On the Negatives of Negative Interest Rates and the Positives of Exemption Thresholds

Work in Progress

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Research question

- How do negative interest rates (NIR) affect:
  - investment decisions of commercial banks?
  - commercial bank profitability?
  - welfare?

- How do exemptions from NIR interact with these results?
Implementation of NIR
Denmark, Euro Area, Japan, Sweden, Switzerland

- Introduction of NIR to increase inflation, economic activity or due to exchange rate considerations.
- In almost all cases, part of the reserves are exempt from NIR.
- Exemptions are due to bank profitability concerns or legal/operational issues.
- Exemptions vary across CBs.
- NIR vary across CB’s from −0.1% (BOJ) to −0.75% (DN, SNB).
Perfect transmission of NIR to money market rates for any (binding) exemption.

Transmission of NIR to deposit rates is key for the effects on investment and welfare.
  ▶ Investments will depend on wedge $i_d - i_n$.

Main message:
  ▶ NIR distorts investment decisions.
  ▶ Negative effects on welfare.
  ▶ Exemptions reduce negative impact of NIR on bank profitability.
The theoretical model closely follows Berentsen, Marchesiani, and Waller 2014 and Berentsen, Kraenzlin, and Müller 2018.

- Time is discrete and continues forever.
- The discount factor across periods is $\beta = (1 + r)^{-1}$.
- Unit measure of two types of infinitely lived agents: Banks and households.
- Medium of exchange: Reserves
- Two sub-periods: a settlement market and an investment-money (IM) market.
Banks receive an i.i.d. idiosyncratic investment shock $\varepsilon$ with distribution $G(\varepsilon)$ and support $[0, \infty]$.

Return $f(\varepsilon, k) = \varepsilon^{1/\alpha} \frac{k^{1-1/\alpha}}{1-1/\alpha}$ from investing $k$ units of capital.

Households produce $k$ at cost $c(k) = k$. 
First-best allocation:

\[ f'(\varepsilon, k_{\varepsilon}) = 1. \]

Solving for \( k_{\varepsilon} \) yields \( k_{\varepsilon}^* = \varepsilon \).
The central bank
▶ issues reserves,
▶ chooses the exemption threshold $\bar{m}$,
▶ and chooses the interest rates $i_p$ and $i_n$ with $i_p \geq i_n$.

A bank with $\hat{m}_\epsilon$ units of reserves at the end of the IM market faces
the following interest rate payments:

$$
\begin{align*}
&i_p \hat{m}_\epsilon, \text{ if } \hat{m}_\epsilon \leq \bar{m} \\
i_p \bar{m} + i_n (\hat{m}_\epsilon - \bar{m}), \text{ if } \hat{m}_\epsilon \geq \bar{m}.
\end{align*}
$$

(1)
Banks purchase capital from households at price $p$.

Households deposit their earnings at accounts held with banks at interest rate $i_d$.

Each household produces the same amount and each bank has the same customer base.
Banks with high ε-shocks can borrow money from banks with low ε-shocks:

- Borrow to spend on capital or to deposit at the central bank at interest rate $i_p$.

Banks need collateral to borrow in the money market.

- A fraction $\theta$ of reserve inflow at the end of the IM.
- A fraction $\sigma$ of reserves held at the central bank.
Agents repay their loans/deposits and readjust their portfolio.

Agents receive utility $x$ from consuming $x$ units of the consumption good.

Agents can work $h$ hours at disutility $h$.

Price of consumption good $P^x = 1/\phi$. 
**Result: Perfect transmission to $i_m$**

<table>
<thead>
<tr>
<th>Perfect transmission to money market rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full pass through of the policy rate $i_n$ to the money market rate $i_m$ if $\bar{m} &lt; m$ and $i_n$ is not too low.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implication</th>
</tr>
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<tbody>
<tr>
<td>▶ The central bank is able to perfectly control the money market rate without affecting bank profitability by setting $\bar{m} \rightarrow m$.</td>
</tr>
<tr>
<td>▶ The interest rate $i_p$ does not affect investment decisions.</td>
</tr>
</tbody>
</table>
The quantities invested satisfy

\[ k_\varepsilon = \varepsilon \left( \frac{\rho_n}{\rho_d} \right)^\alpha, \quad \text{if } 0 \leq \varepsilon \leq \varepsilon' \]

\[ k_\varepsilon = \varepsilon' \left( \frac{\rho_n}{\rho_d} \right)^\alpha \quad \text{if } \varepsilon \geq \varepsilon'. \]
Result: Wedge $i_d - i_n$ is key

- Wedge

\[ i_d - i_n \]

is key for the effects of NIR on investment and welfare.

- We use the following labels:
  - Perfect transmission: $i_d = i_n$.
  - Imperfect transmission: $i_d > i_n$ (NIR countries).
  - Imperfect transmission: $i_d < i_n$ (US Case).
Perfect transmission: $i_n = i_d$
Perfect transmission: \( i_n = i_d \)

\[
\left( \frac{1+i_d}{1+i_m} \right)^\alpha
\]
Imperfect transmission: $i_n < i_d$ (NIR)
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Imperfect transmission: $i_n < i_d$ (NIR)

\[ \left( \frac{1 + i_d}{1 + i_m} \right)^\alpha \]
Imperfect transmission: $i_n < i_d$ (NIR)

- Several observations of limited transmission to deposit rates during NIR periods:

- Observations of high investment for instance in real estate in Switzerland:
  - Both the SNB and the FINMA have stated that there are tendencies to overheat in the Swiss real estate market (10. FINMA Jahreskonferenz, April 2019, SNB Monetary Policy Assessment, June 2019).
Welfare effects of lowering $i_n$

Welfare satisfies

\[(1 - \beta)W = \int_0^\infty \left[ \varepsilon^{(1/\alpha)} f(k_\varepsilon) - k_\varepsilon \right] dG. \quad (3)\]

\[\frac{d(1 - \beta)W}{d\rho_n} = A + B + C\]

where

\[A \equiv \rho_d \int_0^{\varepsilon'} [i_n - i_d] \frac{dk_\varepsilon}{d\rho_n} dG,\]

\[B \equiv \int_{\varepsilon'}^{\hat{\varepsilon}} \left[ (\varepsilon/\hat{\varepsilon})^{1/\alpha} - 1 \right] \frac{d\hat{\varepsilon}}{d\rho_n} dG,\]

\[C \equiv \int_{\hat{\varepsilon}}^\infty \left[ (\varepsilon/\hat{\varepsilon})^{1/\alpha} - 1 \right] \frac{d\hat{\varepsilon}}{d\rho_n} dG.\]
Imperfect transmission: IC $i_n = i_d$

$$\frac{d(1 - \beta) \mathcal{W}}{d \rho_n} = A + B + C$$
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Imperfect transmission: IC \( i_n = i_d \)

\[
\frac{d(1 - \beta)W}{d\rho_n} = A + B + C
\]
Imperfect transmission: IC $i_n = i_d$

$$\frac{d(1 - \beta)\mathcal{W}}{d\rho_n} = A + B + C < 0 : A < 0, B = 0, C < 0$$
Imperfect transmission: $i_n < i_d \ (\text{NIR})$

$$\frac{d(1 - \beta)\mathcal{W}}{d\rho_n} = A + B + C$$
Imperfect transmission: $i_n < i_d$ (NIR)

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Imperfect transmission: $i_n < i_d$ (NIR)

$$\frac{d(1 - \beta) \mathcal{W}}{d \rho_n} = A + B + C : A < 0, B > 0, C < 0$$

\[ k_{\varepsilon} \]

\[ \varepsilon'' \quad \varepsilon' \quad \varepsilon \]

45°
Welfare effects

**Negative welfare effects**

A decrease in $i_n$ unambiguously lowers welfare in all cases.
Conclusion

1. Perfect transmission of NIR to money market rates for any (binding) exemption.

2. Transmission of NIR to deposit rates is key for the effects on investment and welfare.
   ▶ Investments depend on wedge $i_d - i_n$.

3. Main message:
   ▶ NIR distorts investment decisions.
   ▶ Negative effects on welfare.
   ▶ Exemptions reduce negative impact of NIR on bank profitability.
Thank you for your attention


## Implementation of NIR

<table>
<thead>
<tr>
<th>As of 13 September 2019</th>
<th>Exemptions</th>
<th>Interest rates</th>
<th>Degree of transmission</th>
<th>Objective of NIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank of Japan</td>
<td>Yes</td>
<td>0.1%, 0%, -0.1%</td>
<td>Partial transmission</td>
<td>Inflation and economic activity</td>
</tr>
<tr>
<td>Danmarks Nationalbank</td>
<td>Yes</td>
<td>0%, -0.65%</td>
<td>Partial transmission</td>
<td>Exchange rate considerations</td>
</tr>
<tr>
<td>European Central Bank</td>
<td>Yes</td>
<td>0%, -0.5%</td>
<td>Partial transmission</td>
<td>Inflation</td>
</tr>
<tr>
<td>Swedish Riksbank</td>
<td>No</td>
<td>0%, -0.1%</td>
<td>Partial transmission</td>
<td>Inflation</td>
</tr>
<tr>
<td>Swiss National Bank</td>
<td>Yes</td>
<td>0%, -0.75%</td>
<td>Partial transmission</td>
<td>Exchange rate considerations</td>
</tr>
</tbody>
</table>

**Table:** Implementation of NIR across CB
The value function of a household at the beginning of the settlement market is

\[ W_S(\hat{d}) = \max_{d \geq 0} \{ -\gamma d + \beta W_{IM}(d) \} + \hat{d}/\rho_d + \tau_H. \]

FOC:

\[ -\gamma + \beta W_{IM}^d(d) \geq 0, \quad \text{with equality if } d > 0. \]
The value function of a bank at the beginning of the settlement market is

\[
V_S(\hat{m}, \hat{z}, \hat{d}) = \max_{m \geq 0} \left\{ \gamma(m - d) + \beta \int_{0}^{\infty} V_{IM}(m, d|\varepsilon) dG \right\} - \frac{\hat{d}}{\rho_d} - \frac{\hat{z}}{\rho_m} + \min\{\hat{m}, \bar{m}\}/\rho_p + \max\{\hat{m} - \bar{m}, 0\}/\rho_n + \tau_B.
\]

FOC:

\[
0 \leq -\gamma + \beta \int_{0}^{\infty} V_{IM}^m(m, d|\varepsilon) dG, \quad \text{with equality if } m > 0.
\]
The value function of a household at the beginning of the IM market is

\[ W_{IM}(d) = \max_{k_s \geq 0} \left\{ -k_s + \left[ pk_s + d \right]/\rho_d \right\} + W_S(0). \]

**FOC:**

\[ p = \rho_d. \]
The value function of a bank at the beginning of the IM market is

\[
V_{IM}(m, d | \varepsilon) = \max_{k_\varepsilon, m_\varepsilon} \left\{ \varepsilon^{1/\alpha} \frac{k_\varepsilon^{1-1/\alpha}}{1-1/\alpha} + V_S(0) - \frac{d + pk_s}{\rho_d} \right. \\
\left. - \frac{m_\varepsilon + pk_\varepsilon - m}{\rho_m} + \frac{\min\{m_\varepsilon + pk_s, \bar{m}\}}{\rho_p} \right. \\
\left. + \frac{\max\{m_\varepsilon + pk_s - \bar{m}, 0\}}{\rho_n} \right\},
\]

s.t. \[ pk_\varepsilon + m_\varepsilon (1 - \sigma) - m \leq \theta pk_s, \]
\[ m_\varepsilon \geq 0. \]
The model

IM market

The first-order conditions are:

\[ k_\varepsilon : \quad 0 = (\varepsilon / k_\varepsilon)^{1/\alpha} - p(1/\rho_m + \lambda_\varepsilon) \]  \hspace{1cm} (4)

\[ m_\varepsilon : \quad 0 \geq -1/\rho_m + I_+/\rho_n + (1 - I_+)/\rho_p - (1 - \sigma)\lambda_\varepsilon + \mu_\varepsilon \]  \hspace{1cm} (5)

\[ 0 \leq -1/\rho_m + I_-/\rho_n + (1 - I_-)/\rho_p - (1 - \sigma)\lambda_\varepsilon + \mu_\varepsilon \]  \hspace{1cm} (6)
The amount of reserves carried out of the IM market, $m_\varepsilon$ satisfies

$$m_\varepsilon \leq \begin{cases} \bar{m}' & \text{if } i_n < i_m \leq i_p \\ 0 & \text{if } i_m > i_p \geq i_n \end{cases} \quad \text{and} \quad m_\varepsilon \geq \begin{cases} \bar{m}' & \text{if } i_n \leq i_m < i_p \\ 0 & \text{if } i_m \geq i_p \geq i_n \end{cases}.$$
We focus on symmetric stationary equilibria with strictly positive demand for reserves and a positive initial stock of reserves, $M_0$. Market clearing requires

$$k_s = \int_0^\infty k_\varepsilon dG(\varepsilon). \quad (7)$$

and

$$m = \int_0^\infty m_\varepsilon dG(\varepsilon) + pk_s. \quad (8)$$
A symmetric stationary equilibrium with a positive demand for reserves is a policy \((\bar{m}, \rho_n, \rho_p)\) and endogenous variables \((\varepsilon', \rho_m)\) satisfying Equations (8) and

\[
\frac{\gamma \rho_n}{\beta} = \int_{0}^{\varepsilon'} \text{d}G + \int_{\varepsilon'}^{\infty} (\varepsilon/\varepsilon')^{1/\alpha} \text{d}G. \tag{9}
\]

with \(\rho_m = \rho_n\).
Imperfect transmission: \( i_n > i_d \) (US)
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Imperfect transmission: $i_n > i_d$ (US)

Figure: U.S Interest Rates (Andolfatto (2018))
Perfect transmission

\[
\frac{d(1 - \beta)\mathcal{W}}{d\rho_n} = A + B + C
\]
Perfect transmission

\[ \frac{d(1 - \beta) \mathcal{W}}{d \rho_n} = A + B + C \]
Perfect transmission

\[ \frac{d(1 - \beta)W}{d\rho_n} = A + B + C = C < 0 \]
Imperfect transmission: $i_n > i_d$ (US)

$$\frac{d(1 - \beta)\mathcal{W}}{d\rho_n} = A + B + C$$
Imperfect transmission: \( i_n > i_d \) (US)

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$$\frac{d(1 - \beta)W}{d\rho_n} = A + B + C : A > 0, B = 0, C < 0$$