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

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SF Fed, March 4, 2016

[1] The 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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- Is LAW justified?
- Requires a cost-benefit analysis

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  - 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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- 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

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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
- 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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- Acceptable linear approximation to Markov process for relevant range of parameters (appendix)

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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?

The expected future unemployment rate and LAW

- Expected future unemployment rate:

$$\mathrm{E}_1 u_t = (1 - p_t)\mathrm{E}_1 u_t^{\mathrm{n}} + p_t \mathrm{E}_1 u_t^{\mathrm{c}} = \mathrm{E}_1 u_t^{\mathrm{n}} + p_t \Delta u$$

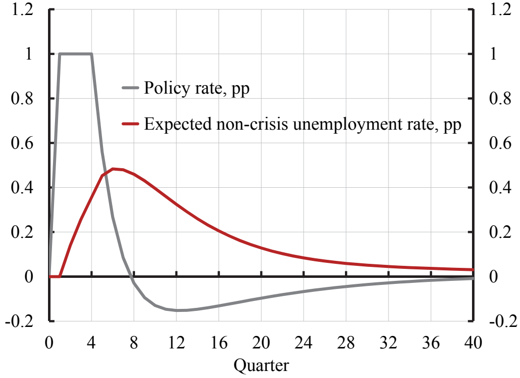
- i_t, policy rate, constant during qtrs 1–4: $i_t = \bar{i}_1, 1 \leq t \leq 4$
- Leaning against the wind (LAW): $d\bar{i}_1 > 0$
- Effect on expected future unemployment rate:

$$\frac{d\mathrm{E}_1 u_t}{d\bar{i}_1} = \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} + \frac{dp_t}{d\bar{i}_1}\Delta u \;\; (+p_t \frac{d\Delta u}{d\bar{i}_1})$$

- Need to determine $\frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$ and $\frac{dp_t}{d\bar{i}_1}$, $t \geq 1$
- Disregard $\frac{d\Delta u}{d\bar{i}_1}$ (appendix: negligible, uncertain sign)

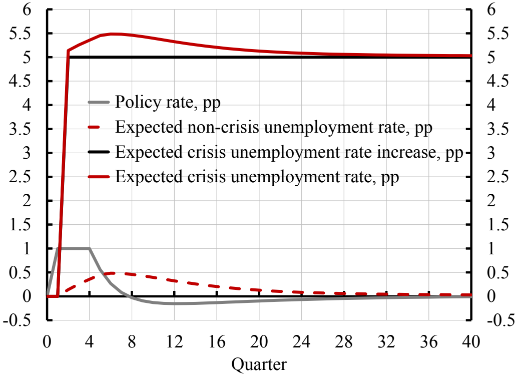
Effect on the expected non-crisis unemployment rate

$\frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$, $t \geq 1$, example and benchmark: Riksbank estimate



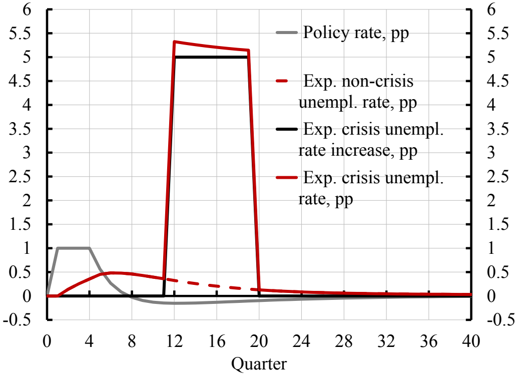
Effect on the expected *crisis* unemployment rate 1

If a crisis happens: $\Delta\bar{i}_1 = 1$, $\mathrm{E}_1 u_t^{\mathrm{c}} = \mathrm{E}_1 u_t^{\mathrm{n}} + \Delta u$



Effect on the expected *crisis* unemployment rate 2

If a crisis happens in quarter 12: $\Delta\bar{i}_1 = 1$, $\mathrm{E}_1 u_t^{\mathrm{c}} = \mathrm{E}_1 u_t^{\mathrm{n}} + \Delta u$



Effect on the probability of a crisis 1

- Schularick and Taylor (2012):
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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

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

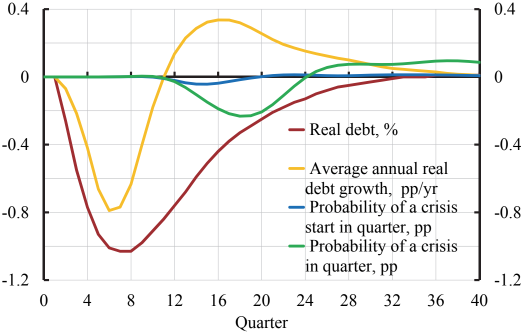
$$X_t = [-3.89] - \underset{(2.110)}{0.398}\, g_{t-4} + \underset{(2.631)}{7.138^{***}}\, g_{t-8} + \underset{(2.948)}{0.888}\, g_{t-12} + \underset{(1.378)}{0.203}\, g_{t-16} + \underset{(1.640)}{1.867}\, g_{t-20}$$

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

d_t real debt, g_t annual growth rate of average annual debt

Effect on probability of a crisis 2

- $\frac{d(d_t)}{d\bar{i}_1}$, $t \geq 1$, example and benchmark: Riksbank estimate



- Determines effects on real debt growth, $\frac{dg_t}{d\bar{i}_1}$,
  on the probability of a crisis start, $\frac{dq_t}{d\bar{i}_1}$, and
  on the probability of a crisis, $\frac{dp_t}{d\bar{i}_1} = \sum_{\tau=0}^{n-1} \frac{dq_t}{d\bar{i}_1}$

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 ($\tilde{u}_t^{\mathrm{n}} \equiv u_t^{\mathrm{n}} - u_t^*$, $\tilde{u}_t^{\mathrm{c}} \equiv u_t^{\mathrm{c}} - u_t^*$)
- Intertemporal (indirect) loss function (relevant loss for $p_t \geq 0$, $t \geq 1$):

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

$$L_t = (\tilde{u}_t)^2$$

- Expected quarter-t loss:

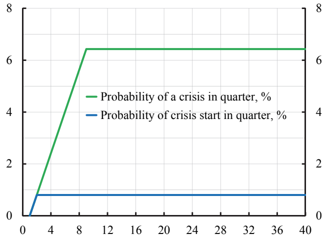
$$\begin{aligned} \mathrm{E}_1 L_t &= (1-p_t)\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t \mathrm{E}_1(\tilde{u}_t^{\mathrm{c}})^2 \\ &= (1-p_t)\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2 \end{aligned}$$

- 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 ($n = 8$):

$$p_t = \begin{cases} 0 & \text{for } t = 1, \\ (t-1)q = (t-1)\,0.8\% > 0 & \text{for } 1 \leq t \leq 8, \\ nq = 6.4\% > 0 & \text{for } t \geq 9. \end{cases}$$



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$$\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 = (\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2 + \mathrm{Var}_1 \tilde{u}_t^{\mathrm{n}}$$

$$\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2 = (\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2 + \mathrm{Var}_1 \tilde{u}_t^{\mathrm{n}}$$

$$\begin{aligned} \mathrm{E}_1 L_t - \mathrm{Var}_1 \tilde{u}_t^{\mathrm{n}} &= (1 - p_t)(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2 + p_t(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2 \\ &= (1 - \bar{p}_t)(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2 + \bar{p}_t(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2 \\ &\quad - (\bar{p}_t - p_t)[(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2 - (\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2] \\ &= \{(1 - \bar{p}_t)(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2 + \bar{p}_t(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2\} \\ &\quad - (\bar{p}_t - p_t)[(\Delta u)^2 + 2\Delta u \mathrm{E}_1 \tilde{u}_t^{\mathrm{n}}] \\ &\equiv \{C_t^{\mathrm{n}} + C_t^{\mathrm{c}}\} - B_t \equiv C_t - B_t \end{aligned}$$

The expected quarter-t loss 2

$$\mathrm{E}_1 L_t - \mathrm{Var}_1 \tilde{u}_t^{\mathrm{n}} = \{(1-\bar{p}_t)(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2 + \bar{p}_t(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + \Delta u)^2\}$$
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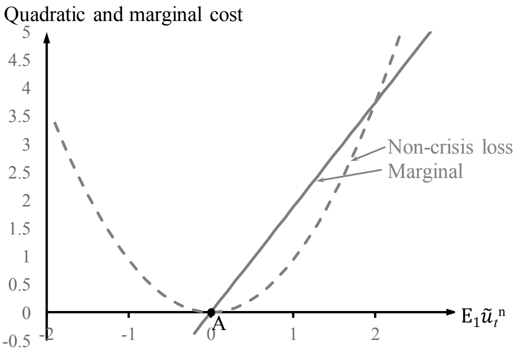
$$\bar{p}_t - p_t = (-dp_t/d\mathrm{E}_1 u_t^{\mathrm{n}})\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} = 0.0085\,\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}},\ \bar{p}_t = 0.064,\ \Delta u = 5$$



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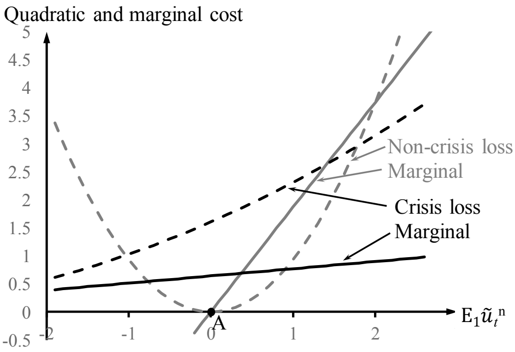

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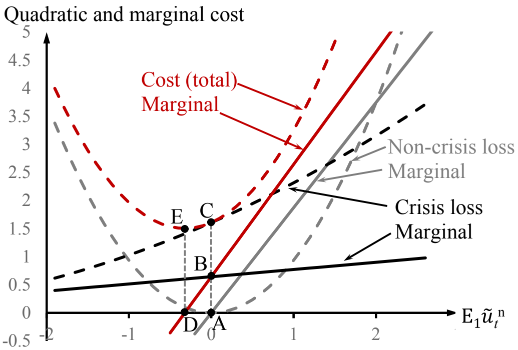

The expected quarter-t loss 5

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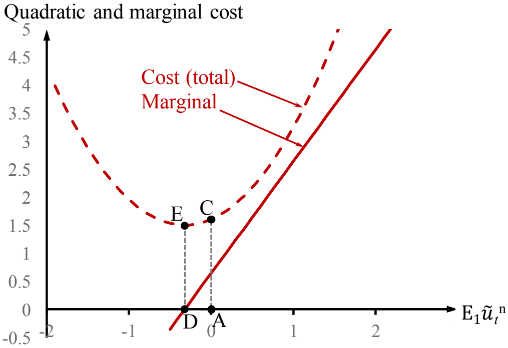

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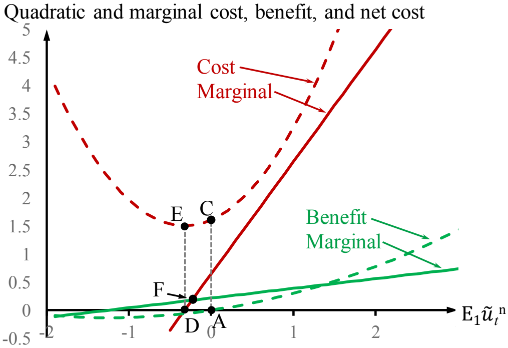
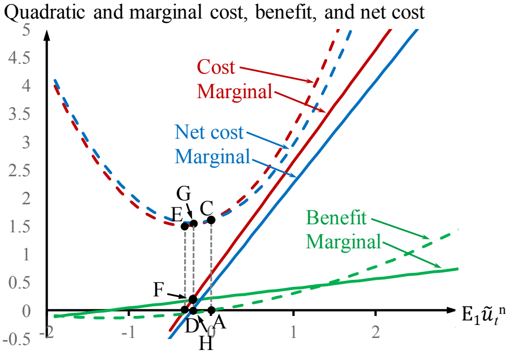


The expected quarter-t loss 7

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

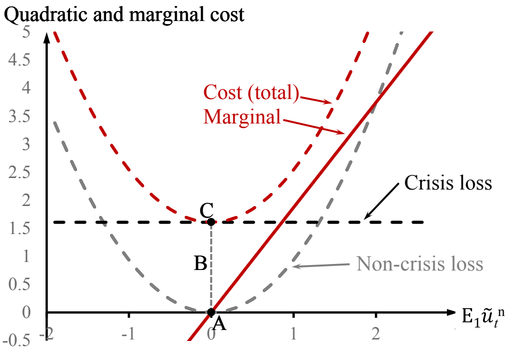
$$\bar{p}_t - p_t = (-dp_t/d\mathrm{E}_1 u_t^{\mathrm{n}})\mathrm{E}_1\tilde{u}_t^{\mathrm{n}} = 0.0085\,\mathrm{E}_1\tilde{u}_t^{\mathrm{n}},\ \bar{p}_t = 0.064,\ \Delta u = 5$$



The expected quarter-t loss, *fixed* cost of a crisis 1

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

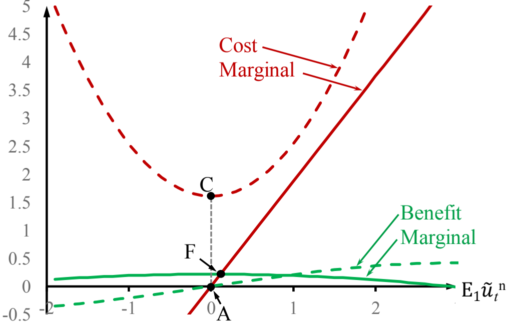
$$\bar{p}_t - p_t = (-dp_t/d\mathrm{E}_1 u_t^{\mathrm{n}})\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} = 0.0085\,\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}},\ \bar{p}_t = 0.064,\ \Delta u = 5$$



The expected quarter-t loss, *fixed* cost of a crisis 2

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

$$\bar{p}_t - p_t = (-dp_t/d\mathrm{E}_1 u_t^{\mathrm{n}})\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} = 0.0085\,\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}},\ \bar{p}_t = 0.064,\ \Delta u = 5$$



The expected quarter-t loss, *fixed* cost of a crisis 3

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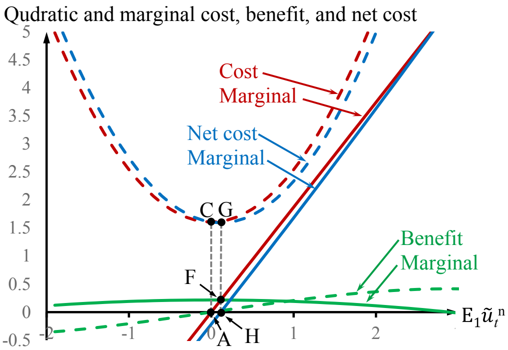


Effect on expected quadratic loss, Net Marginal Cost

$$\begin{aligned} \mathrm{E}_1 L_t &= \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t[\mathrm{E}_1(\tilde{u}_t^{\mathrm{n}} + \Delta u)^2 - \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2] \\ &= \mathrm{E}_1(\tilde{u}_t^{\mathrm{n}})^2 + p_t[(\Delta u)^2 + 2\Delta u \mathrm{E}_1 \tilde{u}_t^{\mathrm{n}}] \end{aligned}$$

- Net Marginal Cost: $\mathrm{NMC}_t \equiv d\mathrm{E}_1 L_t / d\bar{i}_1 =$

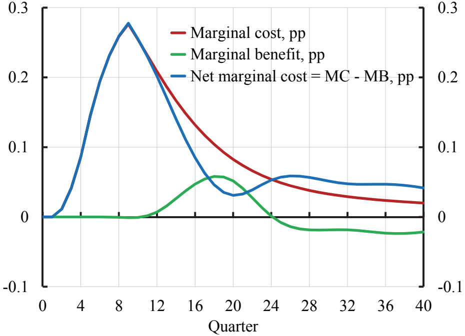
$$\begin{aligned} &= 2\underbrace{[\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} + p_t \Delta u]}_{\mathrm{E}_1 \tilde{u}_t} \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} - \underbrace{[(\Delta u)^2 + 2\Delta u \mathrm{E}_1 \tilde{u}_t^{\mathrm{n}}]}_{\text{Loss increase in crisis}}(-\frac{dp_t}{d\bar{i}_1}) \\ &\equiv \mathrm{MC}_t - \mathrm{MB}_t \end{aligned}$$

- Examine MC_t, MB_t, and NMC_t for $\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} = 0$:

$$\begin{aligned} \mathrm{NMC}_t &= \mathrm{MC}_t - \mathrm{MB}_t \\ &= 2p_t \Delta u \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} - (\Delta u)^2(-\frac{dp_t}{d\bar{i}_1}) \end{aligned}$$

Marginal cost, marginal benefit, and net marginal cost

- $\text{MC}_t = 2p_t \Delta u \frac{d\text{E}_1 u_t^{\text{n}}}{d\bar{i}_1}, \quad \text{MB}_t = (\Delta u)^2 (-\frac{dp_t}{d\bar{i}_1})$
- $\text{NMC}_t = \text{MC}_t - \text{MB}_t$



- Marginal cost dominates over marginal benefit
- Accumulated marginal benefits: $\sum_{t=1}^{40} \text{MB}_t \approx 0$

What if less effective macroprudential policy?

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

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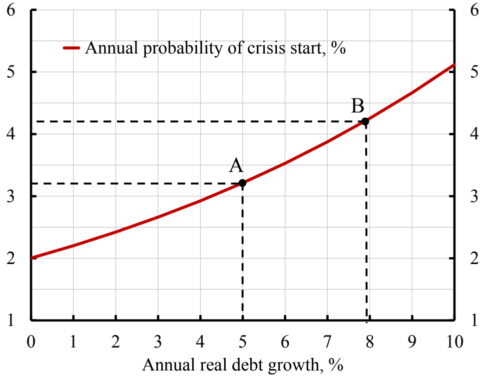
  - Longer duration of crisis, n
- Additional sensitivity analysis

A higher probability of crisis start

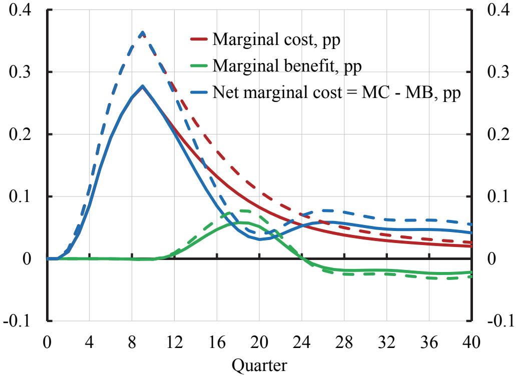
- Increase in annual probability $4q$ from 3.21% to 4.21%



- Increase in steady annual real debt growth from 5% to 7.9%
- dq/dg increases $\Rightarrow \left|dq_t/d\bar{i}_1\right|, \left|dp_t/d\bar{i}_1\right|$ increase

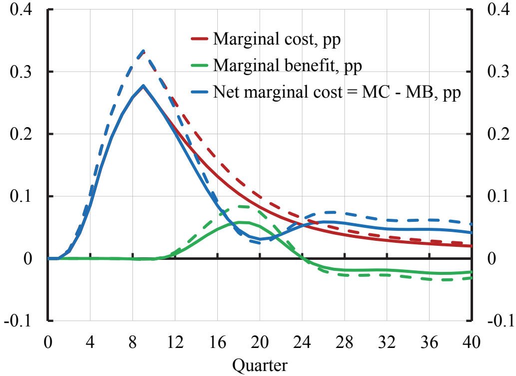
A higher probability of crisis start

- $\mathrm{MC}_t = 2p_t \Delta u \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$, $\mathrm{MB}_t = (\Delta u)^2(-\frac{dp_t}{d\bar{i}_1})$, $\mathrm{NMC}_t = \mathrm{MC}_t - \mathrm{MB}_t$
- Increase in annual probability $4q$ from 3.21% to 4.21% (dashed)



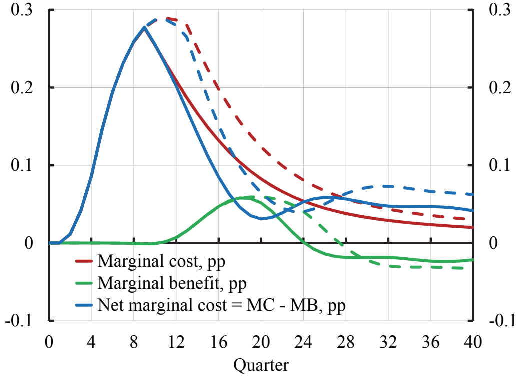
A larger crisis increase in the unemployment rate

- $\mathrm{MC}_t = 2p_t \Delta u \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$, $\mathrm{MB}_t = (\Delta u)^2(-\frac{dp_t}{d\bar{i}_1})$, $\mathrm{NMC}_t = \mathrm{MC}_t - \mathrm{MB}_t$
- Larger Δu, from 5 to 6 percentage points (dashed)



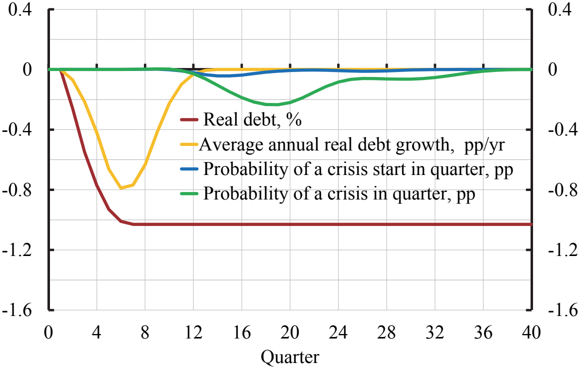
A longer crisis duration

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

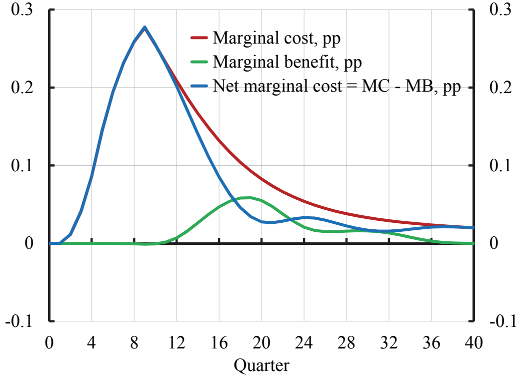
- Real debt stays at its lowest deviation from baseline



- Negative accumulated effect on crisis probabilities

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

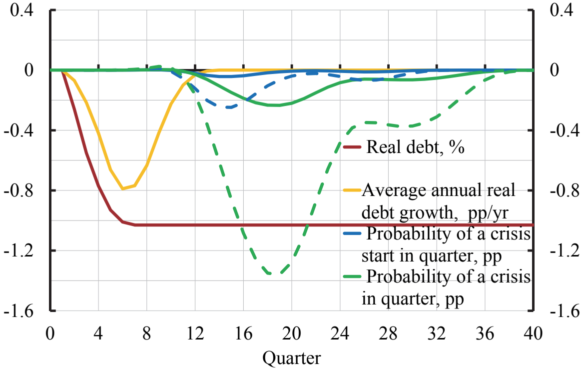
- $\text{MC}_t = 2p_t \Delta u \frac{d\text{E}_1 u_t^{\text{n}}}{d\bar{i}_1}$, $\text{MB}_t = (\Delta u)^2 (-\frac{dp_t}{d\bar{i}_1})$, $\text{NMC}_t = \text{MC}_t - \text{MB}_t$



- Marginal cost still dominates over marginal benefit

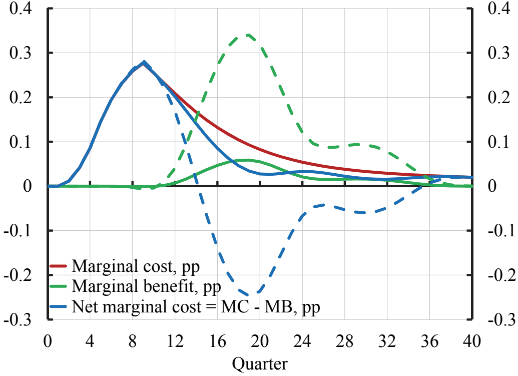
Monetary non-neutrality: Permanent effect on real debt – What is needed for LAW to be justified?

- 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



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: $\sum_{t=1}^{40} \text{NMC}_t = \sum_{t=1}^{40} \text{MC}_t - \sum_{t=1}^{40} \text{MB}_t = 0$



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
- For empirical estimates and channels, effect of LAW on probability of a crisis too small to make marginal benefit exceed marginal cost

Conclusions 2

- 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

Extra slides

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,

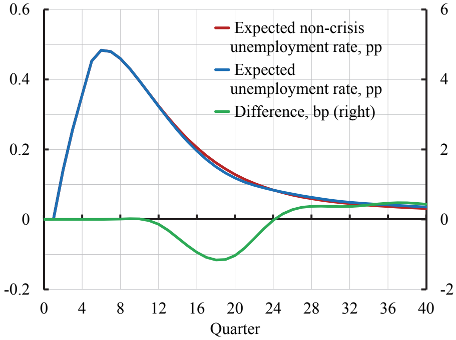
$$\frac{d(d_t)}{d\bar{i}_1} \approx 0 \text{ for } t \geq 40$$

- No accumulated effect on real debt growth, the probability of a crisis start, or the probability of a crisis

$$\sum_{\tau=1}^{40} \frac{dg_t}{d\bar{i}_1} \approx \sum_{\tau=1}^{40} \frac{dq_t}{d\bar{i}_1} \approx \sum_{\tau=1}^{40} \frac{dp_t}{d\bar{i}_1} \approx 0$$

Effect on the expected unemployment rate

$$\frac{d\mathrm{E}_1 u_t}{d\bar{i}_1} = \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} + \frac{dp_t}{d\bar{i}_1}\,\Delta u$$

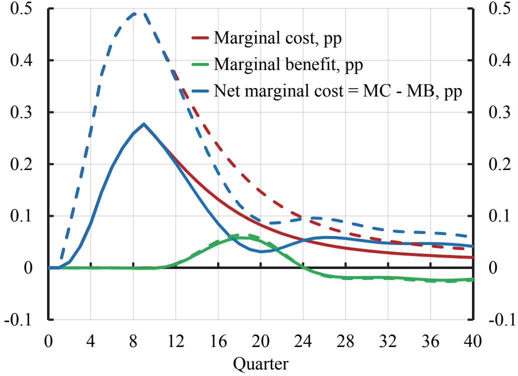


- Effect of reduced probability of crisis negligible (Svensson 2014, 2015), and accumulated effect approximately zero, $\sum_{t=1}^{40} \frac{dp_t}{d\bar{i}_1}\,\Delta u \approx 0$

Sensitivity to initial state of the economy

- $\mathrm{MC}_t = 2[\mathrm{E}_1 \tilde{u}^{\mathrm{n}}_t + p_t \Delta u] \frac{d\mathrm{E}_1 u^{\mathrm{n}}_t}{d\bar{i}_1}$,

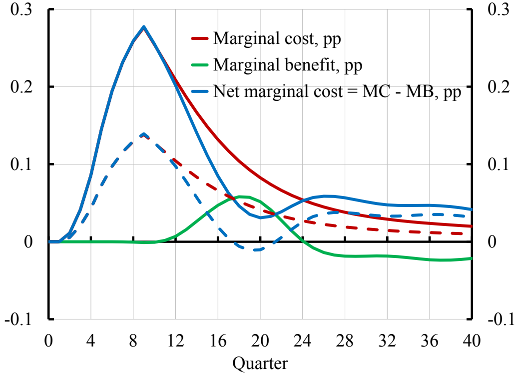
  $\mathrm{MB}_t = [(\Delta u)^2 + 2\Delta u \mathrm{E}_1 \tilde{u}^{\mathrm{n}}_t](-\frac{dp_t}{d\bar{i}_1})$
- Suppose $\mathrm{E}_1 \tilde{u}^{\mathrm{n}}_t = 0.25$ pp > 0 for all $t \geq 1$ (dashed)



- LAW even less justified, also if $\mathrm{E}_1 \tilde{u}^{\mathrm{n}}_t = 0$ for $t \geq 12$

Sensitivity to policy-rate effect on the expected non-crisis unemployment rate

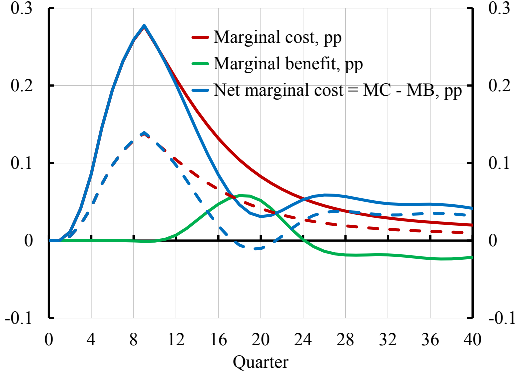
- $\mathrm{MC}_t = 2p_t \Delta u \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$, $\mathrm{MB}_t = (\Delta u)^2 (-\frac{dp_t}{d\bar{i}_1})$.
- Suppose $\frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1}$ is only a half of the benchmark (dashed)



- LAW still not justified

Sensitivity to probability of crisis

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

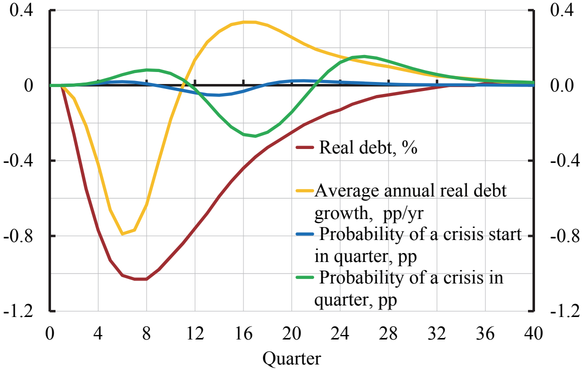
$$q_t = \frac{\exp(X_t)}{1+\exp(X_t)},$$

$$X_t = -\underset{(1.008)}{5.630^{***}} - \underset{(3.171)}{5.650^{*}}\, g_t + \underset{(3.580)}{4.210}\, g_{t-4} + \underset{(5.408)}{12.342^{**}}\, g_{t-8} - \underset{(3.591)}{5.259}\, g_{t-12}.$$

- For 5% annual real debt growth, annual probability of crisis start $4q = 1.89\%$, $q = 0.47\%$:
  A crisis start on average every 53 years

More recent data: Effect on probability of a crisis

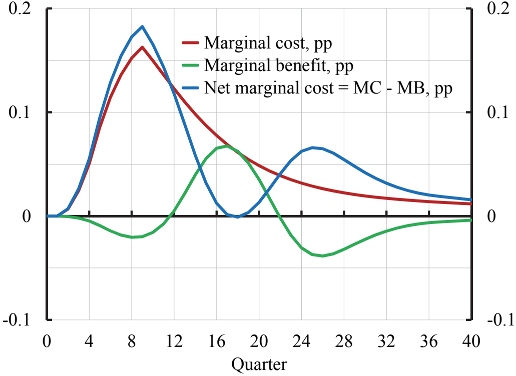
- Riksbank estimate of effect on real household debt, $d(d_t)/d\bar{i}_1$



- Gives effects on real debt growth, $dg_t/d\bar{i}_1$, probability of a crisis start, $dq_t/d\bar{i}_1$, and probability of a crisis, $dp_t/d\bar{i}_1 = \sum_{\tau=0}^{n-1} dq_t/d\bar{i}_1$

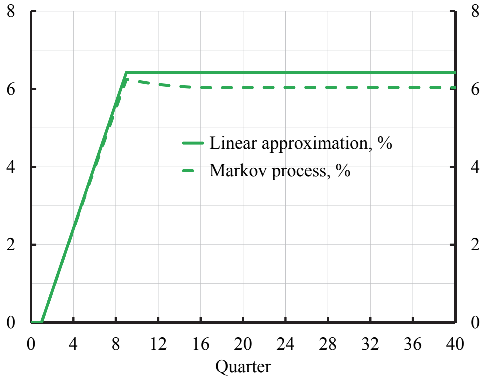
Marginal cost, marginal benefit, and net marginal cost

- More fluctuation in Marginal Benefit, goes to zero at $t = 40$, else similar, no accumulated effect on Marginal Benefits



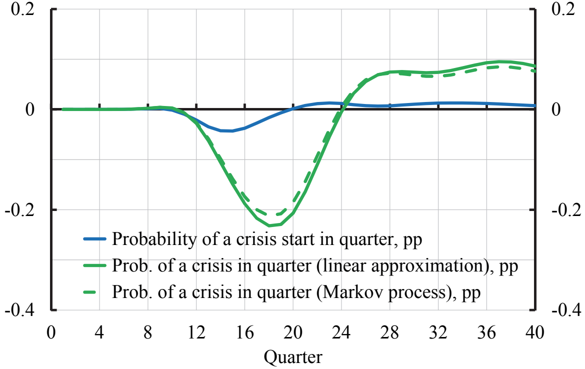
Linear approximation and Markov process

- Probability of a crisis, p_t, $t \geq 1$, conditional on no crisis in quarter 1, $p_1 = 0$



Linear approximation and Markov process

- Effect of policy rate on probability of crisis, $\frac{dp_t}{d\bar{i}_1}$, $t \geq 1$



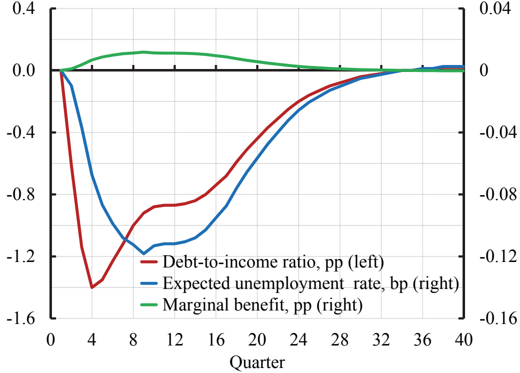
Effect on the crisis increase in the unemployment rate

$$\frac{d\mathrm{E}_1 u_t}{d\bar{i}_1} = \frac{d\mathrm{E}_1 u_t^{\mathrm{n}}}{d\bar{i}_1} + \Delta u \frac{dp_t}{d\bar{i}_1} + \overbrace{p_t \frac{d\Delta u}{d\bar{i}_1}}^{\text{Additional term}}$$

$$\mathrm{MB}_t = (\Delta u)^2 \left(-\frac{dp_t}{d\bar{i}_1}\right) + \underbrace{2 p_t \Delta u \left(-\frac{d\Delta u}{d\bar{i}_1}\right)}_{\text{Additional term}}$$

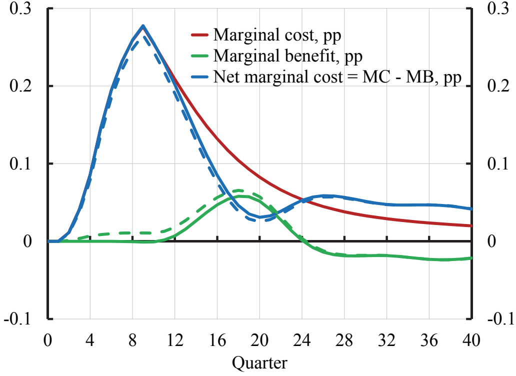
Effect on crisis increase in unemployment rate

- 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 $E_1 u_t$: $p_t \frac{d\Delta u}{d\bar{i}_1}$. Effect on MB_t: $2p_t \Delta u(-\frac{d\Delta u}{d\bar{i}_1})$



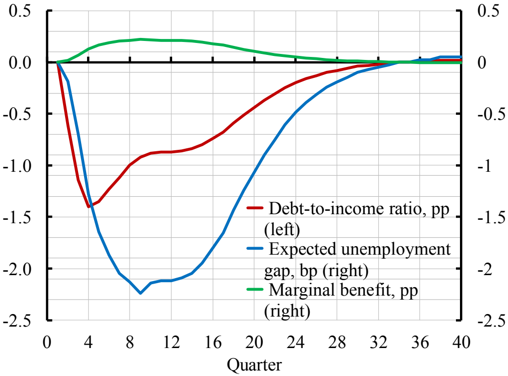
Effect on crisis increase in unemployment rate

- 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 Δu is needed to break even?
- $d\Delta u / d\bar{i}_1$ must be about 19 times larger: $(0.3786/0.02 = 18.93)$



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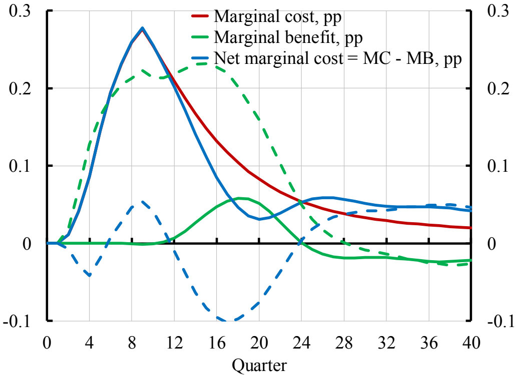
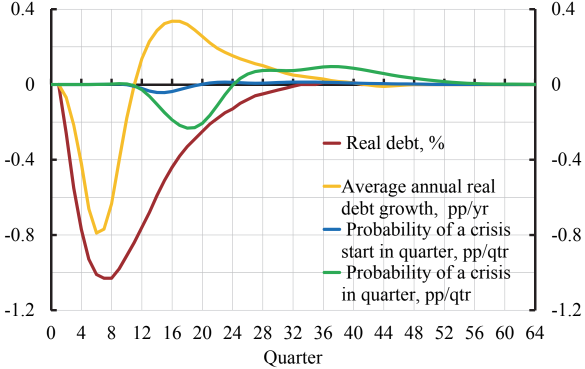


Longer horizon: MC, MB, and NMC



Alternative assumption: Fixed cost of a crisis

- Crisis unemployment rate:
  $u_t^{\mathrm{c}} = \Delta u > 0$ instead of $u_t^{\mathrm{c}} = u_t^{\mathrm{n}} + \Delta u$
- Expected quarter t-loss

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

- Net marginal cost: $\mathrm{NMC}_t \equiv \frac{d\mathrm{E}_1 L_t}{d\bar{i}_1}$

$$= (1 - p_t) 2\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} \frac{d\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}}}{d\bar{i}_1} - [(\Delta u)^2 - (\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}})^2](-\frac{dp_t}{d\bar{i}_1})$$

$$\equiv \mathrm{MC}_t - \mathrm{MB}_t$$

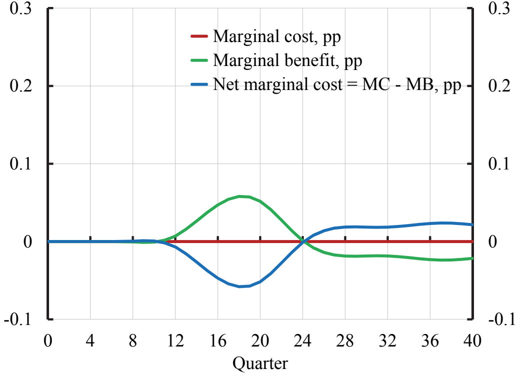
- For $\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}} = 0$,

$$\mathrm{MC}_t = 0$$

$$\mathrm{MB}_t = (\Delta u)^2(-\frac{dp_t}{d\bar{i}_1})$$

Fixed cost of a crisis

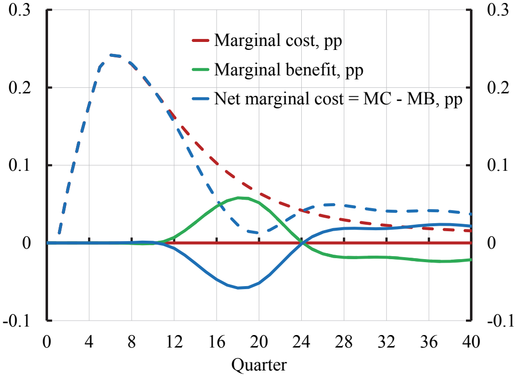
$$\mathrm{MC}_t = 0, \quad \mathrm{MB}_t = (\Delta u)^2 \left(-\frac{dp_t}{d\bar{i}_1}\right)$$



- Some (small) LAW justified (Ajello et al.), *if* horizon not too long (cf. 24 qtrs)

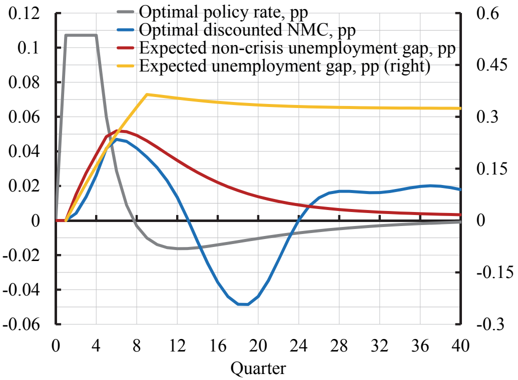
Fixed cost of a crisis: Small initial u gap

- Small initial positive expected non-crisis unemployment gap: $E_1 \tilde{u}_t^n = 0.25$ pp for $t \geq 1$



Fixed cost of a crisis, short horizon: Optimal LAW 1

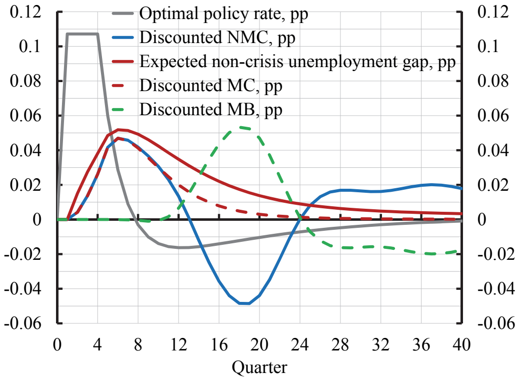
- "Optimal" LAW very small, even if horizon = 24 qtrs (Ajello et al.)



- $\Delta \bar{i}_1 = 0.11$pp: $\max(\mathrm{E}_1 \tilde{u}_t^{\mathrm{n}}) = 0.05$ pp; $\max(-\Delta p_t) = 0.025$ pp (from $p_t = 6.4$ pp); reduction in loss 0.07%

Fixed cost of a crisis, short horizon: Optimal LAW 2

- "Optimal" LAW very small, even if horizon = 24 qtrs (Ajello et al.)



- $\Delta\bar{i}_1 = 0.11$pp: $\max(\mathrm{E}_1\tilde{u}_t^{\mathrm{n}}) = 0.05$ pp; $\max(-\Delta p_t) = 0.025$ pp (from $p_t = 6.4$ pp); reduction in loss 0.07%

A constrained-optimal policy