1 (\tilde{\nu}_t^n + \Delta u)^2 = (E_1 \tilde{\nu}_t^n + \Delta u)^2 + \text{Var}_1 \tilde{\nu}_t^n
\]

\[
E_1 L_t - \text{Var}_1 \tilde{\nu}_t^n = (1 - p_t)(E_1 \tilde{\nu}_t^n)^2 + p_t(E_1 \tilde{\nu}_t^n + \Delta u)^2
\]

\[
= (1 - \bar{p}_t)(E_1 \tilde{\nu}_t^n)^2 + \bar{p}_t(E_1 \tilde{\nu}_t^n + \Delta u)^2
\]

\[
- (\bar{p}_t - p_t)[(E_1 \tilde{\nu}_t^n + \Delta u)^2 - (E_1 \tilde{\nu}_t^n)^2]
\]

\[
= \{ (1 - \bar{p}_t)(E_1 \tilde{\nu}_t^n)^2 + \bar{p}_t(E_1 \tilde{\nu}_t^n + \Delta u)^2 \}
\]

\[
- (\bar{p}_t - p_t)[(\Delta u)^2 + 2\Delta u E_1 \tilde{\nu}_t^n]
\]

\[
\equiv \{ C_t^n + C_t^c \} - B_t \equiv C_t - B_t
\]
\[ E_1L_t - \text{Var}_1\tilde{u}_t^n = \left\{ (1 - \bar{p}_t)(E_1\tilde{u}_t^n)^2 + \bar{p}_t(E_1\tilde{u}_t^n + \Delta u)^2 \right\} \]

\[ - (\bar{p}_t - p_t)[(\Delta u)^2 + 2\Delta uE_1\tilde{u}_t^n] \]

\[ \bar{p}_t - p_t = (-dp_t/dE_1u_t^n)E_1\tilde{u}_t^n = 0.0085 E_1\tilde{u}_t^n, \quad \bar{p}_t = 0.064, \quad \Delta u = 5 \]
The expected quarter-\( t \) loss 3

\[
E_1L_t - \text{Var}_1\tilde{u}_t^n = \left\{ (1 - \bar{p}_t)(E_1\tilde{u}_t^n)^2 + \bar{p}_t (E_1\tilde{u}_t^n + \Delta u)^2 \right\}
- (\bar{p}_t - p_t)[(\Delta u)^2 + 2\Delta u E_1\tilde{u}_t^n]
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\bar{p}_t - p_t = \left( - dp_t / dE_1u_t^n\right) E_1\tilde{u}_t^n = 0.0085 E_1\tilde{u}_t^n, \quad \bar{p}_t = 0.064, \quad \Delta u = 5
\]
The expected quarter-\( t \) loss 4

\[
E_1 L_t - \text{Var}_1 \tilde{u}_t^n = \left\{ (1 - \bar{p}_t)(E_1 \tilde{u}_t^n)^2 + \bar{p}_t(E_1 \tilde{u}_t^n + \Delta u)^2 \right\} \\
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The expected quarter-\( t \) loss 5

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\]

\[- (\bar{p}_t - p_t)[(\Delta u)^2 + 2\Delta u E_1 \tilde{u}_t^n]\]

\[
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The expected quarter-\( t \) loss 6

\[
E_1L_t - \text{Var}_1\tilde{u}_t^n = \left\{ (1 - \bar{p}_t)(E_1\tilde{u}_t^n)^2 + \bar{p}_t(E_1\tilde{u}_t^n + \Delta u)^2 \right\} \\
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\]

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The expected quarter-\(t\) loss, \textit{fixed} cost of a crisis 1

\[
E_1 L_t - \text{Var}_1 \tilde{u}_t^n = \{(1 - \bar{p}_t)(E_1 \tilde{u}_t^n)^2 + \bar{p}_t (\Delta u)^2\}
- (\bar{p}_t - p_t)[(\Delta u)^2 - (E_1 \tilde{u}_t^n)^2]
\]

\[
\bar{p}_t - p_t = (-dp_t/dE_1 u_t^n)E_1 \tilde{u}_t^n = 0.0085 E_1 \tilde{u}_t^n, \quad \bar{p}_t = 0.064, \Delta u = 5
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The expected quarter-\(t\) loss, \textit{fixed} cost of a crisis 2

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E_1L_t - \text{Var}_1\tilde{u}_t^n = \{(1 - \bar{p}_t)(E_1\tilde{u}_t^n)^2 + \bar{p}_t(\Delta u)^2\} - (\bar{p}_t - p_t)[(\Delta u)^2 - (E_1\tilde{u}_t^n)^2]
\]

\[
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Effect on expected quadratic loss, Net Marginal Cost

\[ E_1 L_t = E_1 (\tilde{u}_t^n)^2 + p_t [E_1 (\tilde{u}_t^n + \Delta u)^2 - E_1 (\tilde{u}_t^n)^2] \]
\[ = E_1 (\tilde{u}_t^n)^2 + p_t [(\Delta u)^2 + 2 \Delta u E_1 \tilde{u}_t^n] \]

- **Net Marginal Cost:** \( \text{NMC}_t \equiv \frac{dE_1 L_t}{d\tilde{i}_1} = \)

\[ = 2 [E_1 \tilde{u}_t^n + p_t \Delta u] \frac{dE_1 u_t^n}{d\tilde{i}_1} - [(\Delta u)^2 + 2 \Delta u E_1 \tilde{u}_t^n] \left( - \frac{dp_t}{d\tilde{i}_1} \right) \]
\[ \equiv \text{MC}_t - \text{MB}_t \]

- **Examine** \( \text{MC}_t, \text{MB}_t, \) and \( \text{NMC}_t \) for \( E_1 \tilde{u}_t^n = 0: \)

\[ \text{NMC}_t = \text{MC}_t - \text{MB}_t \]
\[ = 2p_t \Delta u \frac{dE_1 u_t^n}{d\tilde{i}_1} - (\Delta u)^2 \left( - \frac{dp_t}{d\tilde{i}_1} \right) \]
Marginal cost, marginal benefit, and net marginal cost

- \( MC_t = 2p_t \Delta u \frac{dE_1 u^1_t}{di_1} \), \( MB_t = (\Delta u)^2 \left(- \frac{dp_t}{di_1}\right) \)
- \( NMC_t = MC_t - MB_t \)

- Marginal cost dominates over marginal benefit
- Accumulated marginal benefits: \( \sum_{t=1}^{40} MB_t \approx 0 \)
What if less effective macroprudential policy?

• Does less effective macroprudential policy justify leaning against the wind?

Consequences of less effective macroprudential policy:
- Less loss-absorbing capital, weaker balance sheets, lower credit standards,...
- Higher probability of a crisis start, \( q \)
- Larger crisis increase in unemployment rate, \( \Delta u \)
- Longer duration of crisis, \( n \)

Additional sensitivity analysis
What if less effective macroprudential policy?

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- Additional sensitivity analysis
A higher probability of crisis start

- Increase in annual probability $4q$ from 3.21% to 4.21%

- Increase in steady annual real debt growth from 5% to 7.9%

- $dq/dg$ increases $\Rightarrow |dq_t/d\bar{i}_1|, |dp_t/d\bar{i}_1|$ increase
A higher probability of crisis start

- $MC_t = 2p_t\Delta u \frac{dE_1u_t^n}{d_i_1}$, $MB_t = (\Delta u)^2(-\frac{dp_t}{d_i_1})$, $NMC_t = MC_t - MB_t$
- Increase in annual probability $4q$ from 3.21% to 4.21% (dashed)
A larger crisis increase in the unemployment rate

- \( MC_t = 2p_t \Delta u \frac{dE_1 u^t_1}{di_1} \), \( MB_t = (\Delta u)^2 (\frac{dp_t}{di_1}) \), \( NMC_t = MC_t - MB_t \)
- Larger \( \Delta u \), from 5 to 6 percentage points (dashed)
A longer crisis duration

- \( MC_t = 2p_t \Delta u \frac{dE_1u^n}{di_1} \), \( MB_t = (\Delta u)^2 \left( -\frac{dp_t}{di_1} \right) \), \( NMC_t = MC_t - MB_t \)

- Increase in \( n \) from 8 to 12 quarters; \( p_t = \sum_{\tau}^{n-1} q_{t-\tau} \)
Monetary non-neutrality: Permanent effect on real debt

- Real debt stays at its lowest deviation from baseline

- Negative accumulated effect on crisis probabilities
Monetary non-neutrality: Permanent effect on real debt; MC, MB, and NMC

- \( MC_t = 2p_t \Delta u \frac{dE_1 u^n_t}{di_1} \), \( MB_t = (\Delta u)^2 (-\frac{dp_t}{di_1}) \), \( NMC_t = MC_t - MB_t \)

- Marginal cost still dominates over marginal benefit
Monetary non-neutrality: Permanent effect on real debt – What is needed for LAW to be justified?

- Break-even requires 5.8 times larger effect of real debt growth on probability than Schularick & Taylor’s estimates.
- 2 standard deviations corresponds to 1.7 times larger effect.
- Dashed lines in figure show 5.8 times larger effect.

![Graph showing real debt, average annual real debt growth, and probability of a crisis start in quarter.](image-url)
Monetary non-neutrality: Permanent effect on real debt – What is needed for LAW to be justified?

- **MB** and **NMC** for 5.8 times larger effect of real debt growth on probability
- **Break-even point:** \( \sum_{t=1}^{40} NMC_t = \sum_{t=1}^{40} MC_t - \sum_{t=1}^{40} MB_t = 0 \)
For existing empirical estimates, marginal cost of LAW much higher than marginal benefit

Thus, LAW not justified. If anything, modest leaning with the wind justified.

LAW increases not only non-crisis unemployment gap but also crisis unemployment gap; the latter is main component of marginal cost

Lower probability of a crisis is main component of possible marginal benefit of LAW

For empirical estimates and channels, effect of LAW on probability of a crisis too small to make marginal benefit exceed marginal cost
Empirically, probability of a crisis depends on real debt growth.

If monetary policy neutral in long run, no long-run effect on real debt and accumulated real debt growth.

Then, if real debt growth and probability of a crisis lower for a few years, they must be higher in later years; no effect on long-run average probability of a crisis.

Even if monetary policy non-neutral and lowers real debt in the long run, empirically marginal benefit still much smaller than marginal cost.

Less effective macroprudential policy might increase the probability, severity, or duration of a crisis; however, each of these increases marginal cost more than marginal benefit and strengthens the case against LAW.
Previous closely related literature

- **2-period model (Ajello et al. 2015, Svensson 2014, 2015)**
  - Period 1: LAW and higher unemployment, but *no crisis* (understates cost of LAW, because crisis can come any time, and cost of crisis higher if initial unemployment higher)
  - Period 2: Lower probability of crisis with *fixed cost* (understates cost of LAW; overstates benefit of LAW, because monetary neutrality disregarded)

- **Multiperiod quarterly model (Diaz Kalan et al. 2015)**
  - Fixed cost of crisis (understates cost of LAW, because cost higher in weaker economy)

- Still, in these papers either cost higher than benefit, or net benefit and optimal LAW tiny (With fixed cost of crisis, optimal LAW tiny; probability reduction and net gain completely insignificant)
Effect on probability of crisis: 3 limitations

1. Neutrality of monetary policy: No long-run effect on real debt implies no effect on long-run average probability

2. Policy-rate effect on real debt and debt-to-GDP small and of any sign (Svensson)
   - Higher policy rate slows down both numerator and denominator. Numerator (nominal stock of debt) sticky
   - Several papers confirm effect on debt-to-GDP positive or ambiguous (Alpanda & Zubairy, Gelain et al., Robstad)

3. Empirical relation real debt growth-financial crisis reduced form
   - Underlying factors: Resilience of financial system and economy; nature, magnitude of shocks
   - Balance sheets, asset quality, capital, lending standards, liquidity, maturity transformation, risk-taking, speculation,...
   - “Good” and “bad” credit growth
   - Less data on underlying factors
   - Policy-rate effect on underlying factors weak
   - Micro/macroprudential policy stronger effect (IMF staff paper)
Implications of monetary neutrality

- No long-run effect on real debt,
  \[
  \frac{d(d_t)}{d i_1} \approx 0 \text{ for } t \geq 40
  \]

- No accumulated effect on real debt growth, the probability of a crisis start, or the probability of a crisis
  \[
  \sum_{\tau=1}^{40} \frac{d g_t}{d i_1} \approx \sum_{\tau=1}^{40} \frac{d q_t}{d i_1} \approx \sum_{\tau=1}^{40} \frac{d p_t}{d i_1} \approx 0
  \]
Effect on the expected unemployment rate

\[ \frac{dE_1 u_t}{d\bar{\imath}_1} = \frac{dE_1 u^n_t}{d\bar{\imath}_1} + \frac{dp_t}{d\bar{\imath}_1} \Delta u \]

- Effect of reduced probability of crisis negligible (Svensson 2014, 2015), and accumulated effect approximately zero, \[ \sum_{t=1}^{40} \frac{dp_t}{d\bar{\imath}_1} \Delta u \approx 0 \]
Sensitivity to initial state of the economy

- $MC_t = 2[E_1\ddot{u}_t^n + p_t\Delta u] \frac{dE_1u_t^n}{di_1}$,
- $MB_t = [(\Delta u)^2 + 2\Delta uE_1\ddot{u}_t^n](\frac{dp_t}{di_1})$
- Suppose $E_1\ddot{u}_t^n = 0.25 \text{ pp} > 0$ for all $t \geq 1$ (dashed)

- LAW even less justified, also if $E_1\ddot{u}_t^n = 0$ for $t \geq 12$
Sensitivity to policy-rate effect on the expected non-crisis unemployment rate

\[ MC_t = 2p_t \Delta u \frac{dE_1u^n}{di_1}, \quad MB_t = (\Delta u)^2\left(-\frac{dp_t}{di_1}\right). \]

Suppose \( \frac{dE_1u^n}{di_1} \) is only a half of the benchmark (dashed)

- LAW still not justified
Sensitivity to probability of crisis

- $MC_t = 2p_t \Delta u \frac{dE_1 u_t^n}{d\bar{i}_1}$, \quad $MB_t = (\Delta u)^2 \left(- \frac{dp_t}{d\bar{i}_1}\right)$.

- Suppose $p_t$ is only a half of the benchmark (dashed)

- LAW still not justified
More recent data: Probability of a crisis

- IMF staff estimates on Laeven and Valencia (2012), quarterly data, banking crises in 35 advanced countries, 1970-2011,

\[ q_t = \frac{\exp(X_t)}{1 + \exp(X_t)} , \]

\[ X_t = -5.630^{***} - 5.650^{*} g_t + 4.210 g_{t-4} + 12.342^{**} g_{t-8} - 5.259 g_{t-12} . \]

- For 5% annual real debt growth, annual probability of crisis start

\[ 4q = 1.89\%, \quad q = 0.47\%: \]

A crisis start on average every 53 years
More recent data: Effect on probability of a crisis

- Riksbank estimate of effect on real household debt, $d(d_t)/\delta i_1$

\[
\text{Quarter}
\]

- Gives effects on real debt growth, $dg_t/\delta i_1$, probability of a crisis start, $dq_t/\delta i_1$, and probability of a crisis, $dp_t/\delta i_1 = \sum_{\tau=0}^{n-1} dq_t/\delta i_1$
More fluctuation in **Marginal Benefit**, goes to zero at $t = 40$, else similar, no accumulated effect on **Marginal Benefits**

![Graph showing Marginal cost, Marginal benefit, and Net marginal cost over time. The graph indicates that Marginal cost and Marginal benefit peaks at different times, with Marginal benefit reaching zero at time 40, while Marginal cost continues to influence the Net marginal cost.]
Probability of a crisis, \( p_t, t \geq 1 \), conditional on no crisis in quarter 1, \( p_1 = 0 \)
Effect of policy rate on probability of crisis, $\frac{dp_t}{di_1}, t \geq 1$
Effect on the crisis increase in the unemployment rate

\[
\frac{dE_1 u_t}{di_1} = \frac{dE_1 u^n}{di_1} + \Delta u \frac{dp_t}{di_1} + p_t \frac{d\Delta u}{di_1}
\]

\[
MB_t = (\Delta u)^2 \left(- \frac{dp_t}{di_1} \right) + 2p_t \Delta u \left(- \frac{d\Delta u}{di_1} \right)
\]
Flodén (2015), OECD: 1 pp higher DTI ratio 2007 gives 0.02 pp larger unemployment increase 2007–2012; Riksbank estimate of policy-rate effect on DTI ratio

Effect on $E_1 u_t$: $p_t \frac{d\Delta u}{d_i_1}$. Effect on $MB_t$: $2p_t\Delta u \left(-\frac{d\Delta u}{d_i_1}\right)$
Effect on crisis increase in unemployment rate

- Small effect on total marginal benefit and net marginal cost
Break-even effect on crisis increase in unemployment rate

- What effect of policy rate on $\Delta u$ is needed to break even?
- $d\Delta u/d\bar{i}_1$ must be about 19 times larger: $(0.3786/0.02 = 18.93)$
Break-even effect on crisis increase in unemployment rate

- What effect of policy rate on $\Delta u$ is needed to break even?
- $d\Delta u/d\bar{i}_1$ must be about 19 times larger: $(0.3786/0.02 = 18.93)$
Longer horizon: MC, MB, and NMC

-1.2
-0.8
-0.4
0
0.4
Alternative assumption: Fixed cost of a crisis

- Crisis unemployment rate:
  \[ u^c_t = \Delta u > 0 \] instead of \[ u^c_t = u^n_t + \Delta u \]

- Expected quarter \( t \)-loss

\[
E_1 L_t = (1 - p_t)E_1(\tilde{u}^n_t)^2 + p_tE_1(\Delta u)^2
\]

- Net marginal cost: \( \text{NMC}_t \equiv \frac{dE_1L_t}{di_1} \)

\[
= (1 - p_t)2E_1\tilde{u}^n_t\frac{dE_1\tilde{u}^n_t}{di_1} - [(\Delta u)^2 - (E_1\tilde{u}^n_t)^2](-\frac{dp_t}{di_1})
\]

\[ \equiv \text{MC}_t - \text{MB}_t \]

- For \( E_1\tilde{u}^n_t = 0, \)

\[
\text{MC}_t = 0
\]

\[
\text{MB}_t = (\Delta u)^2(-\frac{dp_t}{di_1})
\]
\[ MC_t = 0, \quad MB_t = (\Delta u)^2 \left( - \frac{dp_t}{di_1} \right) \]

- Some (small) LAW justified (Ajello et al.), if horizon not too long (cf. 24 qtrs)
Fixed cost of a crisis: Small initial u gap

- Small initial positive expected non-crisis unemployment gap: 
  \[ E_1 \hat{u}_t^n = 0.25 \text{ pp for } t \geq 1 \]
"Optimal" LAW very small, even if horizon = 24 qtrs (Ajello et al.)

\[ \Delta i_1 = 0.11 \text{pp}; \ \max(E_1 \tilde{u}_t^n) = 0.05 \text{ pp}; \ \max(-\Delta p_t) = 0.025 \text{ pp} \]  
(from \( p_t = 6.4 \text{ pp} \)); reduction in loss 0.07%
"Optimal" LAW very small, even if horizon = 24 qtrs (Ajello et al.)

\[ \Delta \tilde{i}_1 = 0.11 \text{pp}; \max (E_1 \tilde{u}_t^n) = 0.05 \text{ pp}; \max (-\Delta p_t) = 0.025 \text{ pp} \]
(from \( p_t = 6.4 \text{ pp} \)); reduction in loss 0.07%
A constrained-optimal policy

Quarter

Optimal policy rate, pp
Optimal expected unemployment gap, pp
Optimal expected non-crisis unemployment gap, pp
Optimal discounted NMC