CONTENTS

Macroprudential Policy and Financial (In)Stability Analysis in the Russian Federation
Mikhail Andreev, Udara Peiris, Aleksandr Shirobokov, Dimitrios Tsomocos

Commodity and Financial Cycles in Resource-based Economies
Marina Tiunova

The Impact of Inflation Anchor Strength and Monetary Policy Transparency on Inflation During the Period of Emerging Market Volatility in Summer 2018
Tatiana Evdokimova, Grigory Zhirnov, Inge Klaver

Review of Bank of Russia Conference on ‘Macroprudential Policy Effectiveness: Theory and Practice’
Nadezhda Ivanova, Mikhail Andreev, Andrey Sinyakov, Ivan Shevchuk

Estimating a Cagan-type Demand Function for Gold: 1561–1913
Alexei Deviatov
XXI APRIL INTERNATIONAL ACADEMIC CONFERENCE ON ECONOMIC AND SOCIAL DEVELOPMENT

CALL FOR PAPERS

On 6–10 April 2020 in Moscow, the National Research University Higher School of Economics (HSE University), with the support of the World Bank, will be hosting the XXI April International Academic Conference on Economic and Social Development.

The committee will be chaired by Professor Evgeny Yasin, HSE University's academic supervisor.

Detailed information will be published on the Conference website conf.hse.ru

Papers presented at the Conference should contain the results of original Research using an up-to-date research methodology. The Conference programme will be developed based on accepted proposals.

- Submit the proposal through HSE University's online system from 9 September to 15 November 2019 (the link will become available later).
- Online registration to attend the Conference (without a presentation) will be open until 20 March 2019.
- A group of authors, each individually registered on the Conference system, may request permission from the Programme Committee to present their reports in one session. To do so, they must complete the form on the Conference website by 15 November 2019.
- Programme Committee's decision on whether to accept papers will be made by 24 January 2020, based on the reviews conducted by independent experts. Preliminary programme will be available on the Conference website.
- Scholars whose papers are included in the programme must confirm their participation through their personal account in the HSE University system by 10 February 2020 (otherwise, their paper will be excluded from the programme) and provide slides of their presentation in English by 13 March 2020 for publication on the Conference website.

Information about participation fees, payment deadlines and procedures will be available in the respective section of the Conference website.

Conference Organizing Committee
(Contact: interconf@hse.ru)

Information about previous conferences can be viewed here: https://conf.hse.ru/2019/
CONTENTS

Financial Stability

Macroprudential Policy and Financial (In)Stability Analysis in the Russian Federation
  Mikhail Andreev, Udara Peiris, Aleksandr Shirobokov, Dimitrios Tsomocos ............................................................ 3

Commodity and Financial Cycles in Resource-based Economies
  Marina Tiunova ................................................................................................................................................................. 38

Inflation Targeting

The Impact of Inflation Anchor Strength and Monetary Policy Transparency on Inflation During the Period of Emerging Market Volatility in Summer 2018
  Tatiana Evdokimova, Grigory Zhirnov, Inge Klaver................................................................. 71

Conference Review

Review of Bank of Russia Conference on ‘Macroprudential Policy Effectiveness: Theory and Practice’
  Nadezhda Ivanova, Mikhail Andreev, Andrey Sinyakov, Ivan Shevchuk ....................................................................... 89

History of Money

Estimating a Cagan-type Demand Function for Gold: 1561–1913
  Alexei Deviatov ................................................................................................................................................................. 122

All the articles are freely available at: rjmf.econs.online/en
The Russian Journal of Money and Finance
is a scholarly peer-reviewed journal published by the Bank of Russia.
Since 2018 it is issued quarterly both in Russian and in English.

The Journal was established in 1938
(from the middle of 1941 to the end of 1945 was not published).

The Journal is included in the list of leading scientific journals
of the Higher Attestation Commission and in the Web of Science – RSCI.

Submission guideline:
rjmf.econs.online/en/information;
rjmf.econs.online/en
Macroprudential Policy and Financial (In)Stability Analysis in the Russian Federation

Mikhail Andreev, Bank of Russia
andreevmyu@cbr.ru
M. Udara Peiris, National Research University Higher School of Economics
upeiris@hse.ru
Aleksandr Shirobokov, National Research University Higher School of Economics
ashirobokov@hse.ru
Dimitrios P. Tsomocos, Saïd Business School and St Edmund Hall, University of Oxford; National Research University Higher School of Economics
dimitrios.tsomocos@sbs.ox.ac.uk

We study a small open economy New Keynesian model calibrated to the Russian economy with a banking system that trades secured and unsecured debt. Firms endogenously default on their unsecured debt obligations over the business cycle. We examine the effectiveness of four alternative countercyclical policies that respond to the growth in unsecured credit in the economy. The lean-against-the-wind monetary policy is the most effective in simultaneously affecting the real economy and stabilizing the banking system in response to both oil price and total factor productivity shocks. The countercyclical deposit reserve requirement was found to play a stabilizing role following an oil shock, while the countercyclical capital adequacy requirement helped to stabilize the banking system after a total factor productivity shock.

Keywords: business cycles, small open economy, emerging markets, commodity prices, financial stability, macroprudential policy, Russian economy

JEL Codes: F34, G15, G18

doi: 10.31477/rjmf.201903.03

1 We would like to thank the participants in the 2019 Bank of Russia International Research Conference ‘Macroprudential Policy Effectiveness: Theory and Practice’, Bank for International Settlements 12th Annual Workshop of the Asian Research Network at the Reserve Bank of Australia, 2019 Surrey DSGE workshop, and 2nd HSE ILMA workshop, as well as Anthony Brassil, Valery Charnavoki, Mikhail Dmitriev, Vasco Gabriel, Christian Julliard, Madina Karamysheva, Christoffer Koch, Nikos Kokonas, Paul Levine, Oxana Malakhovskaya, Juan Francisco Martinez, Maxim Nikitin, Sergey Pekarskii, Assaf Razin, Sergey Seleznev, Danil Shestakov, Andrey Sinyakov, Konstantin Styrin, Kieran Walsh, an anonymous referee, and especially Ekaterina Kazakova. The contribution of Peiris, Shirobokov, and Tsomocos to this study was funded by the Basic Research Program at the National Research University Higher School of Economics (HSE) and by the Russian Academic Excellence Project 5-100.
1. Introduction

The optimal interaction between macroprudential and monetary policies still remains an important challenge globally for policy. In Russia, the economic difficulties from late 2014 onward have heightened the need to complement existing monetary and microprudential tools with additional policies, that can help stabilize the financial system. In this paper, we study the impact of various candidate macroprudential policies within a New Keynesian model with a banking system and where default on unsecured debt amplifies the business cycle effect of shocks. We find that a monetary policy that leans-against-the-wind (LAW) in reacting to unsecured credit growth can dampen the effects of commodity price shocks.

We study a small open commodity-exporting New Keynesian DSGE model with price and wage rigidities, firms, and banks which are subject to capital requirements. Firms issue secured and unsecured debt in the model, and can renegotiate their unsecured debt obligations to obtain a haircut (default) from the banks. Firms’ default rates vary endogenously over the business cycle. Macroprudential policy addresses the pecuniary externalities resulting from binding collateral constraints and defaults on unsecured debt. Two-period lived risk-averse banks combine household deposits with equity received from households and extend secured and unsecured loans to firms. Banks are subject to microprudential regulation in the form of capital adequacy ratios.

The significance of unsecured credit in Russia is reflected in the importance of credit lines as a source of liquidity for firms and loans to early-stage firms which have limited collateral. Table 6 in the Appendix (see p. 37) displays point estimates for different types of loans. According to this partial data only 17–18% of corporate loans have real estate as collateral. 56–75% of loans are uncollateralized or have financial collateral. The importance of ‘risky’ borrowers in evaluations of financial stability was central to the policy debate in the US following the crisis of 2007–2008. Aikman et al. (2019) describe how the aggregate loan-to-value (LTV) ratio on mortgages remained stable in the years leading up to the US crisis, but with an increase in the concentration of debt among riskier borrowers, while debt build-up among heavily indebted borrowers was not being adequately picked up (see Eichner et al., 2013).

Our closest methodological precursors are Peiris and Tsomocos (2015), De Walque et al. (2010), Goodhart et al. (2018), and Walsh (2016). In the latter two papers, the marginal cost of default depends on the debt-to-capital ratio and the level of wealth respectively, so the propensity to default depends on business cycle fluctuations. We follow this notion here by introducing a macro-variable that governs the marginal cost of renegotiating debt (default), termed

\[ \text{2 We were able to obtain information on this for only two of the 12 largest Russian banks.} \]
‘credit conditions’. This reflects the changing motivations and incentives of debtors to make the necessary sacrifices to repay their obligations, as emphasized by Roch and Uhlig (2016). We introduce optimizing banks subject to regulatory requirements along the lines of Tsomocos (2003) and Martinez and Tsomocos (2018).

Nachane et al. (2006), Ghosh (2008), Gavalas (2015), and Gambacorta and Shin (2016) show that the more restrictive its rules (in particular, capital requirements), the greater contractionary effect a monetary policy may have. However, strict macroprudential regulation may have the opposite effect on banks’ risk-taking. Gale (2010) suggests that excessively restrictive capital requirements may encourage banks to take higher risks in order to earn higher expected profits. In this case, when monetary authorities increase interest rates, this may not have a contractionary effect on the credit market, and banks will form highly risky loan portfolios as the costs of funding increase. As a result, defaults by risky firms may create financial instability.3

In Section 3.4 we turn to candidate macroprudential policy tools that aim to stabilize the economy. We consider LAW, deposit requirements, capital adequacy, and LTV policies that rely on the deviation of unsecured loans from steady state. In line with Cúrdia and Woodford (2010) and Gourio et al. (2018), among others, we show that a LAW policy can potentially mitigate the effect of shocks to the international oil price and total factor productivity (TFP). We also show that a countercyclical deposit reserve requirement, like a liquidity prudential requirement, may be helpful following an oil price shock (for the potential benefits of liquidity prudential requirements see Berben et al., 2010), while a countercyclical LTV policy may be useful following a TFP shock.

As far as studies on Russia are concerned, our paper is closely related to Kozlovcteva et al. (2019), which extends the model of Kreptsev and Seleznev (2017) to study various monetary policy rules and finds that LAW monetary policy serves to stabilize output. The authors show that, when oil price volatility is relatively high and the monetary authority is tending towards minimizing variation in GDP, inflation, and the credit-to-GDP ratio, then a LAW policy is preferable. However, if oil price volatility is relatively small and smoothing the credit cycle is not currently a goal, then a LAW policy does not perform well. The authors also indicate that, under countercyclical fiscal policies, there is a significant reduction in the efficiency gap between inflation targeting and LAW monetary policy in macroeconomic stabilization. Whereas Kozlovcteva et al. (2019) use total credit to GDP in the Taylor Rule, we use the level of unsecured credit. We use unsecured credit because it is a better

3 It is also worth noting that it is not only macroprudential regulation that has an impact on the monetary transmission mechanism. According to Borio and Zhu (2012) and de Moraes et al. (2016), the monetary policy stance itself can affect the optimal level of macroprudential regulation.
metric of financial fragility in our model. We do not normalize by GDP as we focus on the stationary growth path of the economy, posing the question of whether stabilizing unsecured credit is a way to stabilize output fluctuations. Malakhovskaya and Minabutdinov (2014) examine the impact of structural shocks on business cycle fluctuations and show that the risk premium shock and commodity export shock jointly capture the financial crises of 2009 in Russia, while Polbin (2014) studies the stabilizing role of different fiscal policies. Ivashchenko (2013) allows for endogenous default by firms and shows in an estimated model that inflation dynamics in Russia were primarily driven by the actions of the government. He also argues that the influence of the financial sector of the Russian economy on the real sector is weak.

Section 2 presents the model. Section 3 presents the quantitative results of the model and compares the effects of alternative policies in response to shocks. Section 4 conducts a sensitivity analysis given various parameterizations of the policy rules. Finally, Section 5 presents concluding remarks.

2. A New Keynesian small open economy model with a banking sector

2.1. Circular flow of funds

Households which are infinitely lived own capital producers, nontradable goods producers, banks and other firms. They save by making deposits at banks and acquiring domestic and foreign bonds. Wholesale producers require funding to invest in physical capital in order to produce intermediate non-tradable goods. Unsecured loans are repaid next period, a condition which firms may renegotiate and on which they may obtain a haircut. Secured borrowing is subject to a collateral constraint. Banks combine households’ deposits with their equity and lend to wholesale producers. Loan origination requires banks to satisfy capital adequacy requirements imposed by the monetary authority. The tradable sector consists of importers and exogenous oil export. Importers import intermediate goods from the rest of the world and sell them to capital producers, who use them as an input for the production of capital together with undepreciated capital. Oil reserves belong to the government, and it receives all the oil revenue. The monetary authority sets the nominal interest rate on domestic bonds. The fiscal authority spends its revenues on nontradable and imported goods. The circular flow of funds is summarised in Figure 1.

---

4 In practice, credit to trend GDP would be a better measure to use.
2.2. Households

Households are infinitely lived and consume a bundle \((c_t)\) consisting of domestically produced goods \((c_{N,t})\) and imported goods \((c_{T,t})\). Labour \((l_t^h)\) is supplied monopolistically at a wage \((w_t)\) that can be stochastically chosen and updated.\(^5\)

Households own all firms (wholesale and intermediate producers, retailers, and capital producers) and banks in the economy and receive profits from them. Equity is invested in banks and wholesale producers \((e_t^{bank} \text{ and } e_t^{w,total})\) respectively. Equity received by the wholesale producers is composed of the net equity \((e_t^{w})\) and undepreciated capital that households receive from firms ending operations in the current period \(((1 – \tau)p_t^K k^w_t)\). Households also save via bank deposits \((d_t^h)\), foreign bonds \((B_t^f)\), and domestic government bonds \((B_t^{g,h})\).

Households maximize their discounted expected utility subject to their budget constraint:

\[
\max_{c_{T,t}, c_{N,t}, c_{T,t}^{w,total}, e_t^{bank}, d_{t+1}, w_t, B_t^f, B_t^{g,h}} \frac{(c_0^h)^{1-\sigma}}{1-\sigma} - \theta^h \frac{(l_0^h)^{1+\gamma^h}}{1+\gamma^h} \\
+ \mathbb{E}_0 \sum_{t=1}^{\infty} (\beta_t^h)^t \left[ \frac{(c_t^h)^{1-\sigma}}{1-\sigma} - \theta^h \frac{(l_t^h)^{1+\gamma^h}}{1+\gamma^h} \right].
\]

\(^5\) We follow Erceg et al. (2000) in defining wage rigidity and monopolistic competition in the labour market.
The consumption bundle is:
\[
c_t = A^c \left[ \left( \phi^h \right)^{\frac{1}{Vc}} c_{N,t}^{\frac{1}{Vc}} + \left( 1 - \phi^h \right)^{\frac{1}{Vc}} c_{C,t}^{\frac{1}{Vc}} \right]^{\frac{Vc}{Vc-1}},
\]

where \( \phi^h \) is the share of domestic goods in the consumption basket and \( V_c \) is the elasticity of substitution between domestic and foreign consumption goods.

The budget constraint of a household is
\[
d_{t+1}^h + p_{t}^{imp} c_{T,t} + c_{N,t} + e_{t,w,\text{total}}^w + e_{t,\text{bank}}^f + Q_t B_t^f + B_t^{g,h}
\leq (1 + r_t^d) d_t^h + Q_t B_{t-1}^f (1 + r_{t-1}^f) + B_{t-1}^{g,h} (1 + r_{t-1}^h) + w_t l_t^h
+ (1 - \theta^w) \bar{\Pi}_t^w + \theta^w \bar{\Pi}_t^w + \Pi_t^{\text{bank}} + \Pi_t^{\text{cap}} + \Pi_t^{\text{ret}} - A_t^s,
\]

where \( Q_t \) is the real exchange rate, \( p_{t}^{imp} \) is the domestic price of imported goods, \( e_{t,w,\text{total}}^w = (e_{t}^w + (1 - \tau) p_{t}^K k_{w}^t) \), and \( A_t^s \) is the adjustment costs of the household, where
\[
A_t^s = 0.5 a^{s,b,e} (e_{t}^\text{bank} - e_{t}^\text{bank})^2 + 0.5 a^{s,w,e} (e_{t,w,\text{total}}^w - e_{ss,w,\text{total}}^w)^2 + 0.5 a^{s,d} (d_t^h - d_{ss}^h)^2
+ 0.5 a^{s,b,f} (Q_t B_t^f - Q_{ss} B_{ss}^f)^2 + 0.5 a^{s,b,g} (B_t^g - B_{ss}^g)^2.
\]

2.3. Firms

2.3.1. Wholesale producers

Wholesale producers in the economy live for two periods. All newly-born firms are identical, but in the second period of their life their TFP is high (\( \bar{A}_t \)) or low (\( \underline{A}_t \)) with probability \( 1 - \theta_w \) and \( \theta_w \) respectively. Firms receive equity investment from households, issue secured (\( \mu_{t}^{w,u} + \mu_{t}^{w,s} \)) and unsecured (\( \mu_{t}^{w,u} + \mu_{t}^{w,s} \)) debt to banks, and purchase capital (\( k_{t+1}^w \)). Each firm decides how much labour (\( l_t^w \)) it wants to hire on the basis of its productivity. A fraction \( \text{coll} \) of the expected future value capital is used as collateral for secured debt. Unsecured debt can be renegotiated with creditors, after which firms can obtain a haircut of (\( \delta_t^w \)), which we call the ‘loss given default’.

Production is given by
\[
y_t^f = A_t^f (k_t^f)^{\alpha} (l_t^f)^{1-\alpha}.
\]

The first-period real budget constraint of a firm takes the form:
\[
p_t^K k_{t+1}^w + T^w + A_t^w \leq \mu_{t+1}^{w,u} + \mu_{t+1}^{w,s} + e_{t,w,\text{total}},
\]

where \( A_t^w \) are the adjustment costs of the firm:
\[
A_t^w = 0.5 a^{w,u} (\mu_{t+1}^{w,u} - \mu_{ss}^{w,u})^2 + 0.5 a^{w,s} (\mu_{t+1}^{w,s} - \mu_{ss}^{w,s})^2
+ 0.5 a^{w,k} p_t^K (k_{t+1}^w - k_{ss}^w)^2.
\]
The collateral constraint is:

\[ \mathbb{E}_t (1 + r_{t+1}^{w,s}) \mu_{t+1}^{w,s} \leq \text{coll}(1 - \tau) k_{t+1}^{w} \mathbb{E}_t p_{t+1}^K. \]  

(5)

In the second period, profit is given by:

\[
\Pi_{t+1}^w = p_{t+1}^w A_{t+1}^w (k_{t+1}^w)^\alpha (l_{t+1}^w)^{1-\alpha} \\
- (1 - \delta_{t+1}^w) \mu_{t+1}^{w,u} (1 + r_{t+1}^{w,u}) - \mu_{t+1}^{w,s} (1 + r_{t+1}^{w,s}) - w_{t+1} l_{t+1}^w \\
- \frac{\Omega_{t+1}^w}{1 + \psi} \left( \delta_{t+1}^w \mu_{t+1}^{w,u} (1 + r_{t+1}^{w,u}) \right)^{1+\psi} + p_{t+1}^K k_{t+1}^w (1 - \tau). \]  

(6)

Thus, depending on its level of technology (\( \bar{A}_t \) or \( \underline{A}_t \)), the firm’s profit can either be \( \Pi_{t}^\bar{A} \) or \( \Pi_{t}^\underline{A} \).

\( \Omega_t^w \) is a macro-variable that represents the aggregate credit conditions.\(^7\) It evolves according to:

\[
\Omega_t^w = \Omega_s^w \left( \frac{\mu_s^{w,u}}{GDP_s^U} \right)^\omega \left( \frac{GDP_t}{\mu_t^{w,u} (1 + r_t^{w,u})} \right)^\omega \frac{1}{(\delta_t^w)^\psi}. \]  

(7)

The wholesale producer solves:

\[
\delta_{t+1}^w \mu_{t+1}^{w,u} \mu_{t+1}^{w,s} k_{t+1}^w l_{t+1}^w \mathbb{E}_t \lambda_{t+1}^h \left[ \theta_w \Pi_{t+1} + (\theta_w) \bar{\Pi}_{t+1} \right]. \]  

(8)

2.3.2. Intermediate goods producers

Intermediate goods producers are monopolistically competitive and produce a differentiated intermediate good using wholesale goods:

\[ Y_t^{ret} (k) = Y_t^w (k). \]  

(9)

They therefore solve:

\[
\min_{Y_t^{ret}(k)} \frac{P_t^w}{P_t} Y_t^{ret}(k) + \lambda_t^{ret} (Y_t^{ret}(k) - Y_t^w(k)). \]  

(10)

Price stickiness is introduced into the model in a standard New Keynesian manner, following Brzoza-Brzezina et al. (2013). The intermediate goods producer sets the price \( p_t(k) \) by solving:

\(^6\) We assume that renegotiation only occurs when productivity has been low. If productivity is high, the haircut is zero and there is no cost of renegotiation in (6).

\(^7\) As \( \Omega \) is a macro-variable which firms take as given, there is a direct externality arising from the renegotiation of unsecured debt. The cost of renegotiating debt effectively creates a borrowing constraint, as discussed in Shubik and Wilson (1977) and Dubey et al. (2005) and as applied in Tsomocos (2003), Goodhart et al. (2005) and Goodhart et al. (2006).
2.3.3. Domestically-priced final goods producers (retailers)

Domestically-priced final goods producers create a composite final good using as input goods purchased from intermediate goods producers. The good is then demanded by households and the government, and is given by:

\[ Y_{T}^{ret} = \left( \int_{0}^{1} Y_{k}^{ret}(k)^{\theta_{c}^{-1}} \right)^{\frac{1}{\theta_{c}}}. \]  

(12)

2.3.4. Capital producers

Capital producers purchase imported goods \( i_{T}, t \) at price \( p_{T}^{imp} \) and domestic goods \( i_{N, t} \) to produce aggregate investment goods \( i_{t} \) in accordance with their technology, represented by a constant elasticity of substitution (CES) aggregator:

\[ i_{t} = A^i \left[ \left( \phi^i \right)^{\frac{1}{\nu_{i}}} \left( i_{N, t}^{-1} \right)^{\frac{1}{\nu_{i}}} + \left( 1 - \phi^i \right)^{\frac{1}{\nu_{i}}} \left( i_{T, t}^{-1} \right)^{\frac{1}{\nu_{i}}} \right]. \]  

(13)

The capital production technology implies an adjustment cost. The production function takes the form:

\[ K_{t} = (1 - \tau)K_{t-1} + i_{t} \left( 1 - \frac{\tau}{2} \left( \frac{i_{t}}{i_{t-1}} - 1 \right)^{2} \right). \]  

(14)

Capital producers sell new capital to wholesale producers. The profit is:

\[ \Pi_{t}^{cap} = p_{t}^{K} i_{t} \left( 1 - \frac{\tau}{2} \left( \frac{i_{t}}{i_{t-1}} - 1 \right)^{2} \right) - i_{N, t} - i_{T, t} p_{t}^{imp}. \]  

(15)

Capital producers solve:

\[ \max_{i_{t}} E_{0} \sum_{t=1}^{\infty} \left( \beta_{t-1}^{h} \right)^{t} \lambda_{t}^{h} \Pi_{t}^{cap}. \]  

(16)

2.4. Banking sector

Banks live for two periods. New-born banks are capitalized with equity \( e^{bank}_{bank} \). They accept deposits from households \( d_{bank}^{h} \) and extend secured \( (\mu_{t+1}^{bank,s}) \) and unsecured \( (\mu_{t+1}^{bank,u}) \) loans to firms. Given \( \{\delta_{t+1}^{w}, r_{t+1}^{w,s}, r_{t+1}^{w,u}, r_{t+1}^{d}\} \), banks maximize:
where $k_t^{bank}$ is the capital adequacy ratio, defined as the ratio of bank capital to risk-weighted assets net of reserves ($rwa_{t}^{bank}$):

$$k_t^{bank} = \frac{e_t^{bank}}{rwa_t^{bank}} = \frac{e_t^{bank}}{(\bar{r}W_{t+1}^{bank,u} + \bar{r}W_{t+1}^{bank,s})}.$$ (18)

Here, for simplicity, we assume the same risk weights for secured and unsecured lending.

The first-period budget constraint of a bank is given by

$$\mu_{t+1}^{bank} = d_{t+1}^{bank} + e_t^{bank} - A_t^{bank},$$ (19)

where $\mu_{t+1}^{bank} = \mu_{t+1}^{bank,u} + \mu_{t+1}^{bank,s}$, and $A_t^{bank}$ are the adjustment costs for the bank, where $A_t^{bank} = 0.5\delta^{b,s}(\mu_{t+1}^{bank,s} - \mu_{ss}^{bank,s})^2 + 0.5\delta^{b,u}(\mu_{t+1}^{bank,u} - \mu_{ss}^{bank,u})^2 + 0.5\delta^{d}(d_{t+1}^{bank} - d_{ss}^{bank})^2$.

Profits in the second period of operations are given by

$$\Pi_{t+1}^{bank} = \theta^w(1 + r_{t+1}^{w,u})(1 - \delta_{t+1}^{w})\mu_{t+1}^{bank,u} + (1 - \theta^w)(1 + r_{t+1}^{w,u})\mu_{t+1}^{bank,u} + (1 + r_{t+1}^{w,s})\mu_{t+1}^{bank,s} - (1 + r_{t+1}^{d})d_{t+1}^{bank},$$ (20)

where $r_{t}^{w,u}$ and $r_{t}^{w,s}$ are unsecured and secured lending rates, respectively.

2.5. Government

2.5.1. Fiscal authority

The government receives all the revenue ($p_t^{o,dom}O_t$) from oil export $O_t$. The government spends its funds on domestically produced final goods ($G_t$) and imported goods ($G_t^{imp}$), can save or borrow through domestic government bonds ($B_t^g$), and receives constant net taxes from agents in the economy.

The government budget constraint is:

$$G_t + p_t^{imp}G_t^{imp} + B_{t-1}^g \frac{1 + i_{t-1}^{b}}{1 + \pi_t} = B_t^g + p_t^{o,dom}O_t + T^w.$$ (21)

2.5.2. Monetary authority

The Central Bank controls the interest rate $i_t^{b}$ according to the following rule:

$$1 + i_t^{b} = \left(1 + i_{t-1}^{b}\right)^{\rho_i} \left(1 + \pi_t^{cpi}\right)^{1 + \rho_\pi} \left(GDP_t\right)^{\rho_{gd}} \left(GDP_{ss}\right)^{-\rho_{gd}} \varepsilon_t^R,$$ (22)

where $\varepsilon_t^R$ is a monetary policy shock that follows an AR(1) process.
For macroprudential policy analysis, the Taylor rule is augmented by a component representing the ratio of current unsecured lending to its steady state level. This would result in a higher policy rate when there is excessive unsecured lending in the economy.

The Taylor rule applied is the adjusted multiplicative form of the linear Taylor rule proposed in Taylor (1993). It is similar to the rule used in Brzoza-Brzezina et al. (2013) and consistent with other DSGE models (Adolfson et al., 2013; Christiano et al., 2015).

2.5.3. Macroprudential policy tools

The monetary authority is responsible for monetary and macroprudential regulation. Macroprudential regulation can be implemented through several channels. Firstly, the monetary authority can change the capital adequacy requirements imposed on banks. This includes setting the risk weights of different types of assets. Secondly, when setting the nominal interest rate, the monetary authority can follow a LAW-type Taylor rule, accounting for the growth of credit in the economy. Thirdly, deposit requirements can be set to regulate the credit cycle. Finally, the monetary authority can regulate the demand for loans through the LTV ratio. We focus on policies that take the level of unsecured debt as a target, as this was found to result in a larger effect than considering policies that targeted the level of total or unsecured debt.

The LAW rule is a modified Taylor rule represented by the equation

\[
\frac{1 + i_t^b}{1 + i_{ss}^b} = \left( \frac{1 + i_{t-1}^b}{1 + i_{ss}^b} \right)^{\rho_i} \left( 1 + \pi_t^{cpi} \right)^{1+\rho_{\pi}} \left( \frac{GDP_t}{GDP_{ss}} \right)^{\rho_{gap}} \left( \frac{\mu_{t+1}^{bank,u}}{\mu_{ss}^{bank,u}} \right)^{\zeta} \epsilon_t. \tag{23}
\]

In this type of Taylor rule, the policy rate not only depends on the policy rate for the previous period, current CPI inflation, and GDP, but also reacts positively to the growth of unsecured debt in the economy. We set \( \zeta = 0.5 \) for our policy analysis.

A policy rule for deposit requirements suggests the existence of a deposit reserve ratio. In accordance with this rule, all banks transfer a share \( res_t \) of deposits to the budget each period and receive the same nominal amount next period. The dynamics of \( res_t \) are captured by the equation:

\[
res_t = \left( \frac{\mu_{t+1}^{bank,u}}{\mu_{ss}^{bank,u}} \right)^{\nu} - 1. \tag{24}
\]

The deposit reserve ratio is often considered as a tool for regulating liquidity, which is not usually represented in models. However, the deposit reserve ratio also affects banks’ internal return on funding and the attractiveness of investing in the banking sector. The deposit reserve ratio therefore affects financial sector
variables and can be considered a macroprudential tool. We set \( \nu = 0.015 \) for our policy analysis.

The LTV macroprudential policy rule suggests the collateral discount \( \text{coll} \) (equation (5)) should be dynamic and regulates it in accordance with the law:

\[
\text{coll}_t = \text{coll}_{ss} \left( \frac{\mu_{t+1}^{\text{bank},u}}{\mu_{ss}^{\text{bank},u}} \right)^\chi.
\]

(25)

When aggregate unsecured loans exceed the steady state, the amount of capital that is collateralized increases. As a result, firms are forced to finance a larger proportion of their expenditure on capital through secured debt. Firms then need to reduce the loan to (expected) value ratio of undepreciated capital. This changes the internal cost of collateral constraint and the demand for loans. We set \( \chi = -0.5 \) for our policy analysis.

The capital adequacy rule concerns the capital adequacy ratio \( \bar{\kappa}^{\text{bank}} \), a dynamic variable, and regulates it based on the equation

\[
\bar{\kappa}_t^{\text{bank}} = \bar{\kappa}_{ss}^{\text{bank}} \left( \frac{\mu_{t+1}^{\text{bank},u}}{\mu_{ss}^{\text{bank},u}} \right)^\eta.
\]

(26)

Higher aggregate unsecured loans lead to higher capital adequacy requirements. This rule affects the internal profitability of lending and the supply of loans. We set \( \eta = 0.5 \) for our policy analysis.

2.6. Markets and prices

We use the standard definition of equilibrium for a competitive dynamic economy. Given exogenous shocks, equilibrium is a sequence of prices and quantities such that each agent in the economy maximizes his or her value and all markets clear. In particular, the market clearing condition for labour requires:

\[
l_t^h = l_t^w,
\]

(27)

secured loans:

\[
\mu_t^{\text{bank},s} = \mu_t^{w,s},
\]

(28)

unsecured loans:

\[
\mu_t^{\text{bank},u} = \mu_t^{w,u},
\]

(29)

deposits:

\[
d_t^h = d_t^{\text{bank}},
\]

(30)

domestic bonds:

\[
B_t^g = B_t^{g,h},
\]

(31)
domestic output:
\[ y_t^{ret} = c_t^N + i_t^N + G_t + \theta^w \frac{\Omega_t^w}{1 + \psi} \left( \delta_t^w \mu_t^w (1 + \tau_t^{w,u}) \right)^{1+\psi} + A_t^s + A_t^w + A_t^{bank}. \]  

(32)

The household time-preference variable \( \beta_t^h \) is defined as the product of the time-preference parameter and time-preference shock:

\[ \beta_t^h = \beta^h \epsilon_t^{\beta,h}. \]  

(33)

The domestic price of an imported good is:

\[ p_t^{imp} = Q_t p^{imp,*}, \]  

(34)

where \( p^{imp,*} \) is the international price of an imported good, assumed to be constant, and \( Q_t \) is the real exchange rate.

The domestic price of a commodity good (oil) is:

\[ p_t^{o,dom} = Q_t p_t^{o,*}, \]  

(35)

where \( p_t^{o,*} \) is the international price of the commodity good, defined as:

\[ p_t^{o,*} = p^{o,*} \epsilon_t^{p,o}. \]  

(36)

Thus, the international price of oil is a product of some constant oil price \( p^{o,*} \) and its shock process \( \epsilon_t^{p,o} \), which follows an AR(1) process.

The interest rate on foreign bonds is also subject to the shock, which we call the 'foreign interest rate shock'. The interest rate on foreign bonds is therefore defined as:

\[ r_t^f = r^f + \epsilon_t^{i,for}. \]  

(37)

where \( r^f \) is some constant interest rate on foreign bonds and \( \epsilon_t^{i,for} \) is a shock process for the interest rate on foreign bonds, which follows an AR(1) process.

The technology levels of 'lucky' and 'unlucky' firms are \( \bar{A}_t^j \) and \( \bar{A}_t^\tilde{j} \) respectively:

\[ \bar{A}_t^j = A_t \bar{A}^j, \]  

(38)

where \( \bar{A}_t^j \) is some constant and

\[ \bar{A}_t^{\tilde{j}} = A_t \bar{A}^{\tilde{j}}, \]  

(39)

where \( \bar{A}_t^{\tilde{j}} \) is some constant with \( \bar{A}^{\tilde{j}} > 1 > A^{\tilde{j}}. \)
The real interest rate on domestic government bonds is defined as:

\[ 1 + r_t^b = \frac{1 + i_t^b}{1 + \pi_t}. \]  

(40)

3. Simulation

In this section, we simulate our model economy and conduct normative monetary and macroprudential policy analysis. We approximate our model economy by taking a first-order Taylor approximation around a deterministic steady state.

3.1. Calibrated parameters and steady state

The parameter values we use are largely taken from the estimation in Andreev et al. (2019) based on quarterly Russian data from 2001Q2 to 2018Q2 for GDP, consumption, the dollar oil price, real loans, real deposits, non-performing loans (NPLs), CPI inflation, and the one-day interbank interest rate.

Parameter values are given in Tables 1 and 2. In its steady state, the household time-preference parameter \( \beta \) is set to yield an annual risk-free rate of about 9.4%, which corresponds to the average Russian government bond yield for the period we consider. The loss given default value \( \delta_f \) is also set in accordance with the Russian data. The capital requirement for banks \( k_{bank} \) corresponds to the Russian capital requirement for systemically important banks. The depreciation rate \( \tau \) is set to yield an annual depreciation rate of 10%. The fraction of firms that default, \( \theta_f \), is calibrated to Russian banks’ statistics on defaults by firms. We also calibrated the steady state size of the oil sector in the economy to a GDP of about 26%, which is in line with the Russian statistics in our sample period.

The parameter values that we use for our calibration are close to those used or estimated in other models of the Russian economy. For instance, the depreciation rate corresponds to the rate used in Malakhovskaya and Minabutdinov (2014). As follows from Malakhovskaya and Minabutdinov (2014), the estimated value of household risk aversion for the Russian economy is 1.015. In Polbin (2014) the estimated mean value of household risk aversion is close to its prior value of 1.19.

The steady state values of the variables are presented in Table 3.

3.2. Business cycle statistics

The business cycle statistics given by the model are represented in Table 4. By comparing the business cycle statistics simulated by the model with the data, we can see that the model does a good job of capturing the volatility of most of the variables; however, it overestimates the volatility of consumption growth and GDP growth by almost a factor of two.
Table 1. Calibrated parameters and ratios

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Pi^c$</td>
<td>2.9</td>
<td>Consumption aggregator scale</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\Pi^f$</td>
<td>0.8</td>
<td>Capital production technology</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\beta^h$</td>
<td>0.977</td>
<td>Household's time preference</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\phi^h$</td>
<td>1</td>
<td>Household's disutility from labour</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\gamma^h$</td>
<td>1</td>
<td>Household's labour elasticity</td>
<td>Christiano et al. (2010)</td>
</tr>
<tr>
<td>$\sigma^h$</td>
<td>1.5</td>
<td>Household's risk aversion</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\phi^d$</td>
<td>0.65</td>
<td>Household's preference for domestic goods</td>
<td>Kreptsev and Seleznev (2017)</td>
</tr>
<tr>
<td>$\nu^c$</td>
<td>0.94</td>
<td>Elasticity of substitution between domestic and foreign consumption goods</td>
<td>Kreptsev and Seleznev (2017)</td>
</tr>
<tr>
<td>$\phi^i$</td>
<td>0.5</td>
<td>Share of domestic goods in investment</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\nu^i$</td>
<td>0.98</td>
<td>Elasticity of substitution between domestic and foreign investment goods</td>
<td>Kreptsev and Seleznev (2017)</td>
</tr>
<tr>
<td>$\beta^t$</td>
<td>1</td>
<td>Bank's risk aversion</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\phi^b$</td>
<td>0.977</td>
<td>Bank's time preference</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\delta^b$</td>
<td>0.5</td>
<td>Loss given default</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\kappa^b$</td>
<td>0.115</td>
<td>Capital requirements for banks</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\tau$</td>
<td>1</td>
<td>Bank's risk-weight</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\alpha^c$</td>
<td>0.33</td>
<td>Capital share in wholesaler's production</td>
<td>Malakhovskaya and Minabutdinov (2014)</td>
</tr>
<tr>
<td>$coll$</td>
<td>0.65</td>
<td>Collateral value of capital</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\theta_f$</td>
<td>0.05</td>
<td>Fraction of firms defaulting</td>
<td>Calibrated to data</td>
</tr>
<tr>
<td>$\epsilon^e$</td>
<td>4</td>
<td>Elasticity of labour demand</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{id}$</td>
<td>0.052</td>
<td>Household's adjustment cost to deposits</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{hbf}$</td>
<td>0.029</td>
<td>Household's adjustment cost to foreign bonds</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{hdg}$</td>
<td>0.010</td>
<td>Household's adjustment cost to domestic bonds</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{hec}$</td>
<td>0.052</td>
<td>Household's adjustment cost to bank's equity</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{he}$</td>
<td>0.032</td>
<td>Household's adjustment cost to firm's equity</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{w,k}$</td>
<td>0.060</td>
<td>Firm's adjustment cost to capital</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{wx}$</td>
<td>0.005</td>
<td>Firm's adjustment cost to secured loans</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{wu}$</td>
<td>0.006</td>
<td>Firm's adjustment cost to unsecured loans</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{bd}$</td>
<td>0.005</td>
<td>Bank's adjustment cost to deposits</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{bs}$</td>
<td>0.021</td>
<td>Bank's adjustment cost to secured loans</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\sigma^{bu}$</td>
<td>0.005</td>
<td>Bank's adjustment cost to unsecured loans</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\chi$</td>
<td>0.098</td>
<td>Capital producer's adjustment cost to investment</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\theta^{bw}$</td>
<td>0.046</td>
<td>Wage stickiness</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>$\theta^{bs}$</td>
<td>0.408</td>
<td>Price stickiness</td>
<td>Andreev et al. (2019)</td>
</tr>
</tbody>
</table>

Table 1 continues on p. 17
### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho_i )</td>
<td>0.901</td>
<td>Interest rate coefficient</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^\pi )</td>
<td>1.170</td>
<td>Inflation rate coefficient</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho_\text{gdp} )</td>
<td>0.291</td>
<td>GDP growth rate coefficient</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>1.540</td>
<td>Default amplification in ( \Omega )</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \omega )</td>
<td>0.682</td>
<td>Credit to GDP amplification in ( \Omega )</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \psi )</td>
<td>1.998</td>
<td>Default cost</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^P_o )</td>
<td>0.937</td>
<td>Persistence of oil price shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^a )</td>
<td>0.910</td>
<td>Persistence of TFP shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^\text{mon} )</td>
<td>0.062</td>
<td>Persistence of monetary policy shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^i,\text{for} )</td>
<td>0.902</td>
<td>Persistence of foreign interest rate shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \rho^{\beta,h} )</td>
<td>0.099</td>
<td>Persistence of household’s time-preference shock</td>
<td>Andreev et al. (2019)</td>
</tr>
</tbody>
</table>

**Calibrated ratios**

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil export/GDP</td>
<td>0.26</td>
<td>Oil export to GDP</td>
</tr>
</tbody>
</table>

### Table 2. Shocks applied

<table>
<thead>
<tr>
<th>Shocks</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \epsilon^P_o )</td>
<td>0.135</td>
<td>Standard deviation of oil price shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \epsilon^a )</td>
<td>0.035</td>
<td>Standard deviation of TFP shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \epsilon^\text{mon} )</td>
<td>0.019</td>
<td>Standard deviation of monetary policy shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \epsilon^i,\text{for} )</td>
<td>0.008</td>
<td>Standard deviation of foreign interest rate shock</td>
<td>Andreev et al. (2019)</td>
</tr>
<tr>
<td>( \epsilon^{\beta,h} )</td>
<td>0.029</td>
<td>Standard deviation of household’s time-preference shock</td>
<td>Andreev et al. (2019)</td>
</tr>
</tbody>
</table>

### Table 3. Steady state values of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Variable name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{A} )</td>
<td>Lucky wholesale producer’s technology level</td>
<td>2.000</td>
</tr>
<tr>
<td>( \underline{A} )</td>
<td>Unlucky wholesale producer’s technology level</td>
<td>0.500</td>
</tr>
<tr>
<td>( B_f )</td>
<td>Household holdings of foreign bonds</td>
<td>0</td>
</tr>
<tr>
<td>( B_{g,h} )</td>
<td>Household holdings of domestic bonds</td>
<td>0</td>
</tr>
<tr>
<td>( B_g )</td>
<td>Domestic government bond</td>
<td>0</td>
</tr>
<tr>
<td>( c_N )</td>
<td>Household consumption of domestic goods</td>
<td>1.240</td>
</tr>
<tr>
<td>( c_T )</td>
<td>Household consumption of imported goods</td>
<td>1.237</td>
</tr>
<tr>
<td>( d_{\text{bank}} )</td>
<td>Bank’s deposits</td>
<td>5.307</td>
</tr>
<tr>
<td>( d_h )</td>
<td>Household’s deposits</td>
<td>5.307</td>
</tr>
<tr>
<td>( \delta^w )</td>
<td>Loss given default rate</td>
<td>0.5</td>
</tr>
<tr>
<td>( e_{\text{bank}} )</td>
<td>Bank’s equity</td>
<td>0.690</td>
</tr>
<tr>
<td>( e_{w,\text{total}} )</td>
<td>Wholesale producer’s total equity</td>
<td>2.308</td>
</tr>
<tr>
<td>( G )</td>
<td>Government spending on final domestic goods</td>
<td>0.817</td>
</tr>
</tbody>
</table>

*Table 3 continues on p. 18*
Certain of the correlations in the data tally with the corresponding model variables. In particular, the model does a good job of capturing the size of the correlation between GDP growth and oil price growth, although it slightly overestimates the correlation between GDP growth and consumption growth.
The correlation of GDP growth with loans and deposit growth is highly underestimated. The model also implies the wrong correlation between NPLs and GDP growth, as well as between NPLs and oil price growth. The model correctly captures the correlations between the interest rate and loan growth, deposit growth, and CPI inflation; however, the correlation between the interest rate and NPLs is significantly overestimated.

The corresponding business cycle statistics for the Russian economy for the period 2001Q2–2018Q2 are given in Table 5.

Table 4. Model business cycle statistics

<table>
<thead>
<tr>
<th></th>
<th>GDP, q/q growth, %</th>
<th>Consumption, q/q growth, %</th>
<th>Oil price, q/q growth, %</th>
<th>Real loans, q/q growth, %</th>
<th>Real deposits, q/q growth, %</th>
<th>NPL to loans, quarterly, %</th>
<th>CPI, quarterly, %</th>
<th>Interest rate, quarterly, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard deviation</td>
<td>2.91</td>
<td>3.52</td>
<td>14.49</td>
<td>4.37</td>
<td>5.46</td>
<td>1.74</td>
<td>1.34</td>
<td>1.60</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP, q/q growth, %</td>
<td>1</td>
<td>0.81</td>
<td>0.46</td>
<td>0.23</td>
<td>0.11</td>
<td>0.13</td>
<td>-0.33</td>
<td>-0.20</td>
</tr>
<tr>
<td>Consumption, q/q growth, %</td>
<td>0.81</td>
<td>1</td>
<td>0.17</td>
<td>0.20</td>
<td>-0.02</td>
<td>0.07</td>
<td>-0.20</td>
<td>-0.10</td>
</tr>
<tr>
<td>Oil price, q/q growth, %</td>
<td>0.46</td>
<td>0.17</td>
<td>1</td>
<td>0.06</td>
<td>0.76</td>
<td>0.14</td>
<td>-0.35</td>
<td>-0.30</td>
</tr>
<tr>
<td>Real loans, q/q growth, %</td>
<td>0.23</td>
<td>0.20</td>
<td>0.06</td>
<td>1</td>
<td>0.24</td>
<td>0.02</td>
<td>-0.27</td>
<td>-0.44</td>
</tr>
<tr>
<td>Real deposits, q/q growth, %</td>
<td>0.11</td>
<td>-0.02</td>
<td>0.76</td>
<td>0.24</td>
<td>1</td>
<td>0.12</td>
<td>-0.29</td>
<td>-0.35</td>
</tr>
<tr>
<td>NPL to loans, quarterly, %</td>
<td>0.13</td>
<td>0.07</td>
<td>0.14</td>
<td>0.02</td>
<td>0.12</td>
<td>1</td>
<td>0.01</td>
<td>0.68</td>
</tr>
<tr>
<td>CPI, quarterly, %</td>
<td>-0.33</td>
<td>-0.20</td>
<td>-0.35</td>
<td>-0.27</td>
<td>-0.29</td>
<td>0.01</td>
<td>1</td>
<td>0.46</td>
</tr>
<tr>
<td>Interest rate, quarterly, %</td>
<td>-0.20</td>
<td>-0.10</td>
<td>-0.30</td>
<td>-0.44</td>
<td>-0.35</td>
<td>0.68</td>
<td>0.46</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: q/q – quarter-on-quarter.

Table 5. Selected business cycle statistics 2001Q2–2018Q2

<table>
<thead>
<tr>
<th></th>
<th>GDP, q/q growth, %</th>
<th>Consumption, q/q growth, %</th>
<th>Oil price, q/q growth, %</th>
<th>Real loans, q/q growth, %</th>
<th>Real deposits, q/q growth, %</th>
<th>NPL to loans, quarterly, %</th>
<th>CPI, quarterly, %</th>
<th>Interest rate, quarterly, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.82</td>
<td>1.32</td>
<td>1.99</td>
<td>3.19</td>
<td>3.97</td>
<td>4.35</td>
<td>2.33</td>
<td>2.21</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>1.46</td>
<td>2.09</td>
<td>13.45</td>
<td>4.01</td>
<td>4.87</td>
<td>2.68</td>
<td>1.22</td>
<td>0.95</td>
</tr>
<tr>
<td>Correlation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP, q/q growth, %</td>
<td>1</td>
<td>0.66</td>
<td>0.47</td>
<td>0.61</td>
<td>0.7</td>
<td>-0.34</td>
<td>-0.06</td>
<td>-0.53</td>
</tr>
<tr>
<td>Consumption, q/q growth, %</td>
<td>0.66</td>
<td>1</td>
<td>0.36</td>
<td>0.66</td>
<td>0.47</td>
<td>-0.49</td>
<td>-0.14</td>
<td>-0.45</td>
</tr>
</tbody>
</table>

Table 5 continues on p. 20
3.3. Impulse response functions

Figure 2 (see p. 25) gives the impulse response functions (IRFs) to a positive one-standard-deviation foreign oil price and TFP shock. The CPI, domestic price growth rate, and interest rates are given in absolute deviation from the steady state as a percentage change per quarter. The NPL-to-loans ratio and foreign bonds (households’ foreign debt) are given in absolute deviation multiplied by 100. All other variables are presented in percentage deviations from the steady state value.

3.3.1. TFP shock

A positive TFP shock increases the marginal profitability of production. Firms increase their demand for the factors of production, resulting in an increase in real wages, capital and the price of the capital, and production. As the relative price of capital shifts upwards, the collateral constraint is relaxed and the quantity of secured debt issued increases immediately. As the price of capital falls back to its steady state value, firms switch their issuance of debt towards unsecured loans. Higher wages allow households to increase consumption, particularly consumption of relatively cheaper domestic goods, as well as increase equity investment in the banking system, which is used to finance additional loans to the production sector. The higher profitability of the production sector results in an improvement in credit conditions and a sharp decline in NPLs. Government

---

8 The size of the shocks is as obtained from the estimation in Andreev et al. (2019): 13.5% for oil price shock and 3.5% for TFP shock.

9 The cost of collateral here represents the shadow value of the capital value in the collateral constraint implied by the Lagrange multiplier.
consumption rises due to the depreciation of the exchange rate, increasing the
domestic value of foreign oil revenues.

The inflationary response reflects the lower real price of domestic output,
which is a major factor in the depreciation of the currency, resulting in reductions
in inflation and the nominal interest rate.

3.3.2. Oil price shock

A shock to the international oil price causes a sharp appreciation in the
exchange rate, leading to a corresponding large increase in imports. The stronger
exchange rate leads to a reduction in the cost of imported goods for capital goods,
and hence a fall in the price of capital. This causes an increase in the production
of domestic non-tradeable goods. In contrast to a TFP shock, where the price of
capital increases but is absorbed by higher productivity, here the decline in the
price of capital temporarily stimulates production but is not enough to create
efficiency gains and higher total income. The decline in the price of capital
reduces the ability to issue secured debt, and consequently, the higher demand
for investment is financed through the issuing of unsecured debt. Households
switch from domestic savings in equity to foreign bonds to finance imported
consumption, resulting in lower labour supply in subsequent periods. This causes
a decline in the production of domestic non-tradeables in the medium term and
is evidence of a Dutch disease-type effect in Russia: an increase in the tradeable
sector causes the non-tradeable sector to contract as a result of the price of inputs,
here labour. The decline in the interest rate on unsecured debt causes credit
conditions to improve and the rate of non-performing loans to decline. This
effect is pronounced in our model because of the strong substitution between
domestic and foreign consumption goods driven by the high elasticity of the real
exchange rate with respect to the dollar price of oil. Our evidence for this effect
is consistent with Malakhovskaya and Minabutdinov (2014), but contradicts
Kreptsev and Seleznev (2017) and Kozlovtcveva et al. (2019). One reason for this
is that our foreign interest rate does not depend explicitly on the dollar oil price,
as in the case of Kreptsev and Seleznev (2017) and Kozlovtcveva et al. (2019). This
means that, as our foreign interest rate does not decrease when oil prices increase,
households have a greater incentive to accumulate foreign assets and sustain their
consumption of imports in the future. Another reason for our stronger Dutch
disease effect is that oil revenue is given directly to the government, which spends
it, and as a result aggregate demand depends directly and strongly on the domestic
price of oil, which falls due to a strongly appreciating exchange rate. Government

10 The income shock stimulates demand for domestic goods while the exchange rate adjusts to reflect
the substitution effect for imported goods and foreign savings.

11 In the original Dutch disease, growth in the tradable sector causes an increase in demand for
labour and hence higher wages, which causes the non-tradable sector to become unprofitable and
contract. We find that the non-tradable sector contracts because the income effect due to the more
profitable tradable sector causes a reduction in labour supply and higher wages.
spending will not adjust as much as this in practice. However, in our model, government spending substitutes for a hand-to-mouth consumer whose consumption depends directly on domestic currency oil revenues.

3.4. Policy analysis

Here we present IRFs following a positive oil price and TFP shock under different macroprudential policies. Andreev et al. (2019) demonstrate that these shocks account for much of the variation in the business cycle. We consider macroprudential rules of four types: a LAW rule, a deposit requirement rule, a LTV rule, and a capital adequacy rule. All of these rules respond to the deviation of unsecured loans from the steady state.

3.4.1. Oil price shock

Figures 3 and 4 (see pp. 26–27) give IRFs for a positive oil price shock under different macroprudential policies. The augmented Taylor rule that responds to growth in unsecured credit (the LAW policy) and the countercyclical capital adequacy requirement have the largest effect in stabilizing the immediate impact of the shock on GDP and consumption, although the LAW policy results in a larger and more prolonged medium-term decline in GDP. The LAW policy, in particular, has a stronger effect in preventing an initial decline in the real interest rate, and thus causes households to defer their immediate consumption demands to the future. The higher real interest rates under a LAW policy also cut the demand for loans, reducing capital accumulation and domestic production and cushioning the business cycle effects of the shock. This suggests that a LAW-type macroprudential policy could help to manage aggregate fluctuations.

Focusing on the banking system alone, the countercyclical capital adequacy policy leads to the greatest reduction in non-performing loans and the greatest increase in the equity buffer. However, the substitution of deposits for equity means that the cost of bank funding is not significantly affected (reflected in the secured and unsecured interest rate series), causing total loans and capital to rise, which further amplifies the effect on GDP of the oil price shock. The countercyclical LTV policy has a similarly dramatic effect on the banking system, causing large declines in total loans and bank equity. This causes a decline in capital invested. However, as the bank cost of capital is not affected, the real interest rate is also not affected and households do not change their labour supply, resulting in negligible effects on the real economy.

3.4.2. TFP shock

Figures 5 and 6 (see pp. 28–29) give IRFs for a positive TFP shock under different macroprudential policies. Unlike in the case of the oil price shock,
here the LAW policy amplifies the initial response of GDP by sharply increasing real interest rates, resulting in the intertemporal substitution effect being dominated by the income effect for households and causing households to switch away from deposits towards consumption. However, after the shock, the substitution effect dominates and deposits rise, labour falls, and GDP converges to the steady state faster than under other policies. The countercyclical deposit requirement also amplifies the response of GDP but does not stabilize the financial sector as effectively as the LTV policy, which does a better job of stabilizing loans, NPLs, and bank equity. The countercyclical capital adequacy ratio performs similarly to the LAW policy, but does not affect the real interest rate as effectively and consequently has a minimal effect on the real economy. In our environment, a combination of the LAW and LTV policies would seem best suited to respond to a productivity shock.

4. Sensitivity analysis

In this section we consider the robustness of our macroprudential policies under different parameterizations of policy rules. We refer to the baseline model which corresponds to no macroprudential policy as ‘BM’. Model 1 (C1, D1, LTV1, T1 for the capital adequacy, deposit requirement, loan-to-value, and lean-against-the-wind monetary policy rules respectively) corresponds to the parameterization considered in Section 3.4. Model 2 (C2, D2, LTV2, T2 for the capital adequacy, deposit requirement, loan-to-value, and lean-against-the-wind monetary policy rules respectively) corresponds to a parameterization with a higher response to unsecured credit growth.

4.1. Capital adequacy

The capital adequacy rule concerns the capital adequacy ratio $k_{bank}$, a dynamic variable, and regulates it based on equation (26). Our benchmark model corresponds to $\eta = 0$, the C1 model parameterization corresponds to $\eta = 0.5$, and C2 corresponds to $\eta = 1$. Figures 7 and 8 (see p. 30) show the response of our key variables\textsuperscript{12} to different specifications of the policy rule. We find that increasing the sensitivity of the capital adequacy requirement to growth in unsecured lending results in significantly higher volatility in loans, deposits, and NPLs but slightly dampens the response of GDP. A higher risk weight encourages greater equity investment but also greater loan generation. A procyclical policy rule would dampen the fluctuations in the financial sector but exacerbate the fluctuations in the real sector, highlighting the trade-off between financial stability and stabilization of the business cycle.

\textsuperscript{12} The variables from which the model was estimated in Andreev et al. (2019).
4.2. Deposit requirement

The deposit requirement regulation follows the rule in equation (24) with the baseline parameterization of $\nu$ taking the value of 0, while in specification D1 (used in the previous section) this value is 0.15 and in the new specification, D2, it is 0.3. As follows from Figures 9 and 10 (see p. 31), as in the case of the capital adequacy regulation, changing the parameterization has a minor effect on business cycle variables, but large effects on financial sector variables. When the requirement is more sensitive to unsecured credit growth, there is a dampening effect on deposits and NPLs, and, in the medium term, on total loans. In the short term, the effect on total loans is amplified, driven by an increase in deposits held as reserves.

4.3. LTV ratio

The loan-to-value macroprudential policy follows the rule in equation (25) where $\chi$ takes the value of 0 for the baseline specification, $-0.5$ for specification LTV1, and $-1$ for specification LTV2. In this rule, the effect on real variables is similar under specifications LTV1 and LTV2. The initial response of loans and deposits is amplified by the higher elasticity of the rule with respect to unsecured credit, although the effect on non-performing loans is dampened due to the switch from unsecured to secured credit.

4.4. LAW

The lean-against-the-wind type of Taylor rule is represented by equation (23) where $\varsigma$ is 0 in the baseline specification, 0.5 in specification T1, and 1 in specification T2. In Figure 13 (see p. 33), following an oil shock, we can see that the policy with the higher value of $\varsigma$ causes a greater initial response from financial variables but dampens GDP and consumption in the short run. In the medium term, the significantly greater deviation of interest rates from the steady state results in a larger effect on GDP, but dampens consumption and financial variables. Real and financial variables respond differently in each of the three specifications. The policy rate’s heightened response to the growth in unsecured credit results in a greater reduction in both inflation and the nominal interest rate, which helps to stabilize GDP and consumption faster. Following a TFP shock, in Figure 14 (see p. 33), there is a greater initial response from GDP and consumption and financial sector variables, but a faster convergence to the steady state in the medium term.
Figure 2. IRFs to a positive one-standard-deviation shock: oil price and TFP

- GDP
- Nontradable goods
- Capital producer investments
- Import
- Consumption
- Nontradable goods consumption
- Imported goods consumption
- Government consumption
- Total loans
- Unsecurad loans
- Secured loans
- Deposits
- NPL/ Loans
- Bank equity
- Foreign bonds
- Labor
- Capital
- Capital price
- Domestic price growth rate
- Nominal exchange rate growth
- Real exchange rate
- Foreign oil price
- CPI
- Default cost
- Loss given default
- Cost of collateral
- Credit conditions
- Real wage
- Nominal interest rate
- Real interest rate
- Unsecured interest rate
- Secured interest rate

*oil price shock*  *TFP shock*
Figure 3. IRFs to a positive one-standard-deviation oil price shock
Figure 4. IRFs to a positive one-standard-deviation oil price shock
Figure 5. IRFs to a positive one-standard-deviation TFP shock
Figure 6. IRFs to a positive one-standard-deviation TFP shock

- Domestic price growth rate
- Nominal exchange rate growth
- Real exchange rate
- Foreign oil price
- CPI
- Default cost
- Loss given default
- Cost of collateral
- Credit conditions
- Real wage
- Nominal interest rate
- Real interest rate
- Unsecured interest rate
- Secured interest rate

- Benchmark model
- LAW policy
- Deposit requirement policy
- Capital adequacy policy
- LTV policy
Figure 7. Robustness check on capital adequacy requirement policy for oil price shock

Figure 8. Robustness check on capital adequacy requirement policy for TFP shock
**Figure 9.** Robustness check on deposit requirement policy for oil price shock

![Graphs showing economic indicators for oil price shock](image)

- **GDP**
- **Consumption**
- **Deposits**
- **Total loans**
- **Secured loans**
- **Unsecured loans**
- **NPL/Loans**
- **CPI**
- **Nominal interest rate**

<table>
<thead>
<tr>
<th>Line Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>benchmark model (BM)</td>
<td>Model with the first parameterization of deposit requirement policy (D1)</td>
</tr>
<tr>
<td>model with the first parameterization of deposit requirement policy (D1)</td>
<td>Model with the second parameterization of deposit requirement policy (D2)</td>
</tr>
</tbody>
</table>

**Figure 10.** Robustness check on deposit requirement policy for TFP shock

![Graphs showing economic indicators for TFP shock](image)

- **GDP**
- **Consumption**
- **Deposits**
- **Total loans**
- **Secured loans**
- **Unsecured loans**
- **NPL/Loans**
- **CPI**
- **Nominal interest rate**

<table>
<thead>
<tr>
<th>Line Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>benchmark model (BM)</td>
<td>Model with the first parameterization of deposit requirement policy (D1)</td>
</tr>
<tr>
<td>model with the first parameterization of deposit requirement policy (D1)</td>
<td>Model with the second parameterization of deposit requirement policy (D2)</td>
</tr>
</tbody>
</table>

- **GDP**
- **Consumption**
- **Deposits**
- **Total loans**
- **Secured loans**
- **Unsecured loans**
- **NPL/Loans**
- **CPI**
- **Nominal interest rate**

<table>
<thead>
<tr>
<th>Line Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>benchmark model (BM)</td>
<td>Model with the first parameterization of deposit requirement policy (D1)</td>
</tr>
<tr>
<td>model with the first parameterization of deposit requirement policy (D1)</td>
<td>Model with the second parameterization of deposit requirement policy (D2)</td>
</tr>
</tbody>
</table>
**Figure 11.** Robustness check on LTV ratio policy for oil price shock

![Graphs showing changes in macroeconomic indicators under different LTV ratio policies.](image)

- **GDP**
- **Consumption**
- **Deposits**
- **Total loans**
- **Secured loans**
- **Unsecured loans**
- **NPL/Loans**
- **CPI**
- **Nominal interest rate**

- **-** benchmark model (BM)
- **-** model with the first parameterization of LTV ratio policy (LTV1)
- **-** model with the second parameterization of LTV ratio policy (LTV2)

**Figure 12.** Robustness check on LTV ratio policy for TFP shock

![Graphs showing changes in macroeconomic indicators under different LTV ratio policies.](image)

- **GDP**
- **Consumption**
- **Deposits**
- **Total loans**
- **Secured loans**
- **Unsecured loans**
- **NPL/Loans**
- **CPI**
- **Nominal interest rate**

- **-** benchmark model (BM)
- **-** model with the first parameterization of LTV ratio policy (LTV1)
- **-** model with the second parameterization of LTV ratio policy (LTV2)
Figure 13. Robustness check on LAW policy for oil price shock

Figure 14. Robustness check on LAW policy for TFP shock
5. Concluding remarks

In this paper we developed a New Keynesian model of a small open economy with a banking sector and secured and unsecured debt. We calibrated the model to the parameters found in Andreev et al. (2019), which also found that the Russian business cycle is dominated by shocks to the foreign price of oil and TFP. We compared the effectiveness of an unsecured credit-augmented Taylor rule, a countercyclical deposit requirement, a LTV ratio, and capital adequacy requirements in stabilizing the economy in the event of oil price and TFP shocks. In line with the findings of Kozlovteeva et al. (2019), we find that a LAW monetary policy has the potential to play the greatest stabilizing role following both shocks, but may need to be implemented in conjunction with policies such as the countercyclical deposit reserve requirement and LTV ratio policies for oil and TFP shocks respectively. The optimal combination of policies and in particular the welfare implications of policies, as discussed in Kashyap et al. (2017), are important considerations which are left to subsequent work.

References


**APPENDIX**

**Table 6. Corporate loans in Russia: secured and unsecured**

<table>
<thead>
<tr>
<th>Type of loan</th>
<th>Raiffeisen (2017)</th>
<th>Moscow Credit Bank (2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsecured loans</td>
<td>50.3%</td>
<td>–</td>
</tr>
<tr>
<td>Guarantees</td>
<td>24.5%</td>
<td>–</td>
</tr>
<tr>
<td><strong>Total uncollateralized</strong></td>
<td><strong>74.8%</strong></td>
<td><strong>56.2%</strong></td>
</tr>
<tr>
<td>Real estate</td>
<td>18.1%</td>
<td>16.9%</td>
</tr>
<tr>
<td>Other</td>
<td>7.1%</td>
<td>26.9%</td>
</tr>
<tr>
<td><strong>Total collateralized</strong></td>
<td><strong>25.2%</strong></td>
<td><strong>43.8%</strong></td>
</tr>
</tbody>
</table>
Commodity and Financial Cycles in Resource-based Economies

Marina Tiunova, Bank of Russia
tuinovamg@cbr.ru

This research analyses the influence of commodity prices on financial cycle parameters in commodity-exporting countries – Australia, Brazil, Canada, Columbia, Russia, and Chile – over the past two decades. One of the key issues discussed herein is the degree to which the extensive implementation of macroprudential policies can reduce the dependence of a country on global commodity cycles. Methodologically, this research is based on the Bayesian Structure Vector Autoregressive Model, structurally identified by means of variable recursive ranking and the Cholesky decomposition of the error covariance matrix. Changes in commodity prices are shown to provoke a stronger response from such financial cycle parameters as the sovereign risk premium and currency exchange rate in resource-based emerging market economies (Brazil, Columbia, Chile, and Russia) than in advanced economies (Canada and Australia). In Brazil, Columbia, Chile, and Russia, increases in commodity prices result in acceleration of the overall lending and external debt growth rate, while in Russia and Brazil they also trigger growth in the share of FX loans. In Australia and Canada, lending parameters react negatively to positive commodity price shocks. In the developing countries that apply macroprudential policy extensively (Columbia and Chile), lending dynamics are less dependent on changes in the global terms of trade. To reduce the impact of the commodity cycle on the financial cycle, the economic policy authorities of emerging market countries should develop national financial markets and introduce macroprudential policy tools more extensively.

Keywords: terms of trade, commodity shocks, credit and financial cycles, emerging markets, foreign currency predominance, macroprudential policies, vector autoregression

JEL Codes: C32, F38, G15, G28


1 The author would like to express her gratitude to Elizaveta Danilova, Nadezhda Ivanova, Ivan Shevchuk, Olga Pavshok, Evgeny Rumyantsev, and the anonymous reviewers for their assistance, valuable remarks, and comments provided in the process of preparing this research. This research represents the author’s personal opinion and does not necessarily reflect the official position of the Bank of Russia. All errors or inaccuracies that might be found in this paper are those of the author.
1. Introduction

This research analyses the influence of global commodity market prices on national financial cycles in commodity-dependent countries. The importance of this issue stems from the risk of a boom in national credit markets for resource exporters during high commodity price periods, followed by deleveraging and complications in FX debt servicing if capital inflow to domestic markets stops and national currencies depreciate.

In recent years, the interconnection between the commodity and financial cycles of commodity-exporting countries has been widely discussed in the literature (González et al., 2015; Ftiti et al., 2016; Agarwal et al., 2017; Kinda et al., 2016; Moreno et al., 2014; Alodayni, 2016), and has also been brought up in an analytical note by the Bank of Russia (2017). The growth of commodity prices in the global markets leads to an increase in the inflow of foreign currency earnings to local financial markets and the intensification of economic activity in commodity-producing countries, which, in turn, spurs investments and results in the expansion of lending. FX borrowing and borrowing in the foreign debt market grow as the overall risk level in the financial markets of commodity-producing countries decreases. In the case of a sharp shift in commodity prices, the close correlation between the parameters of the commodity and financial cycles in commodity-dependent countries leads to a significant decrease in demand for loans and reduces economic agents’ creditworthiness and banks’ loan portfolio quality. Moreover, excessive dependence on external funding formed during a period of high commodity prices is associated with the risk of external debt arrears. Thus, a material decrease in domestic lending and the failure to service external debt may cause a volatility surge in national financial markets and a financial crisis.

Consequently, the prevalence of commodities in a country’s export structure increases the dependence of its economy on foreign markets and threatens its financial stability. In this regard, it is important to clarify the extent to which the nature and intensity of the influence of global commodity market parameters on resource-based economies’ financial cycle indicators vary when there are changes in these countries’ economic development, resource dependence, and extent of macroprudential policy (MPP) implementation. Several articles have been published recently that study similar issues through analysis of data on emerging markets (Cerutti et al., 2017; Cizel et al., 2016; Gambacorta and Murcia, 2017; Bruno et al., 2017; see Section 2).

The novelty of this article lies in its use of alternative tools – the estimation of Bayesian Structure Vector Autoregressive (BSVAR) models – for several commodity-

---

2 Macroprudential policy is a complex of preventive measures aimed at minimising the risk of a systemic financial crisis or, in other words, the risk that a situation may arise in which a significant proportion of financial sector participants become insolvent or lose liquidity and cannot operate without the support of a monetary authority or a prudential supervision authority (Moiseev and Lobanova, 2013).
exporting countries, including two advanced economies (Australia and Canada). The use of BSVAR tools makes it possible to compare the country-specific sensitivity of financial cycle indicators to commodity price shocks and draw conclusions that supplement and extend the results obtained in papers which analyse panel data solely for developing countries. Thus, this article uses BSVAR models to determine the sensitivity of financial cycle indicators in several countries – Australia, Brazil, Canada, Columbia, Russia, and Chile – to price shocks in commodities that are key to the export structures of the economies in question. We use both the general lending in the economy and the sizes of loans, broken down into specific borrower categories (households and firms) and currencies (national and foreign), as lending activity indicators. Based on the latter, the article arrives at a conclusion concerning the influence of the terms of trade on the level of lending dollarisation in Russia. Moreover, the article analyses the influence of global commodity market conditions on foreign debt load (as an alternative to borrowing in the national credit market), which also reflects the dependence of exporting countries’ economies on external conditions. The countries in the sample were selected based on the availability of detailed statistics on their financial cycle indicators, differences in their overall development and resource dependence, and also their different MPP experiences.

The results of this research are consistent with previously published findings (González et al., 2015; Agarwal et al., 2017; Kinda et al., 2016; Pestova and Mamonov, 2016) providing evidence that commodity cycles have a significant influence on financial cycles in resource-based economies. In the majority of the countries analysed, commodity price growth leads to the strengthening of national currencies and the narrowing of sovereign risk premiums on investments in national assets. It should be noted that exchange rate and risk premiums are more sensitive to price movements in countries that have a higher proportion of the key commodity exported in the overall volume of exports and a lower level of MPP implementation. The advanced economies under review (Canada and Australia) show a negative correlation between commodity price trends and lending, which is determined by the countercyclical movement of the central banks’ policy interest rates in response to change in the global terms of trade (a countercyclical monetary policy) and the implementation of MPP. In the developing countries which apply MPP extensively (Columbia and Chile), market interest rates also increase in response to the growth of commodity prices, which explains the lower sensitivity of the overall and foreign currency lending growth rates to global commodity market shocks as compared to the developing countries which implement MPP to a lesser extent (Russia and Brazil). In Russia, increasing oil prices accelerate growth in lending, corporate sector foreign debt, and the share of foreign currency loans taken by both households and firms. As a consequence, to reduce the dependence of national economies’ and financial systems’ parameters on commodity cycles, the economic authorities of emerging markets, and Russia in particular, should put greater effort into developing financial markets and implementing MPP tools more extensively.
The rest of the paper is structured as follows. Section 2 is dedicated to an overview of the results of theoretical and empirical research on the correlation between commodity and financial cycles in resource-based economies, with a description of the statistical data and analysis methods used. Sections 3 and 4 describe the methods employed in this paper and the statistical data used respectively. Sections 5 and 6 present the estimated sensitivity of the lending activity indicators of commodity-exporting countries to global commodity price shocks, along with cross-country comparisons. Section 7 provides conclusions based on the analysis conducted and policy recommendations for resource-based emerging market economies, which could help reduce the correlation between the commodity and financial cycles.

2. Literature review on the correlation between the commodity and financial cycles and the effectiveness of MPP

The influence of global commodity price shocks on the dynamics of macroeconomic and financial indicators in resource-based economies has been widely discussed in the literature.

The generally accepted point of view is that export earnings influence the balance of payments and exchange rates in countries with predominantly commodity-based export structures (Basher et al., 2012; Dauvin, 2014; Coudert et al., 2015). Foreign trade shocks influence both the volatility levels of macroeconomic indicators (Makin, 2013; Hegerty, 2016) and the dynamics of business cycles in these countries.

The correlation between the dynamics of commodity prices and lending activity in commodity exporters has been less thoroughly covered in the literature. However, individual theoretical and empirical studies confirm the significant interconnection between global commodity market conditions and lending dynamics, especially in countries with commodity-oriented export structures.

In their research using the Dynamic Stochastic General Equilibrium Model (DSGE), González et al. (2015) show that positive oil price shocks lead to growth of the overall lending level. Ftiti et al. (2016) detect a stable long-term correlation between commodity and credit cycles in a sample of African countries, while in the short- and medium-term only substantial negative commodity price shocks lead to changes in lending indicators.

Among other authors, the Bank of Russia (Bank of Russia, 2017; Sinyakov and Khotulev, 2017) has discussed the mechanism for the commodity cycle’s influence on financial stability in commodity-exporting countries. The growth of global commodity prices promotes capital inflow to commodity-exporting countries and the growth of business and investment activity, which, in turn, spurs demand for lending. Moreover, intensification of foreign currency inflow from exports ensures the strengthening of national currencies and the narrowing of risk premiums on investments in national assets. In such conditions, economic agents are more willing
to borrow, both in national and foreign currencies. Thus, growth of commodity prices can lead to a lending boom and increasing foreign currency predominance in national economies, i.e. to the accumulation of systemic financial risks.

If there is a downturn on the global commodity markets, the amount of liquidity in national financial markets goes down, and the national currencies of commodity exporters depreciate. In these conditions, there is a reduction in credit activity and a deterioration in economic agents' ability to fulfil their foreign currency liabilities. As a result, financial stability is threatened, and the likelihood of a financial crisis increases.

The results of recent empirical research analysing the correlation between commodity and credit cycles in resource-based economies confirm that increased (decreased) commodity prices lead to increased (decreased) lending activity in the countries in question, and that the existence of such a dependence is a source of vulnerability for national financial systems (Agarwal et al., 2017; Kinda et al., 2016; Moreno et al., 2014; Alodayni, 2016).

Research by Agarwal et al. (2017) is dedicated to assessing the impact of terms of trade shocks on volumes of bank lending in 78 developing countries in 2004–2015 using the panel regression model. The authors show that negative commodity price shocks lead to a decrease in the overall level of lending. This effect materialises through supply of and demand for bank loans. A deterioration in the global terms of trade leads to a slowdown in economic activity, which weakens incentives to invest and contributes to a decrease in demand for loans. As business activity decreases, the deposit base of the banking sector shrinks, the ability of economic agents to service debt obligations is reduced, and the quality of banks’ assets deteriorates. Consequently, loan supply decreases as well. The negative influence of commodity market dynamics on credit cycle indicators is stronger in countries with lower income and a primarily commodity-based export structure. The greatest credit contraction is experienced by banks with a low level of deposits and a high share of overdue debt.

Kinda et al. (2016) give a more detailed assessment of the correlation between the dynamics of global commodity prices and the vulnerability of the financial sector, also using the panel regression model. Based on analysis of data on 71 countries with a resource-oriented export structure for the period 1997–2013, the authors show that a decrease in commodity prices leads to a decrease in the solvency of economic agents and a deterioration in the quality of commercial banks’ balance sheets. There is also a decrease in the liquidity and profitability levels of the banking sector, an increase in the share of overdue debts, an increase in the probability of a banking crisis, and a decrease in the size of provisions for non-performing loans. A commodity price downturn can result in disruption of the balance of the state budget, forcing governments to use their sovereign funds and central banks to use their international reserves to counter threats to financial stability. In conditions of limited liquidity, economic agents (including the state) may resort to borrowing on the international market, which will trigger growth in the proportion of FX debt in the private and public sectors of the economy. Commercial banks’ performance...
indicators are more sensitive to negative commodity shocks in countries with poor-quality state institutions, a lack of effective fiscal and macroprudential policies, and a low level of manufacturing and export diversification.

Thus, the dependence of national financial systems on external conditions poses a challenge for the economic authorities of commodity-producing countries. Sinyakov and Khotulev (2017) note that optimal economic policy in commodity-exporting countries should include an inflation targeting regime (and, accordingly, a floating exchange rate), a conservative fiscal policy with a fiscal rule, and a set of macroprudential regulation measures.

Moreover, research by Menna and Tobal (2018) concludes that monetary policy tools can turn out to be insufficient to curb financial stability threats in financially open developing economies. The authors draw this conclusion on the basis of calculations under a theoretical New Keynesian model, using statistical data on Mexico’s economy. In response to positive external shocks leading to the improvement of financial cycle indicators, monetary authorities can raise interest rates in an attempt to limit the possible increase in internal lending. However, in the absence of restrictions on cross-border capital flows, and given the high dependence of developing economies on foreign funding (due to the relative underdevelopment of national financial markets), interest rate hikes can provoke an inflow of foreign capital to the domestic markets of developing countries and, contrary to expectations, lead to increased internal lending. This may increase leverage and foreign debt, and add to the accumulation of systemic risks. For this reason, the authors conclude that, in response to positive shocks from the external sector, an optimal strategy for the monetary authorities of countries with open capital accounts would involve reducing interest rates rather than increasing them.

After the global financial crisis of 2007–2009, an approach according to which economic authorities should pursue a countercyclical macroprudential policy to prevent the accumulation of financial system risks is becoming more and more widespread: the tightening of MPP by the regulator during the growth phase of a credit cycle will result in the growth of prices for lending resources, which will inhibit a boom in the financial market.

González et al. (2015) note that, in order to control lending activity during the growth phase of a financial cycle, monetary policy tools (short-term interest rates and foreign currency interventions) and macroprudential policy tools (financial regulation measures influencing the level of market interest rates) are used together, and that the supplementation of monetary policy with macroprudential tools ensures more effective control of lending during the growth phase of a financial cycle.³

Empirical research by Cerutti et al. (2017) and Cizel et al. (2016) provides a detailed analysis of the influence of MPP on lending activity and the financial

³ In this situation, interindustry discrepancies in the structure of economies strengthen due to the more substantial lending decrease in the tradable sector and the continuing growth of lending in the non-tradable sector. However, the scale of this effect is insignificant.
sector, based on cross-country comparisons using panel data regressions. Cerutti et al. (2017) assess the effectiveness of the MPP implemented in 119 countries of various levels of development in 2000–2013. The authors conclude that the use of MPP tools promotes slowdowns in lending growth, especially in the consumer lending sector. The tightened internal lending conditions resulting from MPP implementation stimulate external fund raising in foreign markets. This is why the efficiency of MPP is higher in countries with relatively less developed financial systems and a closed capital account. The effectiveness of MPP is characterised by asymmetry of influence: the influence of regulatory authorities’ policy tools is higher during the growth phases of financial cycles.

The effectiveness of macroprudential regulation of economies has also been confirmed in research dedicated to the economies of specific regions: eight North and South American countries in an article by Gambacorta and Murcia (2017) and twelve Pacific Rim countries by Bruno et al. (2015).

Thus, the results of empirical research show that MPPs are effective with regard to controlling the growth of lending and limiting systemic financial risks. At the same time, the use of MPP does not distort the effect of other economic policy tools. Richter et al. (2018) note that the implementation of MPP tools is accompanied by only a limited reaction from inflation and output, especially in advanced economies; in other words, the pursuit of an effective MPP does not prevent the achievement of central banks' inflation and output targets.

Research publications dedicated to the Russian economy also analyse the influence of the global commodity market situation on the dynamics of national macroeconomic variables. The authors of the majority of studies arrive at the conclusion that the improvement of global terms of trade leads to the expansion of economic activity. Based on Russian data for 1995–2009, Ito (2012) demonstrates that a 1% increase in global oil prices leads to GDP growth of 0.44% in the long term. Increased export income leads to increased consumption, investments, and GDP (Malakhovskaya and Minabutdinov, 2013). The results of a study by Polbin (2017) demonstrate that, contrary to the traditional opinion, growth of oil prices leads to growth of gross production only in the short term (2–2.5 years), while in the mid term, this correlation becomes negative.

That said, only a limited number of studies on the influence of global oil cycle parameters on the level of lending activity in Russia has been carried out. In their article, Pestova and Mamonov (2016) use the BVAR model of the Russian economy to demonstrate, on the basis of 2000–2015 data, that an increase in the Brent oil prices leads to increased gross output, as well as to increased external debt in the corporate sector and an increased overall level of consumer and corporate lending (these effects peak one and two years after the shock respectively). Research by Lomivorotov (2014) does not find any statistical correlation between the dynamics of oil price indicators and overall lending in Russia. Nevertheless, the author includes the volume of lending in his model and explains, on a theoretical level,
that external shocks (including the global energy market situation) influence Russia’s financial variables.

Despite the availability of evidence of a correlation between commodity cycles and financial stability in commodity-exporting countries, and of the role of macroprudential policies in these countries, this area of research is fairly new. This study contributes to the literature in the following regards.

First, it aims to quantify the statistically significant correlation between the parameters of commodity and credit cycles using BSVAR models for six selected resource-dependent countries, including advanced economies. A review of the literature indicates the lack of a sufficient range of studies containing econometric assessment of those effects and making cross-country comparisons. The empirical results of the research confirm the mechanism for the correlation between commodity and financial cycles described in an analytical note by the Bank of Russia (2017).

Second, this study considers more lending activity indicators than other research: not only is overall lending volume analysed, but volumes of lending in national and foreign currencies are also considered, along with lending volumes broken down into borrower categories, which makes it possible to assess the sources of vulnerabilities and risks for specific market segments of the countries in question in detail. The list of lending indicators for each of the countries is defined by the availability of data, and is therefore most complete for Russia. It is especially important to identify the influence of oil market shocks on dollarisation parameters in Russia’s banking sector.

Third, the results obtained for specific countries are grouped based on the extent of these countries’ economic development into advanced economies (Australia and Canada) and emerging markets (Brazil, Chile, Columbia, Russia).

Fourth, observable correlations between the dynamics of commodity price indicators and lending growth rates are found to be consistent with the actual experience of MPP implementation in each of the countries, which enables the conclusion to be drawn that the pursuit of a countercyclical MPP contributes to reducing a country’s vulnerability to the situation on global commodity markets.

### 3. Research methodology

To conduct the research, time series models based on various credit cycle indicators (depending on data availability, see below) are constructed for each of the six countries with a significant share of commodity exports in their overall export structures.

Methodologically, the research is based on the BSVAR model. The vector autoregression (VAR) mechanism makes it possible to take endogenous relationships between different macroeconomic variables into account. The structural identification of the model facilitates qualitative analysis of the
statistically significant correlations observed between the analysed variables. The Bayesian approach to the assessment of VAR model coefficients eliminates the problem of excessive model parametrisation (the ‘dimensionality curse’).

We have decided to construct a model with a large number of regressors, as this will increase the volume of information available for analysis, which will in turn increase the reliability of the estimated relationships between individual macroeconomic variables. This enables us to avoid the potential occurrence of errors and the establishment of false correlations between model variables that contradict macroeconomic theory (Bernanke and Boivin, 2003). This issue is a key for the analysis of Russian data, since in the past 20 years the Bank of Russia has changed its monetary policy stance several times. For this research, it is especially important to take the various monetary policy tools of the Bank of Russia into account, as we are analysing the reaction of interest rates to shocks in the commodity market and drawing a conclusion concerning the performance of lending activity indicators in accordance with the phase of the commodity cycle.

The basic specification for a VAR model with \( m \) variables and \( p \) lags is written as follows (a structural specification of the model is provided below):

\[
Y_t = B_{\text{const}} + B_1 Y_{t-1} + B_2 Y_{t-2} + \cdots + B_p Y_{t-p} + \epsilon_t,
\]

where \( \epsilon_t \sim N(0, \Sigma) \), \( Y_t = (y_{1t}, y_{2t}, \ldots, y_{mt})' \) is the vector of endogenous variables of the dimensionality \( m \) (\( t = 1, \ldots, T \)), \( B_{\text{const}} = (b_1, b_2, \ldots, b_m)' \) is the constant vector of the dimensionality \( m \), and \( B_i \) is the matrix of autoregressive coefficients \( m \times m \), where \( l \) is the number of the lag from 1 to \( p \).

After grouping \( B = [B_{\text{const}} \ B_1 \ldots B_p]' \) and \( X_t = [1 \ Y_t' \ldots Y_{t-p}'] \), the reduced form of VAR is obtained:

\[
Y_t = B'X_t + \epsilon_t.
\]

The need for Bayesian regularisation of the model parameters is explained by the use of a relatively wide range of regressors (around 10 variables) with a maximum lag depth (5 periods for quarterly data-based models and 13 periods for models based on monthly statistical data).

The Bayesian formula is as follows:

\[
p(B, \Sigma|Y) = \frac{p(B, \Sigma)p(Y|B, \Sigma)}{p(Y)},
\]

where \( p(B, \Sigma|Y) \) is the density of posterior distribution; \( p(B, \Sigma) \) is the prior density of model parameters, \( p(Y|B, \Sigma) \) is the likelihood function of a vector autoregression task, and \( p(Y) \) is the distribution density of actual data.

\(^4\) At the same time, we admit that increasing the number of variables leads to a nonlinear extension of the range of parameters assessed and a narrowing of the prior distribution of model coefficients during Bayesian assessment of the model.
Thus, the Bayesian approach is based on a combination of actual data information and prior information on the distribution of model parameters. Taking into account prior information, the researcher obtains an a posteriori distribution of model parameters.

The next phase of Bayesian assessment of a model is the selection of the appropriate type of prior distribution of model coefficients. In this study, an independent normal inverted prior Wishart distribution will be used as the prior distribution of parameters. In accordance with this distribution, the vector $b$ of the model coefficients is distributed in accordance with the normal distribution law (with a prior average $\bar{b}_0$ and a parameter covariance matrix $H$), and the error covariance matrix $\Sigma$ is distributed in accordance with the inverted Wishart distribution law with the prior parameters $\bar{S}$ and $\alpha$ (number of degrees of freedom) (Blake and Mumtaz, 2017):

\[
\begin{cases}
  b = vec(B) \sim N(\bar{b}_0, H), \\
  \Sigma \sim IW(\bar{S}, \alpha), \\
  b \text{ and } \Sigma \text{ are independent.}
\end{cases}
\]

Using a priori ideas makes it possible to take the non-stationary nature of macroeconomic variables into account. The elements of the a priori coefficient matrix of the vector autoregression model in abridged form $\bar{B}(\bar{b}_0 = vec(\bar{B}))$ are as follows (Blake and Mumtaz, 2017, p. 31; Pestova and Mamonov, 2016, p. 61):

- the equation for each particular variable has non-zero coefficients only for the first lag of this variable;
- the equation for each non-stationary variable in the model has the coefficients for the first lag of this variable equal to 1.

This can be presented as follows:

\[
\begin{pmatrix}
  VIX_t \\
  Brent_t \\
  \vdots \\
  CDS_t
\end{pmatrix} =
\begin{pmatrix}
  0 & 0 & \cdots & 0 \\
  0 & \bar{B}_{21} & \cdots & 0 \\
  \vdots & \vdots & \ddots & \vdots \\
  0 & 0 & \cdots & \bar{B}_{m+1,m}
\end{pmatrix}
+ \begin{pmatrix}
  VIX_{t-1} \\
  Brent_{t-1} \\
  \vdots \\
  CDS_{t-1}
\end{pmatrix} + \begin{pmatrix}
  \varepsilon_{VIX} \\
  \varepsilon_{Brent} \\
  \vdots \\
  \varepsilon_{CDS}
\end{pmatrix}.
\]

Matrix $\bar{B}$ (with $(1 + mp)$ lines and $m$ columns) will be:

\[
\begin{pmatrix}
  0 & 0 & 0 & 0 & \cdots & 0 \\
  0 & \bar{B}_{21} = 1 & 0 & 0 & \cdots & 0 \\
  0 & 0 & \bar{B}_{32} = 1 & 0 & \cdots & 0 \\
  0 & 0 & 0 & \bar{B}_{43} = 1 & 0 & \cdots & 0 \\
  \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
  0 & 0 & 0 & 0 & \bar{B}_{54} = 1 & \cdots & 0 \\
  \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
  0 & 0 & 0 & 0 & 0 & \cdots & 0
\end{pmatrix}.
\]
The covariance matrix of parameters $H$ is set as follows. The dimensionality of the covariance matrix of parameters $H$ is $d = ((m(mp + 1)) \times (m(mp + 1)))$.

According to Bank of England economists Blake and Mumtaz (2017), every element of the diagonal covariance matrix of parameters in the model $H$ equals $(\sigma_i \lambda_i)^2$ for the constant, $(\frac{1}{\sigma_i} \lambda_i)^2$ for $i = j$ and $(\frac{\sigma_i \lambda_i \lambda_j}{\sigma_i \lambda_j})^2$ for $i \neq j$, $i$ and $j = 1 ... m$ (the number of variables in the model), where the index $i$ corresponds to the number of the dependent variable in each of its equations, and the index $j$ corresponds to the number of the independent variable in the equation of each dependent variable.

Moreover, to model economic processes in small open economies using the independent normal inverted prior Wishart distribution, limits can be imposed on coefficients of external sector variables (Blake and Mumtaz, 2017, pp. 37–41) in order to exclude the effect of internal real, financial, and monetary variables on the external block indicators.

The list of variables will be described in more detail in the next section. However, for clarity, consider the following. Some specification of the model includes 11 variables (VIX index, commodity price, US/EU GDP, internal GDP, domestic inflation, external debt, interest rate, lending, monetary base, currency rate and credit default swap (CDS) spread) with 13 lags. The dimensionality $d$ of the covariance matrix of parameters $H$ is $1584 \times 1584$. We take the values of those $H_{dd}$ corresponding to the relation between the external sector variables and other macroeconomic variables to be close to zero. As a result, the dynamics of each of the three exogenous variables (the VIX index, commodity price and USA/EU GDP) depend only on its own lags.

Then, to show that VIX (which comes first in the matrix of input data) depends only on its own lags, we approximate all elements $H_{dd}$ to zero, where $d$ takes a value from 1 to 144, except for $d = 1$ (for the constant) and $d = (2 + z \cdot 11)$, where $z = 0, ..., 12$:

\[
\begin{pmatrix}
H_{11} & 0 & 0 & ... & 0 & 0 & 0 & ... & 0 & 0 & ... & 0 & ...

0 & H_{22} & 0 & ... & 0 & 0 & 0 & ... & 0 & 0 & ... & 0 & ...

0 & 0 & H_{33} & ... & 0 & 0 & 0 & ... & 0 & 0 & ... & 0 & ...

... & ... & ... & ... & ... & ... & ... & ... & ... & ... & ... & ...

0 & 0 & 0 & ... & H_{1212} & 0 & 0 & ... & 0 & 0 & ... & 0 & ...

0 & 0 & 0 & ... & 0 & H_{1313} & 0 & ... & 0 & 0 & ... & 0 & ...

0 & 0 & 0 & ... & 0 & 0 & H_{1414} & ... & 0 & 0 & ... & 0 & ...

... & ... & ... & ... & ... & ... & ... & ... & ... & ... & ...

0 & 0 & 0 & ... & 0 & 0 & 0 & ... & H_{3333} & 0 & ... & 0 & ...

... & ... & ... & ... & ... & ... & ... & ... & ... & ...

0 & 0 & 0 & ... & 0 & 0 & 0 & ... & 0 & H_{134134} & ... & 0 & ...

0 & 0 & 0 & ... & 0 & 0 & 0 & ... & 0 & 0 & H_{135135} & ... & 0 & ...

... & ... & ... & ... & ... & ... & ... & ...

0 & 0 & 0 & ... & 0 & 0 & 0 & ... & 0 & 0 & 0 & H_{144144}
\end{pmatrix}
\]

lag 1 lag 2 lag 13 for the 1st variable
The matrix $H$ for the second variable (commodity price) and the third variable (USA/EU GDP) is filled in the same way. For the second variable, we assume all elements $H_{dd}$ to be equal to zero, where $d$ takes a value from 145 to 288, except for $d = 145$ (for the constant) and $d = (147 + z \cdot 11)$, where $z = 0, ..., 12$. For the third variable (USA/EU GDP), we assume all elements $H_{dd}$ to be equal to zero, where $d$ takes a value from 289 to 432, except for $d = 289$ (for the constant) and $d = (292 + z \cdot 11)$, where $z = 0, ..., 12$.

Empirical calculations are performed in the Matlab software package using code from Kolb (2016) and Blake and Mumtaz (2017).

The numerical values for the hyperparameters of prior distribution ($\lambda_1$, $\lambda_2$, $\lambda_3$ and $\lambda_4$) are selected in accordance with certain conceptual considerations (Demeshev and Malakhovskaya, 2016).

The parameter $\lambda_1$ describes the overall ‘rigidity’ of prior distribution. The closer $\lambda_1$ is to 0, the more the researcher relies on prior information concerning the distribution of model indices and the less he or she relies on the actual information contained in the data. In empirical publications, indicator values are established in accordance with model dimensionality. That is why, in this case, the parameter $\lambda_1$ equals 0.1, as for a middle-dimensionality BSVAR.

The Bayesian cross-regularisation parameter $\lambda_2$ reflects the ‘rigidity’ of prior distribution in relation to the current and lag values of other model regressors compared to the current variable. In other words, this parameter is responsible for the importance of other variables in the description of the dynamics of a certain variable compared to its own values (this variable may also abide by the ‘random walk’ law and be defined to a greater extent by its prior values than by other factors). The value of the parameter $\lambda_2$ is set at 0.5.

The hyperparameter $\lambda_3$ reflects the relative importance of lag values compared to its current value. The higher the value of $\lambda_3$, the faster the decrease of prior dispersion values as the lag number increases. The parameter $\lambda_3$ is assigned a value of 1.

The hyperparameter $\lambda_4$ shows the relative ‘rigidity’ of constant distribution. Relatively high values of constant dispersion mean that tighter limitations are applied to its value. In this case, $\lambda_4$ equals 1,000, which also tallies with the results of empirical research (Pestova and Mamonov, 2016).

The error covariance matrix $\Sigma = \text{var} \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{nt} \end{pmatrix}$. The matrix $\tilde{S}$ (the parameter of the prior distribution scale of the matrix $\Sigma$) takes a diagonal form: the main diagonal elements are estimates of the standard error deviations of each model variable in accordance with the AR(1) first-order autoregression models for each of the endogenous variables.

The a priori number of degrees of freedom in the error covariance matrix $\Sigma$ is calculated as follows: $\alpha = m + 1$.

Unconditional posterior distribution parameters may not be represented analytically, which is why the Gibbs algorithm is used for calculations. The conditional posterior distribution parameters are as follows:
\[
\begin{cases}
b|\Sigma, Y \sim N(\bar{b}, \bar{H}), \\
\Sigma|b, Y \sim IW(\bar{S}, \bar{a}),
\end{cases}
\]

where \( \bar{a} = \alpha + T \) (number of observations),
\[
\bar{S} = \bar{S} + (Y_t - B'X_t)'(Y_t - B'X_t);
\]
\[
\bar{H} = (H^{-1} + \Sigma^{-1} \otimes X'_tX_t)^{-1};
\]
\[
\bar{b} = \bar{H} \cdot (H^{-1}\bar{b}_0 + (\Sigma^{-1} \otimes (X'_tX_t))\bar{b}),
\]
where \( \bar{b} = vec(X'_tX_t)^{-1}X'_tY_t. \)

Structurally, the VAR model may be written as follows:
\[
AY_t = F_{const} + F_1Y_{t-1} + F_2Y_{t-2} + \cdots + F_pY_{t-p} + Dv_t,
\]
where \( B_{const} = A^{-1}F_{const}, B_i = A^{-1}F_i \) (i = 1 \ldots p), \( \epsilon_t = A^{-1}Dv_t, E(v_tv'_t) = I, \) and \( A^{-1}DD'(A^{-1})' = \Sigma. \)

Consequently, to identify structural shocks (the impact of isolated shocks of each endogenous variable on all model variables), the only decomposition into the product of matrices \( A^{-1}DD'(A^{-1})' = \Sigma \) for the unit matrix \( A \) and for the lower triangular matrix \( D \) has to be found.

The structural identification of the model is based on recursive ranking of variables (sorting them in accordance with the speed of the shock reaction) and Cholesky orthogonalisation. The recursive ranking method is often used for structural identification of large macroeconometric models (Christiano et al., 1999; Banbura et al., 2010).

This research assesses the influence of changes in global terms of trade on the parameters of national financial cycles in small open economies. In other words, in our research, external sector variables are set as exogenous variables with respect to internal variables, and hence do not react to internal variable shocks. In general, the following order of variable sorting has been chosen, from the ‘most exogenous’ to the ‘most endogenous’ (the parameters are listed in accordance with their location within the endogenous variable vector):

- External sector variables: global market volatility indicator, commodity prices, global GDP;
- National macroeconomic variables: domestic GDP and inflation;
- National financial variables: external debt, interest rate, lending, monetary base, currency exchange rate, risk premium.

Hence, within an endogenous variable vector, the price of a commodity (terms of trade) is placed in second position, and the credit risk indicator is placed in eighth position.

Qualitative interpretation of model results is based on analysis of the impulse response functions of credit cycle indicators in response to commodity price shocks and on the calculation of the maximum commodity price shock elasticities of lending indicators. Credible intervals for median responses are provided in the 16th and 84th percentiles.
Each time series model includes one lending activity indicator; hence, estimates of the sensitivity of different credit cycle parameters to changes in global terms of trade are obtained on the basis of various BSVAR model specifications. Moreover, depending on the availability of statistical information on different financial cycle indicators, we assess models using either quarterly or monthly data frequency.

4. Data

For the purposes of this research, statistical data5 from the official websites of national central banks, statistical services, the International Monetary Fund (IMF), the Bank for International Settlements (BIS), and Bloomberg are used. The countries considered include large exporters, both advanced economies and emerging markets (Table 1): Russia, Columbia, Chile, Canada, Australia, and Brazil.6

The rationale for the inclusion of these countries in the sample for this research is as follows. First, we believe it necessary to include countries with different levels of economic development in the sample: both developed and emerging markets. The countries we consider include Canada and Australia in the former category, and Brazil, Chile, Columbia, and Russia in the latter. Second, we consider it important to select countries specialising in different types of commodities: oil, copper, iron ore, and coal. Third, we have attempted to focus on the analysis of countries where accurate statistical data is publicly available. Finally, with regard to developing countries, we aim to compare the reaction of credit cycles in countries where MPP tools have been used extensively and for a long time (Columbia and Chile) with data on countries in which these tools have been employed for a shorter time (Brazil and Russia).

**Table 1. Share of the key export item in total export earnings in commodity-exporting countries in 2017**

<table>
<thead>
<tr>
<th>Country</th>
<th>Export category</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chile</td>
<td>Copper</td>
<td>58%</td>
</tr>
<tr>
<td>Russia</td>
<td>Crude oil and petroleum products</td>
<td>42%</td>
</tr>
<tr>
<td>Columbia</td>
<td>Crude oil and petroleum products</td>
<td>35%</td>
</tr>
<tr>
<td>Australia</td>
<td>Coal</td>
<td>16%</td>
</tr>
<tr>
<td>Canada</td>
<td>Crude oil</td>
<td>13%</td>
</tr>
<tr>
<td>Brazil</td>
<td>Iron ore</td>
<td>9%</td>
</tr>
</tbody>
</table>

Source: author’s calculations based on Bloomberg data

---

5 The length of the time series is January 2003–November 2017 for Chile, January 2004–November 2017 for Russia, Columbia, Canada, and Australia, and January 2005–November 2017 for Brazil.

6 During the period covered by this study, all the countries have been characterised by a comparable monetary policy framework: an inflation targeting (IT) regime (carrying out an independent monetary policy with free movement of global capital flows) and a floating currency exchange rate. Canada shifted to IT in 1991, Australia in 1993, and Brazil, Chile, and Columbia in 1999 (Martínez, 2008). Among the countries under review, only Russia adopted IT relatively recently, in 2014; therefore, for Russia we additionally assess the relation between the parameters of the commodity and financial cycles in periods of homogeneous monetary policy.
Each of the time series models includes the following variables (listed from the ‘most exogenous’ to the ‘most endogenous’):

**External sector variables:**
1. The imputed volatility of the S&P 500 stock index in the USA (the VIX index of the Chicago Option Exchange)\(^7\).
2. Commodity prices (prices per barrel of Brent crude oil or per metric ton of copper, coal, or iron ore in USD).
3. Real GDP of the USA (or the EU).

**Internal macroeconomic variables:**
4. Real GDP (for quarterly data-based models) or real industrial production index (for monthly data-based models).
5. Consumer Price Index (CPI) in national currency.

**Internal financial variables (financial cycle variables):**
6. Interest rate.
7. Monetary base (broad definition).
8. Credit cycle indicator (see below).
9. Nominal USD – national currency exchange rate (as this indicator grows, the national currency weakens).
10. Risk premium (the spread on five-year sovereign CDS).

In the specifications of models based on Russian monthly data, we use sectoral loan interest rates for up to one year, which correspond to certain lending components (lending for special categories of borrowers and lending currency).

In the specifications of models based on Russian quarterly data (with indicators of external debt and the share of loans in GDP), more general financial market indicators are used, such as the interest rates of the interbank lending market MIACR for overnight rouble loans.

In the specifications of models based on data from other countries aside from Russia, indicative interest rates on short-term and medium-term loans to the private sector (the IMF Lending Rate\(^8\)) are used.

Thus, generating a model based on Russian data we take into account both the Bank of Russia’s monetary policy and credit market conditions (an appropriate loan rate is used for individual lending components). For other countries, for data comparability purposes, data from a single source are used.

---

\(^7\) The VIX volatility index reflects sentiments on the global financial markets and the risk appetite of global investors. This indicator also reflects global monetary policy (including leading central banks, in particular the US Federal Reserve System), which has a significant effect on financial markets in developing countries. Empirical research confirms that the policy pursued by the US Federal Reserve System has a statistically significant effect on the expectations of financial market participants. Krieger et al. (2012) show that, after meetings of FOMC members, VIX decreased substantially, as the regulator’s decisions lessened uncertainty with respect to the future path of interest rates in the US. Rey (2018) points out that VIX changes together with the global financial cycle, in which the monetary policy of leading global economies is one of the key determinants.

for short-term and medium-term interest rates, which are also affected by monetary policy tools.\textsuperscript{9}

The following credit cycle indicators are used to assess the influence of changes in the terms of trade on the level of credit risk in Russia:
- The annual overall growth rate in roubles and in a foreign currency in which individuals and legal entities borrow (% YoY\textsuperscript{10}).
- The shares of overdue debt under loans to individuals and legal entities in roubles and foreign currency (percentage points, p.p.).
- The share of foreign currency loans to individuals and legal entities (p.p.).
- The annual growth rate of the external debt of the corporate sector (% YoY)
- The annual growth rate of the loan-to-GDP ratio (% YoY).

The following credit cycle indicators are used to assess the influence of changes in the terms of trade on the level of credit risk in other countries:
- The annual growth rate of the overall lending level (% YoY).
- The annual growth rate of consumer and corporate lending (% YoY).
- The annual growth rate of foreign currency lending (% YoY).
- The annual growth rates of the shares of foreign currency loans (% YoY).
- The annual growth rate of external debt (of the private sector, the corporate sector, and overall) (% YoY).
- The annual growth rate of the loan-to-GDP ratio (% YoY).

Differences in the credit risk indicators which we include in empirical models for each of the countries, and the reaction of which to commodity shocks we assess, stem from the availability of statistical data in open sources. We include the most indicators for Russia, as a vast quantity of Russian statistical data is available.

Real economy indicators are provided against the base year 2010 (the values of the real indicators equal 100% in January (or Q1) 2010). Data on the overall foreign currency lending level and its share in the loan portfolio of countries other than Russia are obtained from the Financial Soundness Indicators of the IMF. When calculating the indices of foreign currency predominance and the rates of foreign currency lending changes, data adjusted for changes in the exchange rate are used. The time series are seasonally adjusted in the Eviews package using the X-12 filter.

\textsuperscript{9} The influence of monetary policy on interest rates for various terms is a subject of scholarly debate. In a theoretical paper, Chun (2011) shows that changes in the expectations of market participants as a result of the actions of fiscal authorities cause changes in the yield of government bonds with long maturity periods. Empirical work by Bernanke et al. (2005) shows that changes in the Federal Funds rate made by the US Federal Reserve System have a significant effect on the dynamics of the yields of treasury bonds with a maturity period of five years. In developing countries, the sensitivity of yields on long bonds to monetary policy shocks is lower than in countries with more developed financial markets and, consequently, a more effective mechanism of monetary policy transmission. However, research based on Russian data reveals that monetary policy has a significant effect on yields on long-term securities. Using the BVAR model of the Russian economy, Lomivorotov (2014) shows that, on average, a 50bp increase in the REPO rate causes a 0.1–0.15% increase in the yield on 10-year federal government bonds.

\textsuperscript{10} The annual growth rate of an indicator (% YoY).
To perform the calculations, all data series except interest rates are provided as annual growth rates in percent. The shares of overdue debt in the overall loan portfolio and the foreign currency predominance indices of loans to individuals and legal entities for Russia are also included in the model in percent. Some of the data we use are nonstationary, but the Bayesian approach to VAR assessment makes it possible to take nonstationarity into account when establishing the prior distribution of model coefficients (Bańbura et al., 2010; Pestova and Mamonov, 2016).

5. Assessment of the commodity price elasticity of credit cycle indicators

Statistical data on each of the economies under consideration is used as the basis for assessing the impulse response functions of credit cycle indicators in response to commodity price shocks. In the case of a significant impulse response (median impulses and credible intervals do not include the zero point), the maximum possible value of the commodity price elasticity of the credit cycle indicator is calculated. Tables 2–7 show the summary data for each of the countries considered.

Each of Tables 2–7 contains the estimated commodity price elasticities of credit cycle indicators. An elasticity of X means that, if the annual growth rate of a commodity price accelerates by 1 p.p., the growth rate of the credit cycle indicator will increase by X p.p. Besides elasticities, Tables 2–7 provide information on the periods in which commodity market shock has had the maximum impact on credit cycle indicators.

5.1. Russia

According to the Federal Customs Service of Russia, earnings from exports of crude oil and petroleum products account for a significant share of the country’s exports (42% in 2017) (Figure 1). For this reason, to approximate terms of trade shocks, we will use the price of Brent crude oil in US dollars. Calculations for Russia are performed using statistical data for 2004–2017.

The results of assessment of the sensitivity of credit cycle indicators to oil shocks are provided in Table 2. Graphs of the impulse response functions on the basis of which elasticity coefficients are calculated are provided in Figure 1 in the Appendix. The results of assessment of impulse functions show that positive oil price shocks lead to a decrease in the overall risk level in the Russian

---

11 Using data in the form of the indicator’s annual growth rates makes it possible, on the one hand, to preserve information about trend changes in the variable (as compared to monthly growth indicators) and, on the other hand, to reduce the duration of empirical calculations in a large macroeconomic model (as compared to data in levels). An example of the use of this method of data processing is Bergholt et al. (2019). Moreover, using the statistics on lending and its components in the form of annual growth rates is valuable for financial stability research, as they are a generally accepted indicative measure of risk (Alessi and Detken, 2018; Bank for International Settlements, 2019).
financial market (narrowing of the CDS spread) and the strengthening of the rouble against the US dollar through additional inflow of export earnings to the national financial market and improvement of the balance of payments. In general, the dynamics of these macroeconomic variables correspond to the phenomena and effects we observe in other commodity-exporting countries (e.g., see Sinyakov and Khotulev, 2017).

**Figure 1. Russia’s export structure in 2006–2017 (%)**

![Graph showing Russia's export structure in 2006–2017 (%)](image)

*Source: Federal Customs Service of Russia*

It should be noted that the interest rate of the interbank lending market decreases when global oil market dynamics improve, which means that, during the growth phase of a commodity cycle, lending conditions in the Russian financial market ease. This result may be related to the fact that, during the period analysed, the Bank of Russia switched to interest rate management only at the end of 2013 (the switch to the inflation targeting policy was announced in November 2014), that the Ministry of Finance’s implementation of the countercyclical fiscal rule in Russia is relatively recent, and that the country currently has only brief experience of implementing macroprudential regulation.

Thus, during the entirety of 2004–2017, the easing of financial conditions in the Russian market was accompanied by the expansion of lending in Russia. In response to the growth of oil prices, the growth rate of rouble and foreign currency lending to individuals and firms increased, as did the total volume of lending.

The growth rates of rouble and foreign currency lending to individuals increase equally in response to a positive shock to oil prices. This possibly results from the measures taken by the Bank of Russia to restrict consumer foreign currency lending, which were implemented in 2013 (for more details on MPP measures in Russia and other countries, see the Appendix). By comparison, the growth rate of corporate foreign currency lending is more sensitive to oil market shocks than is
ruoble lending to legal entities. This is the result of firms’ greater need for foreign currency liquidity for international debt repayment and the increased opportunities they have to raise foreign currency funding.

Table 2. Oil price shock elasticity of Russia’s credit cycle indicators

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rouble lending to individuals</td>
<td>0.2236</td>
<td>15 months</td>
</tr>
<tr>
<td>Foreign currency lending to individuals</td>
<td>0.2424</td>
<td>22 months</td>
</tr>
<tr>
<td>Share of overdue rouble loans to individuals</td>
<td>-0.0138</td>
<td>15 months</td>
</tr>
<tr>
<td>Share of overdue foreign currency loans to individuals</td>
<td>-0.0714</td>
<td>21 months</td>
</tr>
<tr>
<td>Rouble lending to legal entities</td>
<td>0.0782</td>
<td>27 months</td>
</tr>
<tr>
<td>Foreign currency lending to legal entities</td>
<td>0.2136</td>
<td>7 months</td>
</tr>
<tr>
<td>Share of overdue rouble loans to legal entities</td>
<td>-0.0165</td>
<td>18 months</td>
</tr>
<tr>
<td>Share of overdue foreign currency loans to legal entities</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Total rouble lending level</td>
<td>0.0872</td>
<td>26 months</td>
</tr>
<tr>
<td>Total foreign currency lending level</td>
<td>0.1851</td>
<td>7 months</td>
</tr>
<tr>
<td>Overall lending level</td>
<td>0.0857</td>
<td>30 months</td>
</tr>
<tr>
<td>Share of foreign currency loans to individuals in the total portfolio volume</td>
<td>0.0359</td>
<td>18 months</td>
</tr>
<tr>
<td>Share of foreign currency loans to legal entities in the total portfolio volume</td>
<td>0.0284</td>
<td>21 months</td>
</tr>
<tr>
<td>Share of foreign currency loans in the total portfolio volume</td>
<td>0.0339</td>
<td>20 months</td>
</tr>
<tr>
<td>Corporate sector external debt</td>
<td>0.1194</td>
<td>2 quarters</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>-0.2119</td>
<td>5 quarters</td>
</tr>
</tbody>
</table>

Source: author’s calculations

The growth of oil prices in the global commodity market accelerates the accumulation of external debt in the corporate sector and leads to an economy-wide increase in the share of foreign currency loans. The effect of the growth of foreign debt manifests itself six months after the shock.

Although positive oil market shocks lead to an increase in the overall level of overdue debt and an expansion of the loan portfolio, the share of overdue debt decreases, which may demonstrate an improvement in the overall solvency of economic agents. Hence, the existence of a statistically and economically significant correlation between commodity prices and the share of overdue debt demonstrates the dependence of the Russian banking sector on external global conditions, which, in turn, could lead to the risk of financial instability in the event of a negative oil price shock.

The growth rate of the share of loans to the private non-finance sector as a % of GDP decreases within the first two years, which can probably be explained by the fact that the increase in the inflow of foreign currency earnings to the country influences the level of nominal GDP. This trend is more in line with the experience of emerging markets that have less developed financial markets and lag behind advanced economies in terms of the overall credit burden of the economy.
We also assessed the sensitivity of Russia’s financial cycle parameters during a period of relatively homogeneous monetary policy (Polbin, 2017; Pestova, 2017): before the adoption of the inflation targeting (IT) regime in November 2014 (Figure 2). Assessment of empirical data in the January 2004–November 2014 period indicates a higher oil price elasticity for most lending indicators (the key credit risk indicators out of those in Table 2 are assessed), including the foreign currency predominance ratios, as compared to the elasticity of the same indicators over the entire assessment horizon (2004–2017). This suggests that the transition to an inflation targeting regime could have contributed to the reduced dependence of Russia’s financial indicators on external shocks.

**Figure 2. Oil price elasticity of key lending risk indicators for 2004–2014 and 2004–2017**

![Figure 2: Oil price elasticity of key lending risk indicators for 2004–2014 and 2004–2017](source: author’s calculations)

5.2. Columbia

Like Russia’s economy, the economy of Columbia is largely oriented towards the export of oil and petroleum products: in 2006–2017, the average share of this export category amounted to 37% (Figure 3).

At the same time, it should be noted that, throughout the past decade, the economic authorities of Columbia have made extensive use of macroprudential regulation tools to protect the national economy from external shocks (Vargas et al., 2017; Gómez et al., 2017). For example, Columbia receives the highest score of all the countries considered in the ‘macroprudential policy index’ developed by Cerutti et al. (2017) on the basis of information concerning the number of MPP tools used by economic authorities (see Figure 8 below and Table 1 in the Appendix).

A higher index demonstrates a more substantial level of MPP tool implementation. It can be observed that, among the countries considered in this study, Chile, Columbia, and Canada have the highest levels of macroprudential regulation.
Table 3. Oil price shock elasticity of Columbia’s credit cycle indicators

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall lending level</td>
<td>0.0683</td>
<td>31 months</td>
</tr>
<tr>
<td>Share of overdue debt</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Consumer lending</td>
<td>0.1197</td>
<td>20 months</td>
</tr>
<tr>
<td>Share of overdue consumer loans</td>
<td>-0.0037</td>
<td>2 months</td>
</tr>
<tr>
<td>Corporate lending</td>
<td>0.0564</td>
<td>33 months</td>
</tr>
<tr>
<td>Share of overdue corporate loans</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Private sector’s external debt</td>
<td>-0.1078</td>
<td>9 months</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>-0.0362</td>
<td>3 quarters</td>
</tr>
<tr>
<td>Foreign currency lending</td>
<td>-0.4804</td>
<td>2 quarters</td>
</tr>
</tbody>
</table>

Source: author’s calculations

Figure 3. Columbia’s export structure in 2006–2017 (%)

Source: National Administrative Department of Statistics of Columbia

According to BVAR assessment results for Columbia, the reaction of its sovereign risk premium and the exchange rate of the Columbian peso to growth in oil prices is similar to that of Russia (see Figure 2 in the Appendix). At the same time, the dynamics of interest rates demonstrate the tightening of financial market conditions during the growth phase of the commodity cycle. Increased borrowing costs in the domestic market in response to the improved terms of trade may be explained by the implementation of an inflation targeting policy and the extensive use of MPP tools throughout the period covered by this study.12 Despite increased interest rates, lending indicators demonstrate growth during the period of higher oil

12 Besides the implementation of macroprudential policies, the specifics of Columbia’s economic structure might have influenced the nature of the correlations observed. During the period covered by this study, the economy of Columbia remained relatively closed compared to that of other Latin American countries (Vargas et al., 2017). In connection with this, the dynamics of key macroeconomic indicators (including inflation) are determined more by the condition of domestic demand than by terms of trade (via the currency exchange rate channel) or the rigidity level of financial conditions in the global market. The role of the non-tradable sector remains significant.
prices, which may signify the incomplete isolation of the country’s financial sector from the effects of the global energy resource market, as well as the narrow range of MPP tools, which do not influence the overall lending level, but only specific market segments. The behaviour of the foreign debt indicators of the private sector and the overall level of foreign currency lending demonstrate the effectiveness of the use of restrictions on creating external and foreign currency debt (for more details, see the Appendix): the change rate of those indicators decreases if oil price growth accelerates (Figure 2 in the Appendix, Table 3).

5.3. Chile

Chile specialises in the export of copper: in 2003–2017, the average share of this export item amounted to 54% of the country’s total export volume (Figure 4).

The extensive use of macroprudential regulation in Chile (Cerutti et al. 2017; see Figure 8 below) influences the reaction of market interest rates to the increase in copper prices that we obtained as a result of BVAR assessment. Interest rates grow when copper prices increase, although this effect manifests itself with a significant lag of around two years (Figure 3 in the Appendix). The initial impulse for the strengthening of the Chilean peso fades away 18 months after the shock; however, gradual tightening of monetary market conditions spurs an inflow of foreign capital and leads to the strengthening of the national currency. The reaction of the growth rate of the overall lending level and corporate lending to changes in the price of copper is insignificant overall. On the other hand, the indicator of lending to individuals demonstrates a clear positive response to the commodity market impulse, which corresponds with the high mortgage market risk level of Chile noted in the article by Cifuentes et al. (2017). Moreover, positive copper price shocks lead to faster growth in foreign currency lending and the overall level of foreign debt, which demonstrates the vulnerability of the country’s economy to external shocks.

**Figure 4.** Chile’s export structure in 2003–2017 (%)

![Figure 4](source: Central Bank of Chile)
Table 4. Copper price shock elasticity of Chile’s credit cycle indicators

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall lending level</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Consumer lending</td>
<td>0.0463</td>
<td>9 quarters</td>
</tr>
<tr>
<td>Corporate lending</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>External debt</td>
<td>0.0481</td>
<td>3 quarters</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>-0.0687</td>
<td>7 quarters</td>
</tr>
<tr>
<td>Foreign currency lending</td>
<td>0.2942</td>
<td>10 quarters</td>
</tr>
</tbody>
</table>

Source: author’s calculations

5.4. Brazil

The fact that no single commodity category has predominated in the structure of the country’s exports over the past two decades is a peculiarity of Brazil’s economy (Figure 5). In general, over the period 2000–2017, Brazil exported metals, crude oil, and food products. Use of the composite commodity index of the Bank of Brazil (reflecting the dynamics of prices for Brazil’s various export items) gave insignificant results: the impulse responses of credit cycle parameters to commodity price shocks remained insignificant.

Figure 5. Brazil’s export structure in 2000–2017 (%)

Source: Ministry of Development, Industry, and Foreign Trade of Brazil

Table 5. Iron ore price shock elasticity of Brazil’s credit cycle indicators

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall lending level</td>
<td>0.0804</td>
<td>5 quarters</td>
</tr>
<tr>
<td>Consumer lending</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Corporate lending</td>
<td>0.1213</td>
<td>5 quarters</td>
</tr>
<tr>
<td>Private sector’s external debt</td>
<td>-0.1290</td>
<td>13 quarters</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>0.0898</td>
<td>13 quarters</td>
</tr>
<tr>
<td>Foreign currency lending</td>
<td>0.2178</td>
<td>2 quarters</td>
</tr>
<tr>
<td>Share of foreign currency loans in the total portfolio volume</td>
<td>0.1168</td>
<td>10 quarters</td>
</tr>
</tbody>
</table>

Source: author’s calculations
That said, statistically significant lending indicator responses to iron ore price shocks have been obtained, although the average export of this commodity in 2000–2017 amounted to as little as 9% of the total volume of exports from the country (Table 5). In other words, change in the situation on the global iron ore market is a source of risk for the Brazilian financial market.

According to Table 5, most of the credit cycle indicators change procyclically with the commodity cycles: lending to firms, overall lending, foreign currency lending, loan dollarisation, and the private non-finance sector loans-to-GDP ratio grow in response to improved terms of trade. The reaction of consumer lending to global metal market shocks turned out to be insignificant (Figure 4 in the Appendix), which may be connected with the effect of car loan market regulation measures (Gambacorta and Murcia, 2017). At the same time, most MPP measures were implemented for a short period (De Moura and Bandeira, 2017; Barroso et al., 2017).

Thus, estimates obtained using a long timeframe demonstrate that the national financial system of Brazil is significantly dependent on external conditions.

### 5.5. Canada and Australia

This section is devoted to analysis of the relationship between commodity and credit cycles in resource-based economies with a high level of development. Advanced economies have diversified economic structures (Figure 6), a long-term history of interest rate management, and deep financial markets. As our analysis confirms (see below), these characteristics make it possible to protect national economies from global market risks and reduce the sensitivity of internal macroeconomic variables to external sector shocks.

It has traditionally been assumed that, from a historical perspective, the central banks of advanced economies have had more opportunities to pursue countercyclical monetary policies, while central banks in emerging market economies were more procyclical (Kaminsky et al., 2005). Significant changes in the content of economic policies pursued by emerging market economies occurred only during the global financial crisis of 2007–2009 (Coulibaly, 2012), promoted by financial reforms and the switch to an inflation targeting policy.

According to the results of this study, interest rates in Australia increase during the growth phase of a commodity cycle (Figure 6 in the Appendix). No significant reaction by Canadian interest rates to the growth of oil prices has been detected (Figure 5 in the Appendix). At the same time, Canada, like Chile and Columbia, makes extensive use of MPP tools (Cerutti et al., 2017). Canadian macroprudential policy is mainly aimed at reducing risks in the housing loan market (Allen et al., 2017).

Tables 6–7 demonstrate that the ability of the financial authorities of Canada and Australia to pursue monetary and macroprudential policies
aimed at countercyclical stabilisation allows them to react promptly to
e external challenges and effectively influence lending dynamics. In Canada and
Australia, growth of commodity prices is accompanied by a decrease in the
growth rates of the key financial risk indicators, including the overall level of
lending, its specific components, foreign debt, and the share of foreign currency
loans. Consequently, major commodity exporters are less vulnerable to terms
of trade shocks.

**Figure 6.** Canada’s export structure in 2000–2017 (%)

![Figure 6: Canada’s export structure in 2000–2017 (%)](image)

*Source: Statistics Service of Canada*

**Table 6. Oil price shock elasticity of Canada’s credit cycle indicators**

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall lending level</td>
<td>−0.0453</td>
<td>4 quarters</td>
</tr>
<tr>
<td>Consumer lending</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Corporate lending</td>
<td>−0.0883</td>
<td>4 quarters</td>
</tr>
<tr>
<td>External debt</td>
<td>0.0509</td>
<td>1 quarter</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>−0.0836</td>
<td>4 quarters</td>
</tr>
<tr>
<td>Foreign currency lending</td>
<td>insignificant</td>
<td></td>
</tr>
<tr>
<td>Share of foreign currency loans in the total loan portfolio volume</td>
<td>−0.0983</td>
<td>2 quarters</td>
</tr>
</tbody>
</table>

*Source: author’s calculations*

**Table 7. Coal price shock elasticity of Australia’s credit cycle indicator**

<table>
<thead>
<tr>
<th>Credit cycle indicator</th>
<th>Elasticity</th>
<th>Maximum effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall lending level</td>
<td>−0.0365</td>
<td>7 quarters</td>
</tr>
<tr>
<td>Consumer lending</td>
<td>−0.1444</td>
<td>7 quarters</td>
</tr>
<tr>
<td>Corporate lending</td>
<td>−0.0392</td>
<td>6 quarters</td>
</tr>
<tr>
<td>Private sector’s external debt</td>
<td>−0.0774</td>
<td>5 quarters</td>
</tr>
<tr>
<td>Ratio of non-financial private sector loans to GDP</td>
<td>−0.0628</td>
<td>5 quarters</td>
</tr>
</tbody>
</table>

*Source: author’s calculations*
Compared to emerging market countries, where national financial markets have historically been quite narrow, with the result that economic agents have been forced to turn to international loan markets and raise foreign currency financing, advanced economies are relatively protected from foreign currency predominance in their financial systems. The ‘high base’ effect also comes into play: advanced economies are highly saturated with loans, as a result of which payment balance shocks caused by changes in global commodity markets influence the dynamics of internal macrovariables to a lesser extent. Thus, in advanced economies, it may be enough to use monetary regulation tools to counter external market threats (including terms of trade fluctuations).

6. Cross-country comparisons: impact of commodity market shocks on financial cycles

This study has established a statistically and economically significant correlation between the dynamics of commodity and financial cycle indicators in resource-based economies. In commodity exporters, global commodity market shocks trigger a significant reaction from financial cycle indicators, which confirms the dependence of the national financial markets of resource-based economies on external economic conditions.

It may be noted that, if the export share of a certain item grows, the overall structure of the exports of the country in question shows an increase in the sensitivity of its sovereign risk premium and exchange rate to commodity price shocks (Figure 7). This correlation is most typical for emerging markets (Brazil, Columbia, Chile, and Russia) due to the low diversification of their economies and the significant sensitivity of balances of payments and investors’ perception of national economy risks to changes in terms of trade. In advanced economies (Canada and Australia), the reaction of sovereign risk premiums and currency exchange rates is limited.

In Chile, Russia, and Columbia, which have the highest resource dependence of all the countries considered (with shares of the key export item in the overall volume of exports amounting to 58%, 42%, and 35% respectively), the commodity price elasticities (in modules) of sovereign CDS spreads and currency exchange rates vary within the ranges of 53%–109% and 17%–30% respectively. In Brazil, which is a commodity exporter, but one which supplies different types of commodities to the global market (not only energy resources, but also metals and food), the reactions of the currency exchange rate to commodity market shocks are insignificant in value. At the same time, Brazil’s sovereign CDS spread is subject to considerable fluctuation, which may be explained by prospective investors’ perceptions of the national economies of developing countries.

13 Sensitivity indicators in column charts are calculated as the maximum elasticity of some variables against shocks in other variables based on the results of impulse function calculations.
in general as exposed to global commodity market risks. In Canada and Australia – advanced economies with more diversified export structures – no dependence of risk premiums on the dynamics of global energy resource markets has been identified, and the elasticity of currency exchange rates is lower than in developing countries in general.

**Figure 7.** The correlation between commodity exports and the commodity price elasticities of sovereign risk premium and currency exchange rate by country

![Figure 7](image)

*Source: author’s calculations*

**Figure 8.** The correlation between MPP index levels and the sensitivity of interest rates to commodity market shocks

![Figure 8](image)

*Source: author’s calculations*

This research shows that in Canada and Australia acceleration of commodity price growth leads to a slowdown in credit cycle growth rates. Higher interest rates during the growth phase of a commodity cycle help to suppress a lending boom in the event that the situation in the global commodity markets improves. In Canada and Australia, the reaction we have observed from lending conditions apparently stems from a high level of financial market development and broad opportunities for financial authorities to pursue effective countercyclical stabilisation policies.
Based on the results of this analysis, it can be concluded that, to suppress a boom in the credit market, emerging market economies should supplement their monetary policies with macroprudential regulatory tools: countries with a higher level of MPP tool use show the lending price growth required for the suppression of financial cycles (Figure 8). Cerutti et al. (2017) use the average MPP index for 2000–2013 as the MPP index. It may be noted that, in developing countries with a higher level of MPP tool implementation (Chile, Columbia), interest rates grow in response to positive global market commodity price shocks, while in developing countries that use MPP instruments less extensively (Brazil, Russia), growth of oil prices is accompanied by easing of financial conditions (Russia) or the absence of a significant reaction from lending prices (Brazil).

In addition, analysis of elasticities shows that the sensitivity of general and foreign currency lending dynamics to commodity price shocks is lower (Figure 9) in developing countries with a higher level of use of MPP tools (Chile and Colombia), another piece of evidence supporting the more extensive introduction of macroprudential policies in commodity-producing emerging market economies. In Brazil and Russia,14 where the level of MPP tool application is lower, overall lending growth rates are observed to be generally more sensitive to commodity market shocks (8.3% on average in Russia and Brazil against 5.5% on average in Chile and Columbia). In Columbia, which uses the widest range of MPP tools, the rate of foreign currency lending growth decreases in response to improvement in the terms of trade.

Figure 9. The correlation between MPP index values and the sensitivity of general and foreign currency lending in emerging market economies

Analysis of historical data shows that a correlation between changes in the main parameters of commodity cycles (oil prices) and financial cycles (exchange rate, risk

14 Chile and Columbia also use fiscal rules relatively extensively, to a similar degree to Canada (see the Appendix for more details), which probably also helps restrict the dependence of the national financial system’s parameters on external shocks.
premium, lending, and foreign currency lending) is typical for Russia. An important step in reducing the exposure of financial sector indicators to external shocks is transition to a countercyclical economic policy (inflation targeting and fiscal rules).

The Bank of Russia’s current macroprudential policy measures are intended to reduce lending growth rates, especially in unsecured consumer lending, the segment fraught with the highest risks. To that end, the Bank of Russia uses risk ratios depending on the total cost of loans (TCL). Another source of risks to financial stability is the problem of foreign currency predominance in the banking sector. The Bank of Russia adjusts the risk ratios for foreign currency loans to legal entities with insufficient currency revenue to restrict this type of lending (see the Appendix for more details).

Currently, the Bank of Russia is also working on introducing a debt burden ratio (DBR). This ratio will be calculated from 1 October 2019 (Bank of Russia, 2019). The Bank of Russia’s current macroprudential regulation measures are aimed at limiting the key risks identified in this study.

7. Summary and conclusions

The influence of global commodity market parameters on the dynamics of macroeconomic indicators and financial markets in commodity-exporting countries has been widely discussed in the literature. Growth in commodity prices leads to accelerated debt burden accumulation in resource-based economies and, in the event of a sharp turnaround in commodity prices, to significant deleveraging and deterioration of economic agents’ ability to fulfil their obligations. All of the above is connected with the growth of systemic risks and threats to the overall stability of financial systems.

This study has confirmed these observations. This paper demonstrates that a higher commodity price leads to increased growth in overall lending, foreign currency lending, and external debt in the majority of the countries analysed, including Russia. Moreover, in Russia and Brazil, positive shocks to commodity prices have triggered growth in the share of FX loans to households and businesses. The improvement of global terms of trade for commodity exporters leads to a decrease in the share of overdue loans. Despite the relatively insignificant economic effect of this correlation, decreases in commodity prices may entail growth of the share of non-performing loans, which is connected with nonpayment risks and demonstrates the dependence of national financial systems on external conditions.

A higher degree of resource dependence leads to an increase in economic volatility and in the sensitivity of such economic cycle indicators as currency exchange rate and sovereign risk premium. In advanced economies (Canada and Australia), the influence of the commodity cycle on the financial cycle is

---

15 See http://cbr.ru/Press/event/?id=2678.
insignificant due to the diversified nature of their economic structures, the ability of monetary authorities to pursue countercyclical monetary policies, and a relatively higher historical level of financial market development.

In general, the emerging market economies of Brazil, Chile, Columbia and Russia demonstrate procyclicality in commodity and financial cycle parameter changes. Developing countries that use MPP more extensively have lower procyclicality of commodity price dynamics and lower rates of loan load accumulation.

To reduce the exposure of national economic and financial system parameters to external market shocks (including from global commodity markets), the economic authorities of emerging market countries should develop national financial markets and pursue countercyclical macroprudential policies in addition to their monetary policies. The Bank of Russia has recently been developing macroprudential regulatory tools more extensively.

As an area for future research, we propose including explicit fiscal and macroprudential policy variables in the model, which will contribute to our understanding of the role of countercyclical economic regulation in reducing the interrelationships between commodity and financial cycle parameters in commodity-producing countries.

Appendix is available at
http://rjmf.econs.online/en;
dx.doi.org/10.31477/rjmf.201903.38

References


The Impact of Inflation Anchor Strength and Monetary Policy Transparency on Inflation During the Period of Emerging Market Volatility in Summer 2018

Tatiana Evdokimova, Nordea Bank
tatiana.evdokimova@nordea.ru
Grigory Zhirnov, Nordea Bank
grigory.zhirnov@nordea.ru
Inge Klaver, Nordea Bank
inge.klaver@nordea.com

This paper examines the link between foreign exchange dynamics and inflation in developing countries with respect to the degree of inflation expectation anchoring they employed in 2011–2019. Particular attention is paid to analysis of the inflationary consequences of the considerable weakness of emerging markets’ currencies in summer 2018. Analysis of 2011–2019 confirms that inflation accelerates less in reaction to FX weakness in countries with more anchored inflation expectations. However, similar statistically significant differences were not found during the shock of 2018. One way of anchoring inflation expectations is to make monetary policy more transparent. We have updated the central bank transparency index introduced in Dincer and Eichengreen (2007) and confirm that central bank transparency in emerging markets has considerably improved in recent years. Inflation expectations in these countries have been approaching inflation targets as central banks’ policies become more transparent. We also provide some suggestions for improving the quality of monetary policy communication by the Bank of Russia in order to increase its transparency and consequently contribute to a further decrease in inflation expectations.

Keywords: inflation expectations, monetary policy transparency, inflation targeting, emerging markets

JEL Codes: D84, E31


doi: 10.31477/rjmf.201903.71
1. Introduction

Over recent decades many central banks in developing countries have switched to inflation targeting. According to the International Monetary Fund (IMF, 2019), as of 2018 this regime had been implemented in 41 countries, including 30 developing counties. As inflation expectations are a key factor in ensuring price stability, central bankers have put particular effort into anchoring them around the inflation target. As the experience of many developing countries shows, anchoring can be a lengthy and tedious process. It requires constant effort from the central bank to keep inflation close to the declared target and to maintain clear communication with the market. Analysis of periods of financial stress allows the benefits of anchored inflation expectations in times of elevated market volatility to be assessed, and enables us to establish whether central banks’ efforts are in fact worthwhile. In this paper we perform this analysis for the period of increased volatility in emerging markets during the summer of 2018. Our hypothesis is that countries with more anchored inflation expectations are more resilient to external shocks.

This article consists of six sections. Section 2 contains a review of research on the topic of inflation expectations. In Section 3 we analyse the impact of FX weakening on inflation in countries with more and less anchored inflation expectations in 2011–2019. Particular attention is paid to analysis of capital outflow from emerging markets in 2018 and to the inflationary consequences of this outflow with respect to the degree to which inflation expectations were anchored. This episode of financial market volatility is very recent and therefore has not yet received a full analysis, lending this paper both novelty and relevance. In this analysis we apply the approach suggested in an IMF publication (2018) concerning the ‘taper tantrum’ and its consequences for emerging markets back in 2013. In Section 4 we compare the dynamics of inflation expectations in Russia and other emerging countries to obtain anecdotal evidence for the average time needed to anchor inflation expectations. Clear communication by the central bank with the market is a key tool for anchoring inflation expectations. For this reason, Section 5 is dedicated to measuring the evolution of central bank transparency since 2014, when Dincer and Eichengreen (2014) published their estimates of central banks’ transparency. We update their research following their methodology to determine what progress has been made. This element of our analysis sheds light on the progress achieved by the Bank of Russia (CBR) in terms of its communication in 2015–2018, the period immediately after the transition to inflation targeting. Even though this progress was slightly faster than the average for emerging markets, there is still plenty of room for the Bank of Russia to further improve its communication. The present paper contains some suggestions to this effect. Section 6 concludes.
2. Literature review

Inflation expectations are extensively analysed in a wide range of research papers. Here we give a short review of the papers that are most relevant to this research, discussing the process by which inflation expectations are formed, ways of managing these expectations, and best practices for central bank communication.

The fundamental theory of the nature of inflation expectations was first formulated by Milton Freedman (1951, pp. 119–124), who developed the concept of adaptive inflation expectations. According to this theory economic agents form their inflation expectations based on current or previous inflation alone, and do not try to predict the future. According to this theory, systematic error will always be present in inflation expectations, and a great deal of time is needed to change these expectations. An opposing theory of rational inflation expectations was formulated by Robert Lucas (Lucas and Sargent, 1981). In this theory inflation expectations are formed on the basis of all available information about the future, no longer focusing only on previous experience. As a result, there is no systemic error in rational expectations, which adjust immediately to new information.

A separate strand of research concerns the process by which inflation expectations are formed. Loleyt and Gurov (2011) put forward a theoretical model whereby inflation expectations are a function of the inflation-related information perceivable by economic agents, and also of agents’ trust in the ability of the central bank to keep actual inflation on target. Agents’ ability to perceive information directly depends on their education, while their degree of trust is determined by the previous track record of inflation targeting. The more agents trust central bank policy, the easier it is to bring their inflation expectations in line with the official inflation forecast. The lower the ability of the agents to perceive relevant economic information, the more adaptive (based on their previous experience of inflation) their inflation expectations become.

In a theoretical paper, Brazier et al. (2008) also suggest that economic agents may form their inflation expectations based on either past inflation or the inflation target, depending on which of these two indicators is closer to actual inflation.

A number of papers (Gerberding, 2001; Doepke and Schneider, 2006) prove that, even in developed countries with a long history of inflation targeting, information about past inflation is more important for the formation of inflation expectations than forecasts of future inflation. Łyziak (2010) shows that inflation expectations are only 20% dependent on information about future inflation, with information about past inflation accounting for the remaining 80%. Inflation expectations thus tend to be relatively backward-
looking. Carroll (2003) notes that people may not follow economic news in any depth, which makes inflation expectations sticky and slow to react to the changing environment.

Galati et al. (2011) analyse the formation of inflation expectations on the basis of weekly surveys completed by 129 respondents in the Netherlands for a year. Central banks usually use monthly inflation expectation surveys, but the special high-frequency survey used in this paper is useful in tracking the way survey participants react to the economic news provided along with the survey. The paper confirms that short-term inflation expectations (one year ahead) are much more volatile than long-term expectations (10 years ahead). On average more than one third of respondents (38.5%) changed their one-week-ahead inflation forecast each week, while the long-term forecast was more stable, with only a quarter of respondents changing their expectations. The expectations of less educated respondents tended to be more volatile.

Most research confirms that increased central bank transparency has positive effects. Loleyt and Gurov (2011) note that detailed communication of central bank decisions enables information asymmetry between the regulator and economic agents to be reduced. It is also important to ensure that different authorities’ inflation forecasts are coherent.

The IMF paper (2018) stresses the need to increase the predictability of monetary policy. Poor predictability may signal that economic agents’ understanding of central bank policy is insufficient. The paper confirms that there is a direct link between the predictability of central bank policy and the strength of the monetary policy anchor. The authors note that increased transparency and more active and clear communication improve the predictability of central banks’ actions.

The media plays an important role in transferring the signals sent by the regulator to economic agents. This is a relatively new topic of research, but an extremely important one, as the media is the key link between a central bank and the population whose inflation expectations are to be anchored. The extent of monetary policy coverage in the media has a direct impact on its efficiency. Berger et al. (2006) analyse the media coverage of the policy actions of the European Central Bank (ECB). The authors show that surprising decisions tend to receive negative media coverage, while decisions accompanied by a press conference given by the head of the ECB usually receive much wider coverage. A decision which is unexpected but extensively explained during a press conference has a good chance of being reported positively by the media. More critical discussion of the ECB’s actions becomes more probable in periods when inflation exceeds the target. The paper also highlights the importance of cooperation with media from different countries of the euro zone to ensure the widest possible geographical distribution of information. Applying this
conclusion to the case of Russia would suggest the importance of cooperation with media from different regions of Russia.

Ehrman and Fratzscher (2005) compare the communication strategies of the Fed, ECB and Bank of England. They confirm the hypothesis that a central bank’s communication is most efficient when the various representatives of the regulator share a common view on its policy and when decisions on the key rate are made unanimously.

Plekhanov (2016) analyses the Bank of Russia’s communication using the texts of their press releases, demonstrating that the regulator’s comments on decisions became much more detailed after the adoption of inflation targeting. The Flesch index of readability score for the Bank of Russia’s press releases is similar to that of the major central banks.

Kuznetsova and Merzlyakov (2016) analyse press releases and reports by the Bank of Russia from the point of view of signals from the regulator regarding the future direction of its policy. Their study demonstrates that signals from the Bank of Russia became gradually more precise between 2013 and 2016. At the same time, the Russian regulator prefers signals related to the dynamics of macroeconomic indicators, rather than signals which convey the precise timing of expected monetary policy changes. This gives the Bank of Russia greater flexibility in its decision-making process.

Merzlyakov and Habibullin (2017) assess the impact of the Bank of Russia’s press releases on the interbank market rate. The authors confirm that market volatility increases after press releases are published. Interestingly, this effect is observed even in the case of decisions to keep the key rate unchanged.

The above studies confirm that confidence in central banks is extremely important for anchoring inflation expectations near the target. Another relevant factor is efforts to improve the financial literacy of economic agents, which affects their ability to perceive the regulator’s signals, assess the economic situation and adjust their inflation expectations accordingly. Improving the quality of central banks’ communication, making central banks’ actions more predictable, systematically keeping inflation close to the target, and organising programmes aimed at improving financial literacy are all necessary steps for effectively managing inflation expectations.

3. The impact of FX depreciation on price growth depending on the strength of the inflation expectations anchor

Anchored inflation expectations are generally seen as an important condition for containing inflationary pressure in the case of external shocks. We evaluate the correlation between exchange rate pass-through and inflation dynamics in countries with more and less anchored inflation expectations, and then dig
deeper into the case of capital outflow from emerging markets in summer 2018. Our main hypothesis is that exchange rate depreciation is less inflationary in countries with more anchored inflation expectations.

We have followed the approach of the IMF (2018) and divided countries into two groups: ‘less anchored’ (Russia, Romania, Indonesia, India and Thailand) and ‘more anchored’ (Chile, Hungary, Mexico, Malaysia and Poland). We intentionally excluded Turkey and Argentina from our analysis, as their extreme inflation and exchange rate dynamics (with FX rate depreciation of ~42% and ~45% respectively from March 2018 to September 2018) had country-specific explanations, and they might justifiably be regarded as outliers.

The indicators used by the IMF to measure the degree to which inflation expectations are anchored include the root-mean-square deviation of mean inflation expectations from the target, the dispersion of inflation expectations, the sensitivity of inflation expectations to unexpected inflation changes, and more. IMF researchers calculated these indicators for the period from 2000 to 2017 and ranked countries according to the degree to which they anchored inflation expectations. There are, of course, far more countries with an inflation targeting regime than just the ten included in our analysis, but our sample size was limited by the availability of the inflation expectations data required to divide the countries into two subsamples.

We used monthly data from June 2011 to February 2019 in order to evaluate the impact of local currency depreciation on inflation dynamics in two groups of countries. We applied advanced panel data techniques with country-specific effects. We chose the consumer price index (CPI, yearly change) as a dependent variable. Explanatory variables include a dummy variable reflecting a country’s inflation expectations group (1 – less anchored countries, 0 – more anchored countries), the first lag of foreign exchange rate change and the first lag of the dependent variable itself (to tackle the endogeneity problem caused by the omitted variables).

Kartaev and Yakimova (2018) show that there are two effects of FX depreciation on prices: short-term and long-term. The main purpose of our analysis is to evaluate FX pass-through to inflation in our two groups of countries and not to estimate the timing of this pass-through effect. For this reason, we focus primarily on short-term price sensitivity to FX changes and choose the first lag of the exchange rate change as an explanatory factor in our model. We estimate the model in differences in order to account for the non-stationarity of the time series and avoid the spurious regression problem (the stochastic features of the variables are discussed in Appendix 1).

We do not claim that the strength of its inflation expectations anchor is the key determinant of a country’s macroeconomic dynamics. Moreover, a number of significant factors exist which influence inflation dynamics and might be used as control variables in our model. Nevertheless, for simplicity
we use the lagged values of dependent variables, which helps us to avoid the endogeneity problem. IMF researchers (IMF, 2018) used a similar model specification in exploring the consequences of capital outflows from emerging economies in 2013. They chose dummy variables which reflected the degree of inflation expectations anchoring at the time, along with lagged values of dependent variables.

We estimated all our dynamic regressions using the generalized method of moments (GMM) and Arellano-Bond approach (Arellano and Bond, 1991) to obtain consistent estimates of coefficients. All residuals were tested on normality and the absence of second order autocorrelation in differences (test for AR(2)). We also used robust estimation of covariance matrices in order to tackle the potential heteroscedasticity problem and so test the hypothesis and construct confidence intervals correctly. We also estimated our models excluding one country from each group at a time, to ensure that the results were not driven by any single country (see Appendix 1).

Model (1), for FX pass-through to CPI, was specified as follows:

\[
\Delta \text{CPI}_{t,i} = \alpha \Delta \text{CPI}_{t-1,i} + \beta \Delta fX_{t-1,i} + \gamma d_{1,t,i} \Delta fX_{t-1,i} + \omega_{i,t},
\]

where \(\text{CPI}_{t,i}\) is the CPI change (y/y) in country \(i\) at time \(t\) (\(\Delta \text{CPI}_{t,i} = \text{CPI}_{t,i} - \text{CPI}_{t-1,i}\)), \(fX_{t,i}\) is the local currency change vs USD (y/y) at time \(t\), \(d_{1,t,i}\) is a dummy variable reflecting the inflation expectations group (1 – more anchored group, 0 – less anchored group), and \(\omega_{i,t}\) is the random error CPI change (y/y) in country \(i\) at time \(t\).

Our main hypothesis was that FX depreciation in countries with less anchored inflation expectations led to higher acceleration of inflation in these countries compared to the more anchored group. We therefore expected that the coefficient \(\gamma\) would be positive and significant and that the effect of immediate exchange rate pass-through in countries with less anchored inflation expectations would amount to \(\beta + \gamma\), while the FX pass-through in countries with more anchored expectations would be defined only by the parameter \(\beta\) (as the variable \(d_{1,t,i}\) for these countries is equal to 0).

The results of estimation of model (1) are presented in Table 1. It is clear that the short-term FX pass-through was more than twice as high in countries with less anchored inflation expectations (Figure 1). The coefficient \(\beta\) equals 0.014, while the sum \(\beta + \gamma\) gives 0.0393. This means that, if the local currency depreciates by 10%, inflation in the following month will accelerate by 0.14 percentage points (p.p.) in countries with more anchored inflation expectations and by 0.39 p.p. in countries with less anchored expectations. As a result, countries from the less anchored group suffer more from external instability as inflation reacts more intensely to this instability.
Table 1. FX pass-through to CPI

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient estimates and their significance</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>l1.dcpi</td>
<td>0.3010***</td>
<td>0.0309</td>
</tr>
<tr>
<td>l1.dfxyy</td>
<td>0.0140*</td>
<td>0.0067</td>
</tr>
<tr>
<td>l1.dfxyy*d1</td>
<td>0.0253**</td>
<td>0.0087</td>
</tr>
<tr>
<td>Observations</td>
<td></td>
<td>890</td>
</tr>
<tr>
<td>Hansen’s J-statistic</td>
<td></td>
<td>864.61</td>
</tr>
</tbody>
</table>

Note: * p<0.05, ** p<0.01, *** p<0.001.

Note: For the more anchored group, the figure shows the regression coefficient in front of $\Delta fx_{t-1,i}$; for the less anchored group, the figure shows the sum of the regression coefficients in front of $\Delta fx_{t-1,i}$ and $d_1_{t,i}$.\$

Figure 1. Impact of FX depreciation on prices

We have also attempted to establish whether these differences in FX pass-through between countries with more and less anchored inflation expectations persisted during the capital outflow from emerging markets in 2018. This shock negatively influenced both the exchange rate and inflation dynamics in these counties. Monetary policy tightening by the Federal Reserve System of the US (the Fed) was the main reason for capital outflow from emerging markets. The Fed started to hike the key rate in 2015 and increased the frequency of its hikes to quarterly in 2018. What’s more, the American regulator began quantitative tightening (balance sheet normalization) in 2017Q4. As a result, the USD posted strong results on global markets (DXY gained more than 6% in 2018Q2), while the cost of borrowing in USD increased (the three-month LIBOR increased from 1.7% to 2.3% during 2018Q1). The inflow of capital to emerging markets was reversed. According to the Institute of International Finance, net foreign portfolio investment inflow into emerging markets was negative in 2018Q2 and 2018Q3 (compared to a monthly average of USD 30 billion earlier). Countries with high short-term foreign exchange debt and a high current account deficit (Argentina, Turkey, Colombia and South Africa) were the most affected. In the case of Turkey, the situation was exacerbated by a loss of confidence in the independence of the Central Bank.

In our analysis of the 2018 shock we continued to apply the approach employed by the IMF (2018) and used the same two groups of countries specified above.
At first glance, inflation in countries with more anchored inflation expectations may appear to have reacted less to the shock than inflation in countries with less anchored expectations (Figure 2). However, if Turkey and Argentina are excluded from the analysis, Figure 2 shows that any difference between the two groups of countries in terms of CPI dynamics was barely visible. Interestingly, the currencies under analysis weakened against the USD to an almost equal degree in both groups (Figure 3).

**Figure 2.** Inflation dynamics after capital outflow shock

**Figure 3.** FX dynamics after sell-off shock, %
These two observations were confirmed by the econometric model. We applied advanced panel data techniques in order to evaluate the influence of the capital outflow shock on inflation and exchange rate dynamics in our two groups of countries, controlling for country-specific effects. We built the model using monthly data from December 2017 to February 2019. Among the dependent variables were CPI (yearly change) and exchange rate vs USD (yearly change); explanatory variables consisted of a dummy variable for sell-off shock (equal to 1 in March–August 2018, otherwise 0), a dummy variable reflecting the inflation expectations group (1 – less anchored countries, 0 – more anchored countries) and lagged values of the dependent variables themselves as in model (1).

Model (2), for the FX rate, was specified as follows:

$$fx_{t,i} = \alpha fx_{t-1,i} + \beta d1_{t,i}d2_t + \gamma d2_t + \omega_{i,t},$$

where $fx_{t,i}$ is the local currency change vs USD (y/y) at time $t$, $l1.fx = fx_{t-1,i}$, $d1_{t,i}$ is a dummy variable reflecting the inflation expectations group (1 – more anchored group, 0 – less anchored group), $d2_t$ is a dummy variable reflecting sell-off shock, and $\omega_{i,t}$ is a random error.

Model (3), for CPI, was specified as follows:

$$cpi_{t,i} = \alpha cpi_{t-1,i} + \beta d1_{t,i}d2_t + \gamma d2_t + \omega_{i,t},$$

where $cpi_{t,i}$ is the CPI change (y/y) in country $i$ at time $t$, $l1.cpi_{t,i} = cpi_{t-1,i}$, $d1_{t,i}$ is a dummy variable reflecting the inflation expectations group, $d2_t$ is a dummy variable reflecting sell-off shock, and $\omega_{i,t}$ is a random error.

If the exchange rate and inflation dynamics were truly dependent on the capital outflow shock in 2018, the variable $d2_t$ should be significant in both models. For us to state that inflation accelerated faster in countries with less anchored inflation expectations, the coefficient $\beta$ would need to be positive and significant. Thus, the increased inflationary response to capital outflow shock in countries with less anchored expectations is reflected by the sum of coefficients $\beta + \gamma$, while in countries with more anchored inflation expectations this effect amounts to $\gamma$ alone.

Our models confirm that the effect of capital outflow in 2018 (dummy variable $d2$) was statistically significant for both exchange rate (Table 2) and inflation dynamics (Table 3). Nevertheless, both regressions show that the degree of FX depreciation and CPI acceleration was almost identical in the two groups of countries: the coefficient $\beta$ in both models was insignificant at any reasonable level of significance (Tables 2 and 3).
Table 2. FX reaction to shock

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient estimates and their significance</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>d2</td>
<td>3.3028***</td>
<td>0.8564</td>
</tr>
<tr>
<td>d1*d2</td>
<td>-1.1033</td>
<td>1.3788</td>
</tr>
<tr>
<td>l1.fx</td>
<td>0.9279***</td>
<td>0.1128</td>
</tr>
<tr>
<td>Observations</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Hansen’s J-statistic</td>
<td>38.88</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p<0.05, ** p<0.01, *** p<0.001.

Table 3. CPI reaction to shock

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient estimates and their significance</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>d2</td>
<td>0.2380*</td>
<td>0.1109</td>
</tr>
<tr>
<td>d1*d2</td>
<td>-0.0512</td>
<td>0.1857</td>
</tr>
<tr>
<td>l1.cpi</td>
<td>0.7683***</td>
<td>0.0994</td>
</tr>
<tr>
<td>Observations</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Hansen’s J-statistic</td>
<td>16.44</td>
<td></td>
</tr>
</tbody>
</table>

Note: * p<0.05, ** p<0.01, *** p<0.001.

The hypothesis that inflation increased faster in countries with less anchored inflation expectations during the shock in 2018 is therefore rejected. The exchange rate weakened by the same amount on average in both groups of countries during the period of the shock, and this weakening did not lead to a statistically significant difference in inflation dynamics in these groups of countries. This suggests that exchange rate pass-through to prices in countries with different degrees of anchoring of inflation expectations did not differ significantly in the period of capital outflow in 2018.

We note that the results of our analysis (capital outflow from emerging markets in 2018) and the IMF analysis of a similar episode in 2013 differ in spite of the fact that the magnitude of these shocks was comparable in terms of their impact on the exchange rates of developing countries. During the shock of 2013, as the IMF shows, inflation in countries with less anchored inflation expectations accelerated significantly faster than in the group of countries with more anchored expectations, which was associated with a higher exchange rate pass-through to prices. The results of our research have not revealed similar differences in the dynamics of inflation, although they have confirmed the importance of the impact of the capital outflow shock in 2018 both for the dynamics of inflation and for the exchange rate. This discrepancy between our research and the IMF’s study can be explained by the fact that in 2018 central banks in developing countries (in particular, the central banks of Mexico, Romania, Indonesia and Chile) tightened monetary policy more quickly than at the time of the shock of 2013. Indeed, the central banks of these countries reacted more proactively to the shock in 2018, taking into account their experience...
of previous large-scale capital outflow, which probably helped to mitigate its negative consequences for price stability. Nevertheless, on a broader time horizon, as we have shown in model (1), the short-term effect of exchange rate depreciation on inflation is halved in countries with more anchored inflation expectations, which confirms that managing inflation expectations has positive effects.

4. Inflation expectations in Russia

The CBR managed to bring inflation in line with the target quite fast after adopting inflation targeting, as early as the first half of 2017, i.e. less than 2.5 years after switching to a new monetary policy regime. Inflation was therefore brought in line with the target much faster than average for an emerging market country targeting inflation. Our calculations using IMF data show that it takes developing countries an average of 4.5 years to bring inflation in line with the target after switching to inflation targeting.

Inflation expectations were also sustainably declining in Russia until the middle of 2018, but more than four years after the adoption of inflation targeting, they are still unanchored, exceeding the CBR target by around 5 p.p. In comparison, 11 countries for which sufficiently long time series are available (Chile, Mexico, Peru, Turkey, South Africa, Guatemala, Serbia, Romania, the Czech Republic, Colombia and Hungary) managed to reduce the discrepancy between inflation expectations and the target to just 1.7 p.p. on average over the same timeframe. Thus, while inflation in Russia was brought in line with the target ahead of schedule, the task of combating elevated inflation expectations is proving more challenging. The experience of the same 11 countries shows that it takes seven years on average to bring inflation expectations in line with the target. Two distinct groups of countries can be distinguished: in the countries of the first group (for example Chile, Mexico and Peru) the whole process took no longer than three years, while in the other countries it took around a decade. Russia does not seem to belong to the first group.

The gap between inflation expectations and the inflation target is a commonly used as an indicator of confidence in a central bank’s policy. So far the CBR has already managed to win the confidence of the expert community and financial market participants, but it still has some way to go to win over companies and the public.

5. Inflation expectations and monetary policy transparency

Our analysis for 2011–2019 confirms that more firmly-anchored inflation expectations help to reduce the magnitude of FX pass-through to prices. As is extensively documented in academic research, better anchoring of inflation expectations requires continuous improvements in the fiscal sustainability and credibility of central banks through better communication and transparency.
The benefits of transparency are increasingly widely recognized, and especially since the widespread adoption of inflation targeting regimes in many countries and the spread of democratization and financial liberalization, central banks are putting more effort into improving their transparency (Mishkin, 2000; Dincer and Eichengreen, 2007).

It is increasingly important for central banks to be credible and accountable to the public. To that end, there has been a general trend towards more communication in advanced and emerging market countries alike. Transparency contributes to the transmission of monetary policy in several ways (Freedman and Laxton, 2009). Firstly, it improves public understanding of the goals and means of the central bank, lending it credibility. Secondly, transparency contributes to the effectiveness of policy insofar as it helps to set inflation expectations by providing agents with the same set of information that the central bank possesses to form their expectations and even disclosing likely future policy actions.

A widely used index of central bank transparency that captures many aspects of policymaking is that of Dincer and Eichengreen (2007). Their index was in turn based on the work of Eijffinger and Geraats (2006). The index aggregates results for five dimensions of transparency, capturing the political, economic, procedural, policy and operational aspects of monetary policy transparency with three questions per dimension, adding up to a total maximum score of 15.

The first dimension, political transparency, refers to the central bank’s openness about policy objectives, such as its mandate and relations with the government. Economic transparency means openness about data, models and forecasts. Procedural transparency refers to the way monetary policy decisions are taken, for instance whether the central bank publishes the minutes of their meetings. Policy transparency concerns the provision of information on the implications of policy, explanations for decisions and guidance about future actions. Lastly, operational transparency is openness about the implementation of these decisions and discussions of the transmission of monetary policy.

Dincer and Eichengreen (2010, 2014) originally published their index for a large number of countries for the years 1998–2006, subsequently updating their full sample in 2014. As we are interested in how central bank transparency in emerging markets has progressed over the last few years, we carry out another update of Dincer and Eichengreen’s transparency index for 2019, but for a smaller sample of developing countries. The score reflects the situation that prevailed at the beginning of the year. We draw our data from information on central banks’ websites and in their inflation reports, statutes and other published documents. We admit that the results are likely very subjective. Nevertheless, they enable us to obtain an idea of the general trend in the degree of transparency in developing countries.

In their original analysis, Dincer and Eichengreen found that central banks in advanced countries are more transparent than central banks in emerging markets.
Their results also show that there has been a steady increase in transparency over the period 1998–2014 for advanced countries and emerging markets alike.

The average transparency score in our sample rose from 7.7 out of 15 in 2014 to 10.1 in 2019, with nearly all countries showing some improvement, but there is substantial heterogeneity. The scores for 2014 and 2019 are plotted together in Figure 4. Peru is the only country on the diagonal, indicating no change in the transparency score. Romania, Argentina, Chile, Mexico and Russia made the biggest improvements in their transparency, and Hungary was the most transparent country in our sample in both 2014 and 2019. China was at the same level as Russia and India until 2010 but has fallen behind since then and is now at the bottom of our sample. Russia’s score has increased from 7.5 to 11 points, which is a faster than average increase for our sample. A detailed table with country scores for all components may be found in Appendix 2.

**Figure 4. Central bank transparency index in 2014 and 2019**

![Central bank transparency index in 2014 and 2019](image)

Higher transparency was predominantly the result of more active communication of macroeconomic forecasts by central banks and of more prompt publication of the minutes of meetings. To achieve an even higher transparency level central banks will need to provide more information on their approaches to forecasting, their existing monetary policy rules and voting results at key rate meetings. They will also need to give more detailed accounts of the extent of monetary policy’s contribution to price dynamics. The CBR could improve its transparency by focusing on these same areas.

It appears that the less anchored countries have made the most progress and are catching up with the more anchored group in terms of transparency (Figure 5). At the same time, this group has seen a bigger decrease in inflation expectations. Achievements in transparency may at least partly explain increases in inflation expectations anchoring.
The CBR admits that, more than four years after inflation targeting was adopted, inflation expectations remain unanchored. Although they have considerably decreased in recent years, additional efforts are needed for further progress. These measures may be divided into three subcategories.

Firstly, it is important to continue keeping inflation close to the 4% target to increase the confidence of the population in CBR policy and to confirm the long-term validity of this target and the ability of the CBR to achieve it. The experience of other emerging market countries where inflation used to be significantly above the target (Colombia, the Czech Republic, Romania and Serbia) shows that it may take up to 8–10 years of keeping inflation near or below the target to anchor inflation expectations to the official inflation target.

Secondly, there is significant room for increasing the CBR’s transparency and improving the quality of its communication. IMF (2018) and Isakov et al. (2018) note that CBR decisions are often a surprise to the market and are more difficult to forecast than decisions by other EM central banks. These results may signal insufficient understanding of CBR policy on the part of the market.

The following measures may help improve the situation:

– Publication of the minutes of CBR key rate meetings, including a more detailed explanation of the decisions.

– Accompanying all key rate decisions with a press conference by the head of CBR, in line with ECB and FED practice (since 2019). The research outlined in the literature review shows that rate decisions accompanied by press conferences receive wider coverage in the media, raising popular awareness of the regulator’s activity. The low predictability of the CBR’s actions is partly
the effect of relatively volatile external conditions. Given this uncertainty, additional press conferences may be warranted.

- More regular speeches by central bank representatives, including explanations of current and future monetary policy stances, providing a basis for the discussion of monetary policy in the media.
- More visible coverage of monetary policy issues on federal TV channels to strengthen the CBR’s communication with a broader audience. Even short comments on CBR key rate decisions are often lacking in news releases on the federal TV channels which are an important source of information for a significant proportion of the population. In general, the very limited screen time dedicated to news and programmes with economic content works against efforts to improve the financial literacy of the population.
- Publication of the future interest rate curve. Arguments for and against this initiative are put forward in detail in Yudaeva (2018) and Isakov et al. (2018).

Thirdly, the government and the central bank should continue their efforts to increase the financial literacy of the population. According to OECD research (OECD, 2016), the index of financial literacy in Russia was 12.2 points out of 21 (versus an OECD average of 13.7). Financial literacy is important as even a perfect communication strategy may be inefficient if the target audience is unable to perceive the message because of low financial literacy.

6. Conclusion

The key goal of this paper was to ascertain whether anchored inflation expectations helped reduce the macroeconomic consequences of external shocks. To this end we have analysed the period from 2011 to 2019, along with the not yet extensively studied episode of capital outflow from emerging markets in the summer of 2018 in reaction to monetary policy normalization in developed countries. Our estimates have confirmed that countries with less anchored inflation expectations usually face higher exchange rate pass-through to prices. This result was obtained in the estimates for 2011–2019, but not confirmed for a shorter period of FX volatility in emerging markets in 2018. Our results do not tally with the conclusion of the IMF paper (IMF, 2018) which confirmed that FX depreciation had greater inflationary consequences in countries with less anchored inflation expectations after the ‘taper tantrum’ in 2013. A possible explanation for the difference in results may be the more prudent approach to managing external shocks taken by central banks in 2018. The inflationary consequences of FX depreciation in 2013 encouraged many central banks to switch to a tighter regime faster in 2018 than in 2013.

Although analysis of the 2018 shock has not confirmed that anchored inflation expectations were significantly beneficial, the results for a longer period still point to the importance of inflation anchoring. One way of anchoring inflation expectations is to make central bank policy more transparent. Our update of the central bank
transparency index first proposed by Dincer and Eichengreen (2007) confirms that in the course of the last five years the transparency of the CBR’s monetary policy has been increasing slightly faster than in emerging market countries on average. However, we note that continued progress in communication is needed, with potentially useful measures including the publication of minutes of meetings and more frequent media appearances by CBR representatives. Keeping inflation close to the declared target, further improvement of communication with the market and additional efforts to increase financial literacy are all important elements in the battle with elevated inflation expectations.

Appendices are available at http://rjmf.econs.online/en; dx.doi.org/10.31477/rjmf.201903.71

References


Review of Bank of Russia Conference on ‘Macroprudential Policy Effectiveness: Theory and Practice’

Nadezhda Ivanova, Bank of Russia
ivanovans@mail.cbr.ru

Mikhail Andreev, Bank of Russia
andreevmyu@cbr.ru

Andrey Sinyakov, Bank of Russia
sinyakovaa@cbr.ru

Ivan Shevchuk, Bank of Russia
shevchukiv@cbr.ru

The Bank of Russia’s international research conference, ‘Macroprudential Policy Effectiveness: Theory and Practice’, was held in St. Petersburg in early July. This review will briefly summarise the discussions with a strong focus on research insights, both the authors’ and our own, that are of practical importance to central bank policy.

Keywords: financial stability, macroprudential policy, monetary policy, Bank of Russia

JEL Codes: E58, E52, E44, E61, G21, G28, A39


1. Introduction

Ensuring financial stability is a relatively new aim for central banks. Although financial sector stability has long been part of the mandate of most central banks

---

1 The views expressed here are solely those of the authors and do not necessarily represent the official position of the Bank of Russia. You must obtain permission from the authors to reproduce any of the content in this review.

2 The conference programme and presentations by the speakers are available at the Bank of Russia’s official website. http://www.cbr.ru/ec_research/programma-mezhdunarodnoy-konferenci/.

3 The following is the standard definition of financial stability proposed by the European Central Bank: a condition in which the financial system – comprising intermediaries, markets and market infrastructures – is capable of withstanding shocks, or in which financial imbalances do not accumulate. Researchers often employ the reverse approach and define financial instability (Kockerols and Kok, 2019; Aikman et al., 2018) by examining its temporal and spatial dimensions. The temporal dimension of financial instability explains the build-up of risks related to the functioning of the financial system over time while the spatial dimension refers to the build-up of risks in specific market sectors or segments. Financial instability is said to be significant (vs some benchmark) in the case of significant expected macroeconomic volatility (employment, GDP, inflation). Volatility depends on the probability and depth of a crisis, if such a crisis occurs.
in one way or another, they only came to understand the real meaning of ‘financial stability’ and the need for a dedicated policy in the wake of the global financial crisis.⁴

The 2008 global financial meltdown offered an object lesson in the devastating fallout resulting from a build-up of financial imbalances. It was precipitated by so-called ‘financial market imperfections’ or ‘market failures’.⁵ In the case of an information asymmetry between the borrower and the lender, the volume of loans (or capital inflow, which is particularly relevant for the financial markets of developing countries) depends on actual and expected growth in borrowers’ income or the collateral value, which itself may depend on the exchange rate.⁶ In turn, both the collateral value and borrowers’ income growth depend on credit dynamics (capital inflow). We end up with a vicious circle, leading to the build-up of an excessive debt burden. To compound the problem, neither banks nor borrowers factor in macro-level implications (or, economically speaking, the credit expansion externality) in their individual decision-making.⁷ This explains why risks were fundamentally overlooked and had accumulated excessively in the run-up to the global financial crisis. Then, when a crisis breaks out and the imbalances which have built up can no longer be sustained, the reverse negative cycle kicks in: investors’ rush to shed bad assets leads to their devaluation or borrower default, which saps the liquidity and capital of financial market participants and undermines their capacity to sustain economic activity. Eventually, they curtail their operations pushing asset prices even lower, further damping aggregate demand in the economy and provoking defaults. This is how the devastating effects of financial crises arise.

Since the free market cannot rise to the challenge of risk self-regulation (due to inherent financial imperfections and externalities), regulators have to take over. In most countries, this is the job of central banks. Central banks now employ dedicated tools to neutralise the causes or implications of ‘market failures’: they have to address the excessive build-up of risks on the eve of a crisis, bolster the resilience of the financial system to potential shocks, and prevent the negative effects of vicious circle on economic entities’ capital in the event that a crisis does break out. These types of special tools have come to be known as macroprudential. Although the focus of these tools is on individual financial institutions, they seek to ensure systemic stability rather than the stability of any individual institution,

---

⁴ Article 3 of the first draft of the Federal Law ‘On the Central Bank of the Russian Federation’ from 1995 lists the aims that under certain circumstances may be aligned with the need to ensure financial stability: ‘to protect and ensure stability of the rouble, including its purchasing capacity and the exchange rate vs other currencies; develop and strengthen the banking system of the Russian Federation; and ensure effective and uninterrupted operation of the settlements system’.

⁵ Six types of ‘market failures’ are given in Borchgrevink et al. (2014); see also the chapter ‘Literature Review’ in Diamond and Kashyap (2016, pp. 2268–2275).

⁶ For developing countries see Caballero and Krishnamurthy (2002) or González et al. (2016).

⁷ Borchgrevink et al. (2014).
in contrast to microprudential tools. The large number of conferences on financial stability held every year is further evidence of the issue’s relevance for central banks and researchers. The Bank of Russia stepped up its use of macroprudential tools in 2012 to curb excessive risk build-up in unsecured consumer lending, and went on to expand its range of macroprudential tools on a regular basis.

Conducting a policy to ensure financial stability and employing macroprudential tools raises a number of questions for central banks (including the Bank of Russia): What are the key risks and vulnerabilities that a particular economy is facing? What range of tools should be used to identify and measure such risks? Could, and should, monetary policy respond to financial stability issues? Could macroprudential tools be employed in addition to monetary policy to smooth over the standard business cycle rather than to promote financial stability? What is the theoretical and practical effectiveness of various macroprudential policy measures and what are their adverse effects?

One reason for the Bank of Russia’s keen interest is the fact that Russia’s financial sector is currently playing catch-up, which highlights the trade-off between steady state processes and excessive risk build-up. The Bank of Russia held its 2019 research conference ‘Macropudential Policy Effectiveness: Theory and Practice’ to probe potential solutions and exchange opinions with colleagues from academia, research centres, and central banks. The programme featured four breakout sessions which built on each other. Session 1 was entitled ‘Identifying and Measuring Financial Stability Risks’. To date there is no consensus on the definition of ‘financial stability’. Could financial stability be expressed in terms of standard macroeconomic indicators (output volatility and inflation) or is it reflected in completely different indicators (e.g. the quality and continuity of financial intermediation)? Lack of an accepted definition is not the only issue. How do we measure financial instability in practice? How do we measure the force of those financial imperfections and market failures that increase financial stability risks in the system? And another question: what is different about financial stability in small open economies, particularly those driven by commodity exports like Russia? All these questions should help to define financial stability in theory and practice.

The first presentation in the Session 1, by the Bank of England economist Sinem Hacioglu Hoke and her co-authors (Aikman et al., 2019), offered a solution to the definition issue and ways to measure financial stability risks.

---

8 Recent conferences include ‘Financial Frictions: Macroeconomic Implications and Policy Options for Emerging Economies’, organised by the Inter-American Development Bank (IDB) and the Central Bank of Chile, and ‘Systematic Risk and Macroprudential Policy’, organised by the Bank of Israel and CEPR.

9 Descriptions of macroprudential instruments can be found in the ‘Financial Stability’ section of the Bank of Russia’s official website, www.cbr.ru.
The authors define financial instability as a substantial decline in GDP, which is a rare occurrence, and measure it using the GDP-at-risk indicator. According to the authors, financial instability factors such as credit-to-GDP, balance of payments' indicators, financial market volatility, and real estate price changes lead to a higher GDP-at-risk, while employing higher capital ratios for banks as a prudential policy tool tends to lower GDP-at-risk, i.e. to reduce financial stability risks.

The second presentation in the Session 1, by the International College of Economics and Finance, Higher School of Economics (ICEF, HSE) Professor Udara Peiris, laid out the conclusions of ‘Commodity Cycles and Financial Instability in Emerging Economies’, a research paper he produced jointly with the Bank of Russia (Andreev et al., 2019). The paper examines the role of global oil price changes in the build-up of financial stability risks and, consequently, in the volatility of macroindicators. According to the authors, a model with an endogenous credit-risk premium (the risk of default) reflected in interest rates is better suited to describe the performance of macroeconomic variables in the case of oil price changes than a model in which the risk premium is fixed, regardless of oil and business cycles. Such prudential policy measures like caps on Loan-to-Value (LTV), loan loss provisions, or capital ratios can contain both the build-up of risks and economic volatility if negative shocks do materialise.

The topic of Session 2 was optimal monetary and macroprudential policies. Now that the conference had discussed ways to define financial stability and measure its risks, it was time to consider a new group of regulation-related questions of practical importance. What is the best way for a central bank to respond to financial stability risks? For instance, a particularly relevant question that provokes heated debates in academia is whether monetary policy can be leveraged to ensure financial stability as a substitute for or addition to macroprudential policy. A similar question concerns the nature of monetary policy constraints and whether macroprudential policy could overcome these constraints as part of its conventional aim of stabilising the economy.

A presentation by Eddie Gerba from Danmarks Nationalbank, ‘The Quest for Robust Optimal Macroprudential Policy’ (Aguilar et al., 2019), examined the optimal choice of parameters for macroprudential policy instruments. The authors looked at optimal prudential policies (the optimal level of bank capital) and macroprudential policies (the countercyclical capital buffer) for the euro area. Another important requirement for such a policy is robustness,

---

10 In the literature, the debate on the effectiveness of the approach is generally referred to as ‘leaning against the wind’ (Svensson, 2017a, 2017b; Adrian and Liang, 2016; see also the presentation by Claudio Borio (BIS) in Section 5).

11 The debate is known as ‘dilemma, not trilemma’, and concerns central banks’ ability to conduct an independent monetary policy (Rey, 2015, 2016; Gourinchas, 2018).
i.e. application based on immediately observable indicators only. The authors discovered that the negative implications of overshooting in regulation pale in comparison with the effects of undershooting (low bank capital). A combination of both policies based on robust policy rules yields a more sustainable path for the economy than does a regime that implements each policy in isolation. Optimal prudential regulation balances out the benefits and costs of tighter regulation, which differ for borrowers and depositors, as well as opposite effects on household consumption from higher demand and accumulated risks of default during credit growth.

There is an important objection found in the literature against applying monetary policy to ensure financial stability in small open economies. Critics argue that monetary policy is potentially not sufficiently effective to achieve even its priority objectives of stabilising prices and output, and will therefore fail to accomplish this goal too. This critique casts doubt upon the ability of small open economies’ central banks to pursue a monetary policy that is independent from global financial markets. As a result, attempts to tighten monetary policy amid an expanding credit boom, particularly one that is financed through capital inflow, may prove ineffective, merely triggering further currency appreciation and an additional wave of capital inflows. A tighter domestic financial context would be offset by softer external conditions, leading to an accumulation of external debt and so extra financial stability risks.

The second presentation in the session, ‘The Expansionary Lower Bound: Contractionary Monetary Easing and the Trilemma’ (Cavallino and Sandri, 2019), by the International Monetary Fund (IMF) economist Damiano Sandri, simulated a loss of monetary independence and studied alternative policy instruments. The authors determine the conditions in which, at a certain point in time, monetary easing, coupled with certain shocks, begins to create a drag on the economy. The authors identify policy alternatives and come to the conclusion that a preventive macroprudential policy could help restore monetary independence in this context.

Session 3 was entitled ‘(Unintended) Effects of Macroprudential Policy’. The practice of macroprudential regulation is often ahead of research into its potential effectiveness, since assessment of practical effectiveness requires data. This makes the practical experience of conducting macroprudential policy a critical source for the information needed to design an optimal policy and

---

12 Indicators such as the credit gap (deviation of the ratio of loans issued to GDP from a certain equilibrium level) are not immediately observable, since their calculation requires an estimate of an unobservable value, which is the equilibrium level of loans that corresponds to the level of financial development in the economy.

13 See Rey (2016).

14 Integration of financial markets and the presence of financial imperfections may lead to a situation in which the floating exchange rate does not enable the central bank anymore to set domestic interest rates (a monetary policy regime) that are different from foreign rates under free capital movement.
identify the undesirable or unexpected effects that such a policy can entail. Why should a special session be devoted to the unintended effects of macroprudential policy? The latter is designed to prevent economic entities from taking on excessive risk through certain constraints. However, these macroprudential restrictions may push entities that are subject to regulation to change their behaviour, which could have undesirable (and unintended) effects for the financial system or the economy as a whole.

Theoretical works identify several factors behind those undesirable effects of macroprudential policy that can have an impact on its ultimate effectiveness. One of them is regulatory arbitrage and incentives for the regulated sector to move its operations to other unregulated forms. For instance, change in incentives under tighter regulation (the so-called ‘moral hazard’) may lead the regulator to form the impression that higher capital requirements have made financial market participants resilient to shocks, which could in turn lead them to underestimate risks in decision-making or even provoke riskier behaviour on the part of market participants. This was the focus of Session 3.

The goal of the session was to use existing experience of applying macroprudential policy to assess the effectiveness of its instruments and the scale and channels of any unintended effects, and to measure the significance of these effects and their impact on the effectiveness of macroprudential policy.

The first report of the session, ‘Digging Deeper: Evidence on the Effects of Macroprudential Policies from a New Database’, was presented by Erlend Nier from the IMF, who was one of the authors (Alam et al., 2019). It provides a quantitative evaluation of the target and side effects of macroprudential policy using a unique database of macroprudential tools. According to the authors, macroprudential policy measures are effective.

In the second report of the session, ‘Has Regulatory Capital Made Banks Safer? Skin in the Game vs Moral Hazard’, Ernest Dautović (University of Lausanne) makes the important point that macroprudential policy may encourage risk-taking, with side effects that could entirely neutralise the effectiveness of macroprudential policy (Dautović, 2019).

The conference closed with a panel discussion of financial stability policy recommendations for central banks, set out in a special report by Claudio Borio from the Bank for International Settlements (BIS), as well as applied findings from the reports presented during earlier sessions. Along with Claudio Borio (BIS), the panel discussion featured Patricia Mosser (Columbia University), Richard Portes (London Business School), and Ksenia Yudaeva (Bank of Russia).

Claudio Borio’s presentation criticised monetary policy’s narrow focus on addressing price stability issues in an environment in which various global and sustainable factors have pushed inflation down to a systemically low level while increasingly provoking bubbles in financial asset markets. Below is a list of the key issues raised by the panellists:
opportunities and constraints in applying monetary policy and macroprudential policy to ensure financial stability and manage the standard business cycle, in particular the need to extend the monetary policy horizon;
- opportunities for simultaneously tightening one policy and easing the other;
- estimates of equilibrium interest rates. The need to ensure financial stability pushes estimates of the equilibrium rate up: a lower interest rate leads to a build-up of excessive risks;
- options for a combination of monetary policy and macroprudential policy.

Our review of the conference continues as follows. Each section is devoted to a particular session of the conference. The conclusions summarise key takeaways for central bank policies based on the authors’ research findings.

2. Identifying and measuring financial stability risks

The paper by Sinem Hacioglu Hoke and her co-authors (Bank of England), ‘How do Financial Vulnerabilities and Bank Resilience Affect Medium-Term Macroeconomic Tail Risk?’ (Aikman et al., 2019), explores macrofinancial factors that shape the risk of an economic crisis and the effectiveness of macroprudential regulation. The ‘fat left tail’ in the empirical distribution of GDP growth arises when the probability of a decline in GDP is higher than the probability of its growth. Research into economic cycle volatility should therefore employ methods that factor in the asymmetrical nature of the distribution. In the paper, the authors use a panel quantile regression to build a function describing the probability distribution of GDP growth rates in the medium term based on a dataset of 16 developed countries between 1980Q4 and 2017Q4. As a measure of the ‘tail’ (crisis) risk, the paper uses GDP-at-risk, defined as the real GDP rate that corresponds to its lower 5th quantile.

Analysis of financial resilience relies on the existence of a correlation between the level of capitalisation in the banking system and GDP-at-risk. According to the authors, a higher level of bank capital substantially mitigates risks of a major output cut, although it also cools growth in the short term. This re-affirms the expedience of introducing a countercyclical capital buffer in the face of the growing vulnerability of the banking system as an effective macroprudential policy tool. The authors propose a potential cost-benefit analysis framework for macroprudential intervention. Using vulnerability measures for the banking system, the authors also establish that financial imbalance indicators such as credit growth, rapid house price growth, and a large current account deficit create material ‘tail risks’ to GDP in the medium term. In contrast, the financial conditions index that is widely utilised in practice has not been found to exert any significant impact on GDP-at-risk.
Alexey Ponomarenko (Bank of Russia) acted as discussant for the report. During the discussion, he highlighted the importance of the findings for calibrating early warning systems for financial crises as well as analysing the costs and benefits of macroprudential regulation. However, Ponomarenko argued that the short-term effect from higher actual capitalisation may not coincide with the effect from increasing the required level of capitalisation. The discussant also pointed out that a potential quantile model could prove a useful tool for routinely monitoring financial stability risks as well as for identifying the effect of macroprudential measures that are deployed to prevent crises. However, this would require evidence that the model had good predictive properties.

The second report of Session 1, ‘Commodity Cycles and Financial Instability in Emerging Economies’ (Andreev et al., 2019), was presented by Professor Udara Peiris from the ICEF, HSE. The paper was drafted as part of collaboration between the Bank of Russia and the ICEF with input from Professor Dimitrios Tsomocos (Said Business School and St Edmund Hall, University of Oxford).

As Professor Peiris said in his introductory remarks, dynamic macroeconomic models with rational expectations initially used unobservable shocks to explain the causes of economic fluctuations, primarily the total factor productivity shock (TFP). The New Keynesian revolution in economic modelling, which uses various imperfections such as price and wage rigidity, habitual consumption, cost of producing new capital, and financial frictions, did not change the situation much, since the shocks remained unobservable. It is only in the past decade that the design and evaluation of open economy models with observable shocks has come to be included as an element of dynamic stochastic modelling. Depending on the model specification, observable shocks could include export price shock, exogenous interest rate shock, and exchange rate shock. As a rule, these shocks have a sizeable, if not paramount, impact on developing economies. It is vital to estimate the impact of observable shocks on the economy, as this enables the regulator to rely on observable variables in pursuing a policy that seeks, among other goals, to consolidate financial stability.

During the presentation, the speaker gave his thoughts on the extent to which financial frictions should be factored in when estimating the role of an observable commodity price shock, as well as on the type of economic policy that should be conducted with regard to financial frictions.

To this end, the authors have built a New Keynesian model with a banking system and firms which can default on their contractual obligations. The model was estimated using Russian quarterly data. The model examines two types of financial frictions that correspond to two types of loans. In the first case, of risk-free loans with the collateral constraint, the friction comes from the time-varying collateral value. In the second case, of collateral-free loans, a defaulted corporate borrower incurs costs in proportion to the loss given the default and
credit conditions prevailing in the economy. In this case, frictions come from the
loss given default.

The speaker emphasised that the Russian data are better described by a
type of model that factors in financial frictions and time-varying values for
the collateral constraint and the loss given default. It is frictions related to
unsecured loans that are of the greatest importance, and it is this type of loan
that acts as a driver (important transmission mechanism) of the business cycle.
According to the report, with financial frictions at play, 65% of the variation
in GDP growth rates is explained by the observable oil price shock, while 31%
is explained by the unobservable TFP shock. If financial frictions are absent,
these figures are 55% and 41% respectively, which shifts the responsibility to
unobservable shocks. In both cases, the observable oil price shock remains the
primary explanation.

The conclusion presented model experiments with macroprudential policy
tools. For instance, regulating the required reserve ratio for bank deposits may
smooth the credit cycle but also even out output dynamics. The Taylor rule with
the ‘lean against the wind’ modification also stabilises the credit cycle, albeit at the
cost of some underperformance in inflation. In general, the authors conclude that
macroprudential measures in the model have a weak effect on macroeconomic
indicators. According to the authors, the findings from the model are trustworthy,
which could render the model suitable for use by a regulator to monitor the
implications of various macroeconomic policy tools, including macroprudential
policy tools.

Valery Charnavoki (New Economic School) acted as discussant for the
report. Charnavoki noted that the model does not specify the source of oil
price shocks, which can stem either from global demand for oil or from the
oil supply side, and argued that this could affect the response of the model
variables. Oil demand shocks are not accounted for in the model. Furthermore,
the discussant highlighted major differences in the responses of real GDP and
household consumption to the model’s main shocks. First, the oil price shock
explains only a fraction of the variation in consumption (the key contribution
comes from the unobservable TFP shock, which is not the case for GDP
variation). Second, impulse response functions suggest that consumption
exhibits counter-intuitive dynamics: in response to a positive oil price shock,
GDP rises significantly while consumption picks up marginally before falling
in several quarters’ time.

According to the discussant, the model could be extended by adding in
habitual consumption, factoring in oil consumption in domestic production,
and examining fiscal policy rules. Furthermore, the discussant believes it
important to add a proxy for foreign demand for Russian non-oil exports
to the model, for instance, as a variable of the state of demand in the global
economy.
3. Optimal monetary and macroprudential policies

In Session 2, ‘Optimal Monetary and Macroprudential Policies’, Eddie Gerba (Danmarks Nationalbank) presented a paper entitled ‘The Quest for Robust Optimal Macroprudential Policy’, penned jointly with Pablo Aguilar, Stephan Fahr, and Samuel Hurtado (Aguilar et al., 2019). The authors examine such macroprudential policy tools as the bank capital adequacy ratio (CAR) and countercyclical capital buffer (CCyB). It is assumed that the CAR does not vary with time and has an impact on the steady state of the economy. However, the CCyB responds to changes in financial stability indicators, like the Taylor rule for monetary policy,15 and facilitates lower short-term volatility in the economy.

The authors look for the optimal CAR level and the optimal CCyB rule for the euro area using the Dynamic Stochastic General Equilibrium model (DSGE model) proposed by Clerc et al. (2015), maximising the analytically derived economy-wide welfare function. According to their findings, the optimal CAR value in the euro area is 15.6%, 2.4 percentage points (p.p.) higher than the actual mean coefficient of banks’ capital adequacy in 2001–2014. The combination and the weights of the financial stability variables in the CCyB optimal rule depend on the pre-set CAR: under the optimal CAR, the optimal CCyB rule includes a response to the general credit volume and the spread in mortgage interest rates.

The CAR is one of the most widely used instruments of macroprudential and (initially) prudential policy (Cerutti et al., 2017).16 It is believed that a change in the CAR makes it possible to have a large-scale effect on the sources of financial instability, and in particular on debt accumulation in the economy, by exerting influence on credit supply to the real sector by the banking sector, a key element of financial systems in most countries.

Since the findings of Aguilar et al. (2019) rely on the DSGE model by Clerc et al. (2015), we will focus here on the specifics of this model. Clerc et al. (2015) model an interaction between the real and the financial sectors of the economy, financial market imperfections that lead to endogenous defaults by borrowers, and macroprudential regulatory instruments. The model features the following economic entities: households, entrepreneurs, banks, bankers (bank shareholders), and the macroprudential policy regulator. The model does not factor in nominal rigidities, and therefore has no space for monetary policy.

The model includes a number of financial market imperfections that amplify the transmission of shocks in the economy and justify the use of

---

15 Under the classic Taylor rule for monetary policy the short-term interest rate set by the central bank responds to deviations in (expected) inflation and the (expected) output gap from target (potential) indicators.

16 The CAR and CCyB have been recommended as prudential and macroprudential instruments by the Basel Committee on Banking Supervision (Basel Committee on Banking Supervision, 2010b). The CAR value and calculations used for regulatory purposes have been subject to major evolution as part of the transition from Basel I to Basel II and then to Basel III (see Basel Committee on Banking Supervision, 2010a).
macroprudential policy. First, like households and entrepreneurs, banks have only limited liability. If a bank defaults, full recovery of deposits and interest payments is guaranteed to depositors by the Deposit Insurance Agency (DIA),\textsuperscript{17} and not by the bank or its owners, whose capital cannot be negative. Similarly, households and entrepreneurs who have borrowed from banks are liable to them to the extent of their assets only.

Second, despite the deposit insurance system, households incur certain transaction costs (10\%) if a bank defaults.\textsuperscript{18} Consequently, in an equilibrium, banks have to pay a risk premium on deposits that rises in sync with the aggregate default probability, since depositors cannot estimate the behaviour of an individual bank. The cost of funding for each bank depends on the average default risk in the banking sector, not the risk level of the operations it performs to attract deposits and issue loans. Along with the deposit insurance framework, this situation, defined in Clerc et al. (2015) as the ‘bank funding cost externality’, creates ‘incorrect’ incentives for banks to assume additional risks (the so-called ‘moral hazard’ problem).

Furthermore, the transfer of the borrower’s rights to the creditor in the event of bankruptcy and the subsequent liquidation of the assets concerned are accompanied by deadweight losses. These losses are partly due to asset depreciation (the model includes the aggregate shocks of real estate and capital depreciation). However, it is also assumed that the borrower can sell only a certain share (70\%) of the property that has been taken over while the rest is lost in a costly state verification (CSV) procedure or in bankruptcy proceedings. The CSV assumption is used as standard when modelling a relationship between investors and borrowers in the form of standard debt contracts that take into account the possibility of the borrower’s bankruptcy in the context of information asymmetry (realisation of idiosyncratic or borrower-specific shocks) and borrowers’ limited liability.\textsuperscript{19}

The infinitely lived households in the model are split into two types: saving (patient) and borrowing (impatient) households.\textsuperscript{20} Patient households have deposits with banks. Impatient households take out mortgage loans from banks to purchase real estate and make interest payments on the loans. Each impatient household is exposed to an idiosyncratic shock related to the state of the property that may push households to default if payments to service the mortgage exceed the collateral (property) value. If a household defaults on a

\textsuperscript{17} DIA income is generated from the tax paid by saver households (see below).

\textsuperscript{18} This assumption is justified by the fact that in reality not all bank liabilities are insured and investment in these liabilities requires certain risk premia.

\textsuperscript{19} The CSV approach first proposed by Townsend (1979) and subsequently applied to capital markets by Gale and Hellwig (1985) was further developed in Bernanke et al. (1999), which examines the impact of financial market imperfections on the business cycle as part of the DSGE model.

\textsuperscript{20} Patient and impatient households differ in the values of discount coefficients in the utility function with the following arguments: number of consumer goods, durables (real estate), and hours worked in the sector that produces consumer goods.
mortgage, the bank takes over only the title rights to the property listed as collateral (non-recourse loan).

Risk-neutral entrepreneurs are combined into two-period lived generations that hold capital stock and have a unique right to rent capital to firms that produce consumer goods. Entrepreneurs purchase capital from firms that produce capital goods using the capital inherited from previous generations and corporate loans from banks. The ability of entrepreneurs to service loans depends on an idiosyncratic shock that realises after the loan has been issued and has an impact on the entrepreneur’s returns on capital investment. The entrepreneur goes into default on a bank loan if the returns on capital investment does not cover his or her loan payments.

Bankers are modelled similarly to entrepreneurs, and are the only agents in the model to hold the right to invest in bank's equity capital. In the first period, bankers make the decision to split inherited capital into two classes of investment: capital of banks that issue loans to households, and capital of banks that issue loans to entrepreneurs. Banks finance mortgage and corporate loans through the issue of shares that are purchased by bankers and the acquisition of deposits from saver households. Banks exist for one period. In the case of deposits, banks make interest payments that are common for all banks since deposits are fully insured by the DIA, and depositors cannot estimate the risk level of each bank's credit policies. Loan interest payments vary for corporate and mortgage loans. Bank return from loans is exposed to idiosyncratic shocks, which, along with the conditions of borrowers (the realisation of their idiosyncratic shocks), may lead a bank to default on its liabilities to depositors. Like other borrowers in the economy, banks hold only limited liability on their obligations. Each bank (banker) perceives interest rates for loans (of a certain type) and deposits as pre-set. Each bank's default probability has an impact on the aggregate default probability indicator in the banking system and on interest rates for deposits and loans.

The ratio of bank capital to loans cannot be lower than the CAR set by the macroprudential regulator (in an equilibrium it is equal to the CAR). The role of the CAR is to curb a bank's risky behaviour in a context of limited liability on deposits. The need to comply with the CAR pushes banks to make more use of capital that is more expensive than deposits (due to its limited supply) as a source of funding, which in its turn lowers banks’ probability of default. However, the use of a more costly source of funding leads to higher loan interest rates and fewer loans in a

---

21 At the end of every second period, entrepreneurs pass on some of their capital as inheritance to the next generation of entrepreneurs while the rest is shared with saver households free of charge (for instance, in the form of dividends).

22 There is an infinite set of initially equal banks of both types that operate in a perfectly competitive environment. In the steady state, bankers’ expected return on investment in both types of capital is the same. The transfer of some of the capital by bankers and entrepreneurs to households allows the analysis of general welfare in the economy to be focused on household utility functions.

23 All idiosyncratic shocks in the model are characterised by a lognormal distribution.
steady state. This gives rise to the issue of trade-offs and the search for an optimal CAR value given a certain criterion of optimality.

The first important finding of the paper by Aguilar et al. (2019) is the authors’ determination of the optimal CAR value that maximises the aggregate welfare function of the economy (the weighted average of the utility functions of saver and borrower households) while minimising the volatility (deviations from mean values) of the function arguments. The authors obtain an analytical expression to approximate the welfare function around the steady state value with the Taylor series including first- and second-order terms. As a result, according to the authors, deviation of the welfare function from the steady state value may be approximated as the sum of the terms that depend on the mean values and the variance of four variables (the housing stock of saver and borrower households, wages, and capital). The choice of weight values in the expression is based on the results of the model calibration in Clerc et al. (2015) for the euro area.

The authors thereby determine the optimal CAR value, at which welfare in the economy peaks at 15.6% for the euro area, 2.4 percentage points (p.p.) higher than the mean capital adequacy coefficient observed in 2001–2014. The authors build a graph of welfare gains depending on CAR values in the range of 10% to 18%. If the CAR increases from low values, a significant welfare gain is achieved. Once the optimal CAR value is reached, welfare goes down insignificantly. Therefore, the authors conclude that undershooting on CAR is more costly in terms of welfare losses than overshooting. The result of the model stems from the assumptions concerning the presence of externalities and deadweight losses in case of defaults.

Breaking down welfare gains due to the optimal CAR versus the actual capital adequacy indicator reveals that gains from a higher CAR occur primarily due to lower depositor costs (lower probability of default for banks), but with somewhat fewer benefits for borrowers. As the CAR approaches the optimal value, virtually all changes in welfare gains occur due to higher depositor gains. When the CAR is higher than the optimal value, the economy sees a significant increase in losses due to inadequate levels of credit, economic activity, and wages.

Comparative analysis of the performance of the key model variables reveals that raising the CAR from the actual to the optimal value results in the following insignificant changes in the steady state: lower credit in the economy, higher interest rates, fewer bankruptcies by all borrowers, and higher GDP.

Furthermore, the authors explore the potential historical behaviour of the key model variables if the CAR mean value had been at its optimal level rather than its actual level (i.e. a counterfactual scenario). The authors first break down the historical performance of the model variables (deviations from equilibrium values) in terms of the model’s structural shocks, and then use the estimated shocks to run a model simulation with the optimal CAR value. According to the authors, a higher CAR would have decreased the share of bank defaults by 3.5 p.p.
during the sovereign debt crisis in the euro area in 2011–2013, which would have pushed credit and GDP 5% and 0.8% higher than the actual figures respectively. The authors conclude that, although raising the CAR from its actual to its optimal value (up 2 p.p.) would increase general welfare marginally, it would substantially dampen volatility in the economy.

The authors point out that it is possible to further contain volatility in the economy in the short term if the optimal permanent CAR is coupled with a variable Countercyclical Capital Buffer (CCyB) that automatically responds to a change in indicators reflecting financial stability risks. The second important finding of the paper by Aguilar et al. (2019) is the modelling of the CCyB rule (like the Taylor rule in monetary policy) that responds to indicators related to financial stability and the determination of the optimal CCyB rule that minimises the loss function in the economy. As in the literature on optimal Taylor rules in DSGE models (Woodford, 2003; Gali and Monacelli, 2005; De Fiore and Tristani, 2013), the authors take as the loss function an approximation of the aggregate function of welfare in the economy around the steady state by the second-order Taylor series in which they ‘bring together’ second-order terms in the form of variance of the four main model variables (housing stock of saver and borrower households, wages, and capital) in the loss function in the economy.

With the goal of minimising the loss function, the authors consider several rules, all of which presuppose the linear dependence of the CCyB (with certain weights) on two of the following variables (or rather, on their deviations from steady state values): aggregate credit volume, housing prices, spreads in mortgage loans, corporate loans, and housing investment in the economy. The authors give separate consideration to cases in which capital adequacy takes actual and optimal values.

Taking the actual value of the CAR in the euro area, the optimal CCyB rule depends on the aggregate credit volume (with a weight of 0.3) and on housing prices (with a weight of 0.6). Sensitivity analysis demonstrates that even a marginal deviation in the value of the variables’ weights from the optimal values in the CCyB may lead to substantial welfare losses in the economy (higher values of the loss function).

When the permanent CAR is optimal, the optimal CCyB responds to changes in credit and mortgage spreads. The optimal CCyB rule combined with the optimal CAR produces a significantly larger gain in welfare than the optimal CCyB under the actual CAR. Furthermore, when the CAR is optimal, the sensitivity of welfare to the values of variables’ coefficients (weights) in the CCyB rule is lower, i.e. the cost of error in setting a non-optimal coefficient is lower and the sustainability of the rule increases.

Armen Nurbekyan (Bank of Armenia) acted as discussant for Aguilar et al. (2019). He pointed out that the model’s assumption that financial cycles are driven by the deposit insurance system, which is the source of moral hazard for banks, does not
seem very plausible. In connection with this, to generate significant fluctuations in the model’s financial indicators, the authors had to assume unrealistically large losses (30%) for creditors in the case of default by borrowers (see also Kiyotaki, 2015). The discussant proposed using an analysis of impulse response functions to check how well the model describes stylised facts about the relationships between the variables during financial cycles. The discussant also suggested that paper by Aguilar et al. (2019) would benefit from a comparison of the results of estimating the optimal CCyB rule with the findings of other research on the topic (for instance, studies by the BIS).

Damiano Sandri (IMF) explored situations in which monetary policy in the economies of emerging markets (EMs) may lose its effectiveness and independence with a report entitled ‘The Expansionary Lower Bound: Contractionary Monetary Easing and the Trilemma’, which builds on joint research with Paolo Cavallino (Cavallino and Sandri, 2019).

Central banks in EMs often do not want to cut interest rates in an economic crisis, fearing capital outflow and national currency depreciation, which could cause a slowdown in aggregate demand in the economy rather than spur growth. Regression analysis on a panel of eight large EMs\(^2\) demonstrates a significant statistical and economic response from central banks’ short-term interest rates not only to standard variables in the Taylor rule (expected inflation and output gap), but also to indicators that reflect global and monetary conditions (the US Fed rate and the VIX global market volatility indicator).

Cavallino and Sandri (2019) offer a theoretical substantiation for the ‘dilemma’ as opposed to the ‘trilemma’, i.e. evidence of the significant impact of global financial and monetary factors on monetary policy independence and financial stability in EMs, which have been well represented in the literature in recent years (Rey, 2015, 2016; Rajan, 2015; Bruno and Shin, 2015, 2017). The authors describe two models for which the monetary policy trilemma does not work. With free movement of capital and a floating exchange rate, central banks in EMs may find it impossible to pursue an independent monetary policy and ensure economic stabilisation (in particular in terms of GDP). Such situations occur when the effects of volatile global capital flows and internal collateral constraints come into play at the same time. These models predict the existence of the so-called Expansionary Lower Bound (ELB): a monetary policy easing with central bank rates lower than the ELB would cause output contraction, not growth. The economy also has a corresponding upper output bound that can be achieved through an expansionary monetary policy.

The ELB may prove to be an even tighter constraint for monetary policy than the Zero Lower Bound (ZLB), if the ELB is positive. Moreover, as the authors’ models reveal, the ELB may change due to exogenous shocks: a tightening of global financial and monetary conditions pushes the ELB up. Consequently, the models

\(^2\) Brazil, China, India, Indonesia, Mexico, Russia, Turkey, and South Africa.
provide a theoretical explanation for the need for central banks in EMs to raise interest rates in response to a tightening in exogenous conditions, which is in line with the results of the regression analysis.

The first model proposed by the authors explains the ELB with reference to the impact of monetary policy on volatile carry-trade capital flows given leverage constraints in EMs. Foreign investors (carry-traders) purchase sovereign government bonds in EMs, the demand for which is positively correlated with the expected currency risk premium over peer foreign government bonds. Domestic banks’ assets include loans and sovereign government bonds. An easing in monetary policy in the model prompts capital outflow; as a result, domestic banks ramp up investment in sovereign government bonds. In the case of a fairly sizeable interest rate cut by the central bank that entails a major capital outflow, banks face the leverage constraints and are forced to cut lending (and raise loan interest rates), which leads to lower output. Therefore, an easing in monetary policy may cause output contraction.

In the second model, the emergence of the ELB is related to the effect of currency mismatches on collateral constraints for banks in EMs. Domestic banks in EMs borrow in global financial markets at low interest rates and issue loans to domestic borrowers in national currency. As in the first model, banks face constraints on leveraging depositor funds (leverage constraints). Where the capital adequacy constraint is not binding, an easing in monetary policy has a conventional expansionary impact on the economy, including through higher foreign demand for domestic goods in the case of national currency depreciation. However, in the case of a substantial easing in monetary policy and national currency depreciation, bank capital shrinks and loan interest rates go up, while lending drops. As a result, the economy goes into recession.

The conclusions made in the paper regarding changes in the ELB due to exogenous factors and monetary policy in previous periods are of relevance to economic policy. A higher ELB is triggered by a tightening in external financial conditions that dampens demand for domestic sovereign government bonds, in the first model, and higher global interest rates that prompt a weakening in the national currency, in the second model. Furthermore, a tighter monetary policy stance in the current period reduces the ELB in the future, making monetary policy less effective even in the range of central bank rates that exceed the ELB.

Faced with ineffectiveness and loss of monetary policy independence due to the ELB, countries may have to rely on alternative macroeconomic policy tools. As Cavallino and Sandri (2019) illustrate with the help of their models, unconventional monetary policy, macroprudential policy, and capital flow controls may help overcome ELB-related constraints, depending on how these constraints originated.

Both models presented by Cavallino and Sandri (2019) explore three periods: Period 0, Period 1, and Period 2. Period 2 reflects a steady state with no market
imperfections.25 Period 0 and Period 1 are considered by the authors as short-term equilibriums. Period 1 sees the materialisation of conditions that give rise to the ELB. Period 0 may see events that will shape the value of the ELB. The model is calculated with the backward induction method, with the steady state values in Period 2 calculated first, followed by the short-term equilibrium values in Period 1 and Period 0.

Both models have saving and borrowing households. Both types of households maximise their intertemporal utility functions that depend on consumption of domestic and foreign goods. Borrowing households take out loans from banks and make interest payments on them. Saving households place deposits with banks and earn interest on them. The net total income of borrowing households depends on wages, profits from domestic firms,26 and lump-sum taxes. Short-term prices (Period 0 and Period 1) for domestic and foreign goods are presumed to be fixed, so monetary policy has an impact on the real sector. Long-term (Period 2) prices are flexible, and monetary policy has an impact on nominal economic indicators only.

In modelling the banking sector, a representative bank is examined that uses capital and deposits to issue loans, purchase government bonds, and support a certain level of reserves with the central bank. The bank’s capital in the subsequent period is the bank’s profit from the preceding period (the difference between interest income on loans and interest losses on deposits).27 The share of risk-weighted assets (loans and government bonds)28 to bank capital may not exceed the capital adequacy ratio. Banks operate in a competitive environment and change the structure of their balance to maximise profit (capital) in each period.

With no opportunities for arbitrage, interest rates for deposits and reserves with the central bank are equal. Interest rates for loans, government bonds, and central bank reserves are the same only in situations in which the leverage constraint is not binding (in this case, the transmission channel of monetary policy operates and a change in a central bank key rate is fully passed through to other rates in the economy). If the leverage constraint is binding, loan interest rates exceed the central bank rate.29 Under baseline scenarios in the models, the central bank sets the remuneration rate on reserves, and

25 In Period 2 both models make a number of simplified assumptions, demonstrating that the nominal exchange rate is equal to the share of money supply in domestic and foreign economies.
26 The model features a continuum of firms in a competitive monopolist environment which produces differentiated domestic goods (the foreign economy correspondingly produces foreign goods). The first model assumes that the law of one price does not hold for equivalent domestic and foreign goods, and firms use Local Currency Pricing (LCP) in foreign markets.
27 The banks are presumed to be unable to increase capital through the issue of new shares in the short term.
28 Government bonds are viewed as less risky assets than loans.
29 Government bond yields in this case will remain between the central bank rate and the loan rate due to the lower risk level of government bonds versus loans.
the government issues bonds in the amount that is needed to redeem bonds from the preceding period.

We will now look at the first model in the paper by Cavallino and Sandri (2019) in greater detail. Foreign capital is injected into the economy by foreign financial intermediaries that purchase government bonds through borrowings in foreign currency in global financial markets. Expected return in foreign currency from holdings in domestic government bonds depends on the current and expected exchange rates, on the yield of domestic government bonds, and on global interest rates. Cavallino and Sandri (2019) assume that the incentive compatibility constraint initially considered in Gabaix and Maggiori (2015) is at play in the case of foreign financial intermediaries. The constraint states that expected return in foreign currency from holdings in government bonds should not be lower than the return from improper activities on the part of foreign intermediaries in diverting some of the borrowed funds (instead of investing them in government bonds). The constraint operates in a binding form, presenting the dependence of foreign investors’ demand for government bonds as a function that grows along with rising expected returns and risk appetite on the part of investors.

In Period 1, in an equilibrium, if the country is a net borrower, a monetary policy easing triggers capital outflow (or lower inflow) due to a lower expected return from government bonds in foreign currency. As long as capital adequacy permits, domestic banks may boost their holdings in government bonds. However, a major policy rate cut by the central bank triggers a situation in which the capital adequacy condition begins to act as a constraint for banks investing in government bonds. This situation arises when a certain minimum amount of foreign capital which is needed to satisfy the domestic demand for credit by the public sector (a country’s capital shortfall) is reached, which, in turn, is equivalent to a certain policy rate, which, in certain conditions (see below), constitutes the Expansionary Lower Bound (ELB) in the economy. The higher the minimum necessary capital inflow, the higher the ELB. Furthermore, the ELB shows positive dependence on the rigidity of global financial conditions (the opposite value to foreign investors’ risk appetite).

When the policy rate is lower than the ELB, the monetary policy transmission mechanism stops working. The authors demonstrate that under fairly tight global financial conditions a monetary policy easing may trigger tighter lending conditions (a credit crunch): due to the leverage constraints, banks have to raise interest rates on loans. This ineffectiveness and, in certain conditions, counterproductivity of monetary policy is due to the leverage constraint, which may generate financial frictions in the economy that do not allow foreign capital to be fully replaced with funds from domestic depositors.

To simplify, household demand for loans does not depend on the policy rate, and in Period 1 households take out loans from banks that are needed to pay off loans from Period 0.
A monetary policy easing that triggers a simultaneous hike in lending rates and lower deposit rates decreases consumption by borrowing households while boosting consumption by saving households. An easing in monetary policy will prompt a recession (output contraction) in the economy, i.e. the ELB comes into play when the impact of changes in loan rates for borrowing households proves to be greater than the impact of changes in deposit rates on saving households. The model links the ELB with a certain upper output bound: the maximum output level around which a non-monotonic dependence on the interest rate level can be observed.

According to the authors, the ELB may undermine the stabilising role of monetary policy in the case of adverse external shocks. For instance, tighter global financial conditions (a lower risk appetite on the part of foreign investors) trigger a higher ELB and bring the upper output bound in the economy down. Tighter global monetary conditions (a higher borrowing rate in global markets for foreign investors) bring down external demand for domestic goods and therefore also the upper output bound in the economy.

In addition to this analysis, the authors also considered equilibrium in Period 0 to establish how the possibility of coming up against the ELB issue in the future affects current monetary policy. They demonstrate that, under certain quite probable conditions, a tighter monetary policy in Period 0 triggers a lower ELB in Period 1 at the expense of slower lending in Period 0 (which ‘delays’ the onset of the leverage constraint for banks). Therefore, central banks in EMs may be forced to conduct a relatively tight monetary policy in advantageous exogenous conditions in order to be in a position to sustain the economy through a lower rate in the case of negative shocks in the future. As a result, the possibility of having to tackle the ELB problem in the future places constraints on output in the economy in the present, too.

On an intuitive level, the authors debate which alternative economic policy tools might reduce the urgency of the ELB issue, i.e. lower the ELB. For instance, in general, there is a chance that fiscal consolidation might not resolve the ELB issue, in fact exacerbating it through higher demand for loans due to Ricardian equivalence. Government subsidies for capital inflow, one option provided by macroprudential regulation, brings down the ELB despite an increase in public debt.

An unconventional monetary policy in the form of a larger central bank balance sheet resulting from the purchase of government bonds results in the same outcome, despite some capital outflow due to lower yields. One effective tool for overcoming the ELB issue is recapitalisation of banks, even if this is achieved through a tax on borrowers: in this case, higher credit supply by banks would exceed demand growth on the borrower side. Furthermore, unsterilised FX purchases and sterilised FX sales by the central bank to purchase government bonds also trigger a lower ELB.
Damiano Sandri’s discussant was Konstantin Egorov (NES), who pointed out that the paper explores a very relevant topic and is quite ambitious. The discussant believes that this area of research lacks a fundamental basic model with a minimum set of assumptions. The models in Cavallino and Sandri (2019) are very stylized models with a set of ad hoc assumptions, like many other existing models in which ineffective monetary policy in a small open economy is explained by financial frictions. As an alternative approach to modelling monetary policy issues in small open economies, the discussant referenced the paper by Egorov and Mukhin (2019), which takes into account the dominant role of the US dollar in dollar invoicing in international trade.

4. (Unintended) effects of macroprudential policy

In Session 3, entitled ‘(Unintended) Effects of Macroprudential Policy’, Erlend Nier (IMF) presented a report based on an IMF paper, ‘Digging Deeper: Evidence on the Effects of Macroprudential Policies from a New Database’, co-authored with other researchers (Alam et al., 2019). The key original contribution of the research was the creation of a unique database of macroprudential policies (iMAPP), which allowed the authors to undertake a comprehensive review of their application in the global economy and a quantitative estimate of the target and side effects of macroprudential policy.

The speaker described the new macroprudential policy database as follows. First, the iMAPP database is characterised by maximum geographic and temporal coverage, with information on 134 countries between January 1990 and December 2016.

Second, all the macroprudential policy tools in the database are classified into 17 categories, with subcategories and a breakdown by sector and currency, as well as instruments which are essentially macroprudential but may be used for other purposes (for instance, the required reserve ratio for bank deposits).

Third, the data confirmed the existence of a reverse causal relationship between macroprudential instruments and performance of key variables for the regulator. In particular, the presentation illustrated that macroprudential policy tightens in periods of growth in household lending. The reverse causal effect has not previously been taken into account in standard regression models of macroprudential policy, and its inclusion is one of this paper’s original contributions.

Fourth, unlike earlier research, the paper provides quantitative as well as qualitative analysis of macroprudential policy effects. For instance, alongside some widely used indices of macroprudential policy areas in the form of dummy

31 Following the global financial crisis, many countries (not just EMs) experienced monetary policy constraints; potential ways of overcoming these constraints are a matter of lively debate in economic research.
variables, the database also features data on the numerical values of average LTV limits across 66 countries.

The authors used the database to confirm a finding established by other earlier papers (Cerutti et al., 2017; Akinci and Olmstead-Rumsey, 2018): the significant impact of macroprudential policy tools on the dynamics of real household loans (adjusted for inflation), and, to a lesser extent, on relative housing prices. Another discovery was the side effect of macroprudential policy’s negative impact on real consumption, although the scale of this impact proved not that significant.

At Stage 1, the authors estimated a panel regression based on specifications proposed in earlier papers (Arregui et al., 2013; Kuttner and Shim, 2016):

$$\Delta_4 C_{i,t} = \rho \Delta_4 C_{i,t-1} + \beta MaPP_{i,t-1} + \gamma X_{i,t-1} + \alpha_t + \mu_t + \varepsilon_{i,t}.$$  

In the regression, the variable $C_{i,t}$ describes the annual growth rates of the target variable (real household loans, relative housing prices, real household consumption, and real GDP). The factor $X_{i,t}$ is responsible for the control variables, while $\alpha$ and $\mu$ take into account country-specific and temporal factors respectively. The variable $MaPP_{i,t}$, the key component of the model, is a digital representation of macroprudential policy, while the coefficient $\beta$ reflects the extent of the macroprudential policy tool’s impact on the target variable.

The results of the model estimate revealed that a tighter policy with loan-targeted instruments restrains real credit growth by an average of 2 p.p. across the panel of countries, with a stronger effect for developing versus developed countries. The policy has a side effect in the form of lower performance of real consumption, by an average of 1 p.p. The impact of the policy on the dynamics of real GDP is significantly lower, at around 0.07 p.p.

At Stage 2, the authors go beyond the traditional model described above to apply numerical LTV values as a macroprudential policy variable, and to factor in the reverse relationship of cause and effect described above through the use of propensity score matching. According to the findings, an LTV decrease of

---

32 Given the considerable differences in the application of macroprudential instruments across countries and the limited capacity for comparing their parameters, macroprudential policy tools are now widely described in research through dummy variables: +1 (policy tightening), -1 (policy easing), and 0 (maintaining policy).

33 The model assumes that $MaPP$ is equal to 1 for all macroprudential policy instruments in the case of tightening.

34 The loan-targeted instruments include two subgroups of macroprudential instruments: demand loan-targeted instruments including LTV and debt service-to-income ratio (DSTI), and supply loan-targeted instruments. The second subgroup, according to the authors, includes credit growth caps, loan loss provisions, direct loan limits, loan-to-deposit ratio limits, and limits on FX loans.

35 The AIPW (Augmented Inverse Propensity-Score Weighted) estimate is an extended version of the IPW estimate that facilitates identification of the effect of the cause-and-effect relationship through a decrease in the weights that have the highest propensity. Such estimates can be found in e.g. Richter et al. (2018).
1 p.p. triggers a credit decline of 0.7 p.p., confirming the hypothesis that the dependence is non-linear (the greater the scale of an LTV change, the lower the unit impact). The side effect of the impact of LTV changes proved to be weak and unsustainable.

Andrea Nobili (Bank of Italy) acted as the discussant for the paper. He pointed out that the impact of macroprudential policy depends to a great extent on borrowers’ welfare, the structure of loans, and the state of the housing market. He also pointed to the importance of an estimate of the risk-taking channel in analysing macroprudential policy effectiveness.

The risk-taking channel and its role in the implementation of macroprudential policy was described by Ernest Dautović (University of Lausanne). Unlike the previous presentation, his presentation ‘Has Regulatory Capital Made Banks Safer? Skin in the Game vs Moral Hazard’, based on Dautović (2019), shifts the focus of analyses of macroprudential policy side effects from macroeconomic implications to banking sector resilience.

The presented empirical research is theoretically underpinned by two hypotheses with opposite economic effects. According to the first hypothesis of ‘skin in the game’, banks’ response to a tighter macroprudential policy will involve the risk-off approach, since a focus on risk investment will push the probability of losses up and eventually complicate compliance with regulatory requirements.

The second hypothesis of ‘moral hazard’ relies on the principal-agent theory, and assumes a potential increase in risk-taking behaviour on the part of banks (the risk-on approach) to offset the negative impact of higher regulatory requirements on financial organisations’ profitability.

The purpose of the research is to ascertain which of these hypotheses best describes banks’ behaviour and the ultimate effect of macroprudential policy on their resilience. The author utilises quarterly balance sheet data across 205 systemically important banks in 28 EU countries and Norway (14 global systemically important banks and 191 other systemically important banks) from 2006Q1 to 2017Q3.

As a macroprudential instrument, the author takes the Systemic Macroprudential Capital Requirements (SMCR), which include the system risk (SRB), global importance (G-SIB), and national importance (O-SIB) buffers stipulated in the European regulations.

The methodology uses the following model, in which the variable SMCR for each bank is calculated as a difference and relative to other banks (the estimate method is given in Angrist and Pischke, 2009):

\[
\ln Y_{i,t} = \alpha_i + \beta SMCR_{i,t} + \ln X_{i,t-1} + \delta_{i} + u_{i,t}.
\]

In this regression, \(\alpha_i\) and \(\delta_i\) take into account fixed factors that are specific to the bank and to the country in which it is registered (economic growth rate, fiscal...
and monetary policy, etc.) respectively. The factor $X_{ic,t}$ is responsible for control variables linked to the performance of the bank’s indicators (assets, amount of payments, importance for the financial system, etc.). The coefficient $\beta$, the end indicator in the research, reflects the extent of the impact of the macroprudential policy tool on the target variable.

The author considers several indicators as the target (dependent) variable $Y$. First, the author estimation the impact of higher buffers on Common Equity Tier 1 capital (CET1). The results of the model estimate indicate that a 1 p.p. rise in buffers pushes CET1 up by an average of 8.9%. The closer the bank to the restriction (the lower its capital stock), the greater the effect will be (17.7%).

Second, the paper considers the CET1 ratio as a dependent variable. A 1 p.p. rise in buffers triggers an increase in the CET1 ratio of 0.83 p.p. (only for banks with capital adequacy close to the minimum level), which testifies to banks’ desire to sustain a certain capital buffer above the regulatory minimum.\(^{36}\)

Third, the author also uses the risk ratio, in the form of the ratio of risk-weighted assets to total assets as a dependent variable. A 1 p.p. rise in buffers brings the risk ratio up by an average of 6.9 p.p. The paper thereby uncovers a significant effect from the materialisation of the moral hazard channel for banks.

In addition to the average figures, the presenter shared his assessment of the extent to which his conclusion could be applied to specific groups of banks. The author concluded that the moral hazard risk effect is largely typical of: a) big banks; b) banks that do not apply the IRB (Internal Ratings-Based\(^{37}\)) approach; c) low-profitability banks; and d) banks which primarily rely on retail funding.

Finally, the author gave an answer to the key question posed by the research using a bank’s probability of default\(^{38}\) as a dependent variable. The extent of the buffer effect on the probability of default proved insignificant in statistical terms. As the author concludes, the side effect of moral hazard fully offsets the target effect of increasing bank capital, while the aggregate effect of macroprudential policy on banks’ probability of default is close to zero.

**Stephen Cecchetti (Brandeis International Business School)** acted as discussant. He shared an alternative view on the performance of bank indicators based on statistics from the Bank for International Settlements (BIS). According to his data for the 2008–2015 period, the total assets of European banks shrank while risk-weighted assets remained at approximately the same level, a finding which does not fully tally with the descriptive statistics in Dautović’s paper. In his view, the paper’s findings require additional confirmation.

---

\(^{36}\) The conclusion is consistent with the findings of earlier research (Shriives and Dahl, 1992; Jacques and Nigro, 1997).

\(^{37}\) An approach to assessing the credit risks of a bank to estimate its regulatory capital adequacy based on internal borrower ratings, i.e. ratings set by banks themselves.

\(^{38}\) The probability of default was estimated by the author based on changes in credit ratings from the three international rating agencies (Fitch, S&P, Moody’s).
5. Keynote report by Claudio Borio and a panel discussion on key takeaways for central bank policy practices

Claudio Borio (BIS) presented the findings of the paper 'Monetary policy in the grip of a pincer movement' (Borio et al., 2018). The authors established that the past 30 years have seen the exposure of monetary policy with a focus on price stability (inflation targeting) to two trends that put substantial constraints on the ability of monetary policy to sustain price stability in developed (and some developing) countries.

The authors bring up the need for greater flexibility in the conduct of monetary policy, arguing that questions of financial stability must be taken into account, either implicitly or explicitly. Such an approach to monetary policy over a longer horizon would also help to stabilise inflation, since financial crises are a source of major price changes.

What are the two trends to which monetary policy is being exposed? The first trend is a major strengthening of the impact of the financial cycles dynamics (financial shocks) on economic performance in the past 30 years. Fluctuations in financial cycles now tend to be more amplified. The author defines financial cycles as the self-reinforcing dynamics of credit, collateral value and borrowers’ income, optimism, and borrowers’ demand for credit, along with risk appetite on the part of the banks that shape credit supply. This generates a self-reinforcing spiral that comes to a halt either in the wake of certain exogenous shocks or through endogenous changes when market participants realise that the imbalances are too big. Financial crises result. This spiral makes the implications of financial crises more devastating, partly because of large imbalances that build up before crises (the turning points of a cycle), and partly because of the negative effects that imbalances and the crisis have on productivity (long-term economic growth).39

More pronounced financial cycles with an increased role in the economy are the result of globalisation. Global financial markets increase the speed and the magnitude of the response by capital flows to shocks, while stronger linkages between non-financial sectors in national economies (global value chains, global trade growth) and linkages between the financial and non-financial sectors conclusion enable financial markets play an important role in the origination and spread of macroeconomic shocks.

Why have strengthened financial cycles become a constraint on standard monetary policy in its aim of ensuring macroeconomic stability? The traditional monetary policy paradigm for price stability is founded on inflation targeting over approximately a two-year timeframe. Since financial cycles are longer-lasting, some of the build-up of financial imbalances remains outside the regulator’s focus.

---

39 Through underinvestment following a crisis amid poor expectations and project financing issues which existed even before the crisis. At the same time, other sectors where demand was bloated have excessive capital, but re-allocation of capital is a very difficult task.
of attention. Meanwhile, financial crises lead to major and protracted change in GDP and prices/inflation. However, a response to the financial cycle over the policy horizon takes place only when lending growth or higher prices for financial assets push up inflation. If inflation does not speed up, or even slows down as a result of other factors in play at the time, monetary policy either does not prevent a build-up in financial stability risks or indeed provokes such risks, since the textbook reaction to a slowdown in inflation is to ease monetary policy. A loose monetary policy can lead to the build-up of extra risks in the financial system as a result of higher credit supply and lower interest rates. This leads to a vicious circle situation in the form of a price hike for financial assets, credit-induced income growth, and higher risk appetite and credit supply.

On the other hand, as the authors indicated, financial crises are accompanied by a major contraction in demand require a major monetary policy easing to offset a demand contraction and stabilise GDP and inflation. This also acts as a constraint on monetary policy, which is supposed to be particularly effective during such episodes. Here we come to the second trend that constrains the effectiveness of conventional monetary policy as regards price stability.

The second trend consists in a slowdown in inflation and its lower sensitivity to the business cycle under the influence of a number of factors (a flatter Phillips curve). According to the authors, these factors include globalisation (whereby lower production and trade costs have an impact on inflation and increased global competition, which in turn has an impact on companies' ability to increase prices in the business cycle) and successful anchoring of inflation expectations by central banks at a low level (when only strong shocks can force companies to depart from the usual price adjustment, which is the case in Japan, for instance). Consequently, an overheating in the economy is not accompanied by a milder inflation acceleration compared to earlier, and inflation itself may even remain stable (if the overheating effect is offset by a structural slowdown in inflation). In this situation the central bank does not receive signals to tighten its policy. However, when a crisis breaks out, aggregate demand experiences a strong contraction, and a rate cut by the central bank to offset its impact can have only a limited effect due to the flat Phillips curve. The inability of the central bank to restrain a contraction in demand triggers additional adverse effects for the financial sector: the spiral mentioned earlier has begun spiralling in the opposite direction.

Under the reciprocal effect of these two trends, monetary policy finds itself ‘in the grip of a pincer movement’: during good times low inflation proves uninformative about bubbles, with a loose monetary policy being a contributing factor. Due to the low sensitivity of inflation to business cycle indicators, policy turns out very loose in practice. Such a situation merely encourages high future volatility, i.e. a financial crisis. During bad times (in a crisis), monetary policy proves unable to offset shrinking demand, which only amplifies further compression of demand through the financial channel. Eventually, monetary policy itself contributes to the
build-up of risks and heightened future volatility. Attempts to stabilise the economy in the short term therefore only bring about inflation and GDP instability over a longer timeframe.

It is noteworthy that the build-up of real debt fed by monetary policy in good times does not slow down in bad times. As monetary policy cannot offset changes in aggregate demand, the economy finds itself in a deflation spiral, which boosts real debt and borrowers’ debt burden.

Claudio Borio criticises the approach to monetary policy which relies on the use of the equilibrium interest rate concept because this indicator is unobservable. The definition of the equilibrium interest rate depends on the theoretical model employed, which may lead to ambiguous estimates. For instance, the authors demonstrate that the equilibrium rate is underestimated if the definition of equilibrium and, correspondingly, of the equilibrium rate does not factor in the need to minimise financial stability risks (ensure a lack of imbalances). They run a simulation analysis revealing that the use of the equilibrium rate in monetary policy with financial stability factors in mind will ensure a steadier GDP and inflation path on average over a long period of time.

Another important finding of the paper is the important contribution monetary policy has made to a persistent decrease in interest rates over the past 30 years, the consequence of which has been an ever-growing gap between actual and equilibrium rates; this played a key role in the build-up of risks in the run-up to the 2008 global financial crisis.

As a policy recommendation, the authors suggest that, conducting their monetary policy, central banks should focus on financial cycle indicators. This does not mean that central banks should abandon inflation targeting in favour of other goals. The authors merely propose a slight modification of inflation targeting to make it more flexible, accepting the possibility that inflation may systemically (over a policy horizon) remain below the regulator’s target.

The authors discuss critiques of the use of macroprudential policy as an alternative to monetary policy in preventing the build-up of financial stability risks in good times. First, they point out that evidence in favour of macroprudential policy effectiveness is quite limited, while monetary policy, in the form of an interest rate change (or a change in the entire yield curve), is a very powerful tool for countering an excessive accumulation of risks. This is why central banks should not resort to tightening macroprudential policy at the same time as softening monetary policy (‘putting your foot down and braking at the same time’). It would be even more questionable to tighten macroprudential policy when the goal is to contain the business (rather than the financial) cycle, i.e. in situations in which there is no financial stability issue.

---

40 Due to a lower inflation risk premium following Volcker disinflation, the asymmetrical rate response during boom and bust periods, and efforts to offset protracted demand compression in the aftermath of the global financial crisis.
Second, macroprudential policy may not prove very effective in averting the debt deflation issue following crises. Macroprudential policy seeks to prevent the build-up of imbalances and to create buffers in the case of crises in specific market segments, whereas the debt trap deals with the implications of deflation, a major demand contraction across the economy.

As an operational change in monetary policy, the authors suggest supplementing the Taylor rule with a response to the financial gap in the form of indicators that measure the build-up of financial stability risks, which would equip inflation targeting with the necessary flexibility. It is vital that policies are implemented in advance and in a systemic manner, rather than seeking to contain high credit growth with an overdue and abrupt rate hike.

In her comments after Claudio Borio’s presentation, Patricia C. Mosser (Columbia University) pointed out that the lack of an estimated (calibrated) theoretical model of the economy that includes linkages between monetary policy and macroprudential policy, with a well-described transmission mechanism for each of the policies, has somewhat undermined the credibility of the conclusions on the leading role of monetary policy in containing financial stability risks. In turn, low inflation as a result of favourable factors on the supply side raises the question of whether it makes sense for central banks to respond to such changes. The weak response by inflation to the output gap that Borio cites de facto means that central bank policy is ineffective in terms of its impact on the economy’s non-financial sector. However, it does have a major impact on the financial cycle. In this regard, further investigation of the linkages between the financial and the non-financial sectors and the impact of the financial sector on the non-financial sector would be worthwhile. Further research is also required to explore the role of financial globalisation in inflation dynamics and to ascertain whether or not central banks are able to have an impact on domestic financial conditions (the trilemma versus the dilemma). In her conclusion, Patricia C. Mosser pointed to macroprudential policy which was unduly overlooked in the report despite its proven effectiveness, which had been demonstrated earlier at the conference.

Ksenia Yudaeva (Bank of Russia) highlighted one important difference between economic conditions in Russia and the scenario described by Claudio Borio: inflation in Russia is relatively high. However, she pointed out that a number of other factors make the BIS’s research relevant to Russia. She then focused on the difference in the approaches taken by Basel and the US Federal Reserve to defining financial stability risks and the equilibrium interest rate. According to the US Federal Reserve, equilibrium interest rates are low. The solvency of firms and of the US financial sector are at a good level, while risks to financial stability stem from low inflation, which is generated by low demand. Since collateral lending is more widespread in the US, the Federal Reserve is less concerned with financial

41 See Rey (2015).
stability risks and more preoccupied with the issue of low inflation. A different point of view, and one shared by the BIS, would be that financial stability risks are actually high, and that through lower rates central banks give an additional impetus to the financial cycle, which triggers crises. In turn, crises force central banks to maintain low rates due to low inflation. This approach would suggest that central banks should disregard low inflation.

Several features specific to developing countries were identified in terms of financial stability risks and the role of monetary policy in containing them. First, developing countries have higher inflation and poorly anchored inflation expectations. Therefore, monetary policy should primarily seek to control inflation. Second, the problem of collateral constraints is particularly relevant to developing countries. It feeds the financial cycle, which makes developing countries particularly vulnerable to shocks in global financial markets. Third, the domestic foreign exchange market in developing countries is an important source of financial and price shocks. The dollarisation issue remains relevant to many developing countries, acting as a constraint on the ability of monetary policy to support the economy in a crisis. Macroprudential policy should help monetary policy overcome this constraint. Fourth, even in the context of high rates, risks may build up in some sectors, in particular due to structural changes (for instance, the use of fintech for assessing a borrower’s solvency in the case of consumer loans). In this context, monetary policy would be of limited effectiveness.

Richard Portes (London Business School) also believes that, before adding financial variables to monetary policy decision-making, it is important to make sure that central banks have an effective macroprudential policy. Improving macroprudential policy would be an alternative to modifying inflation targeting. He also disagreed with the assumption that the Phillips curve does not hold anymore. That business cycle variables in the data reveal very weak inflation elasticity is the result of a successful central bank policy to anchor expectations. He also cited recent research by Rachel and Summers (2019), which demonstrates that a lower equilibrium rate in the US and the global economy is not triggered by failure to take into account financial factors, but in fact has far deeper roots. On the use of loan indicators (or other financial variables in terms of their deviations from the equilibrium levels) in the modified Taylor rule by central banks, Portes pointed out that, in practice, it is difficult to distinguish between the gap and the equilibrium process against the backdrop of financial market development. Portes was also sceptical about including financial stability goals in the framework of monetary policy, as this would overburden monetary policy with various different goals. Instead, the focus should be on developing macroprudential policy.

---

42 The issue is covered in Damiano Sandri’s presentation, ‘The Expansionary Lower Bound: Contractionary Monetary Easing and the Trilemma’ (see Section 3).
In response to these comments, Claudio Borio said that it was indeed important to improve understanding and the modelling of the endogenous mechanism of the financial cycle and its non-linear effects on the economy. The Phillips curve, whatever its current appearance, should not be the key policy benchmark. If the inflation target is not achieved, central banks will in any case do whatever they can to bring inflation to the target using an unreliable policy benchmark. On the other hand, macroprudential policy alone is not sufficient to counter the financial cycle.

6. Conclusions

The following conclusions may be drawn from the presentations and debates at the Bank of Russia conference ‘Macroprudential Policy Effectiveness: Theory and Practice’:

1. Financial stability goals may be expressed in terms of the volatility of standard macroeconomic indicators (GDP, price, and employment stability). However, for a policy that also ensures financial stability, the horizon for targeting these goals may be longer than the standard monetary policy cycle.

2. In oil-exporting countries, oil price changes may become the source of the financial cycle, i.e. of excessive debt growth in good times. This is driven by higher collateral value and borrowers’ income, which has an impact on credit supply and demand through the feedback mechanism. Therefore, macroprudential policies should be countercyclical in an oil cycle.

3. The application of macroprudential tools is necessary because of financial market imperfections in the economy. The information asymmetry between creditors and borrowers as well as limited liability of borrowers (both banks and the real sector) may encourage an excessive build-up of risks, moral hazard, and strategic defaults on their part, a problem intensified by macro-level externalities generated by individual actions. Bankruptcy proceedings for borrowers will incur costs that, along with the imperfections of financial markets listed above, amplify the fluctuations of real and financial indicators during the financial cycle. Central bank policies in general, and macroprudential policy tools in particular, should address specific financial market imperfections and their effects. For instance, it is better to implement policies to contain an excessive foreign debt burden through constraints placed on borrowers that do not factor in the macroeconomic implications of excessive foreign debt (LTV constraints) rather than through FX interventions to weaken the exchange rate, which makes foreign borrowings more costly, or through capital inflow controls. In the latter case, the role of the exchange rate as a stabilising factor for many other processes in the economy will be impaired.
4. Optimal calibration of prudential and macroprudential tools, and of the capital adequacy ratio for banks in particular, can increase welfare in the economy in the long term and bring down volatility in real and financial sector indicators in the short term, in times of crisis in particular. Volatility in the economy can be significantly smoothed out in the short term in response to temporary shocks using the CCyB. Each specific economy has its own optimal rule for the CCyB, similar to the Taylor rule for monetary policy, based on the mix and weights of financial stability variables that trigger a response from the regulator which is setting the buffer value.

5. Standard monetary policy in small open economies that focuses on interest rate management by central banks may lose its independence (the 'dilemma, not trilemma' case) and prove ineffective or even counter-productive in terms of stabilising output. This situation may arise if the economy is dependent on the inflow of foreign capital and if there are financial 'frictions' in the economy that hinder the rapid substitution of foreign capital with domestic funding for the banking sector. The ineffectiveness threshold of monetary policy in terms of the interest rate level depends on the parameters of the economy and on the occurrence of external shocks: tighter global financial and monetary conditions erode small open economies' capacity to lower rates to stabilise output. Macroprudential policy may restore monetary policy's independence and effectiveness.

6. Macroprudential policy can have side effects. These are triggered by a change in the behaviour of creditors and borrowers, who assume extra risk to offset (or bypass) existing constraints. In this case, the effectiveness of macroprudential policy is undermined. Furthermore, its side effects may theoretically have unintended consequences for macroeconomic indicators, although empirical estimates illustrate that the impact of these consequences is not significant. These side effects may vary across different macroprudential instruments, a fact which should be taken into account by the regulator in planning and implementing macroprudential policy.

7. A protracted structural inflation slowdown in the global economy poses a real threat to the price stability mandate of central banks and may trigger amplified financial cycles and the build-up of financial stability risks in a soft monetary policy environment. Central banks pursuing inflation targeting as their monetary policy should be flexible to a certain extent in order to disregard changes in relative prices (structural inflation slowdown) as much as possible, given the parameters of their mandate. However, price stability should remain a monetary policy priority.

8. Macroprudential policy measures should be applied in the expansionary phase of the credit cycle to target those financial market imperfections that are specific to a particular situation. In times of crisis, this would
allow monetary policy to support the economy, ensuring it is not over-leveraged. Ex ante monetary policies to smooth out the credit cycle may face major constraints in small open economies.

References


Estimating a Cagan-type Demand Function for Gold: 1561–1913

Alexei Deviatov, Russian Presidential Academy of National Economy and Public Administration
deviatov@list.ru

Long time series on gold production and the value of gold, taken from Jastram’s book The Golden Constant, are used to estimate a Cagan-type demand function that relates the total real value of gold to its expected rate of return. The model assumes that gold production and a latent scale variable (income or consumption) are jointly exogenous and that the data are measured with error. The data reject the model: the estimates imply that the real value of gold varies a great deal relative to the expected return and depends on it negatively, rather than positively.

Keywords: gold, Cagan demand function, estimation

JEL Codes: E41


1. Introduction

A Cagan demand function for money (Cagan, 1956) posits that its real value depends positively on its expected return, as measured by the inverse of the inflation rate. Here, we attempt to estimate such a function for gold using data for 1561–1913. The initial date is determined by the available data, while the terminal date is chosen in accordance with our view that World War I marks the beginning of a period of turmoil regarding the role of gold in private portfolios and in the world’s monetary system. The data we use are from The Golden Constant by Roy Jastram (1977): a time series on the price of gold in terms of consumption (Jastram, 1977, pp. 34–37, Table 3: The Index of Purchasing Power of Gold, England, 1560–1976), which we interpret as the inverse of the price level, and a time series on gold production (Jastram, 1977, pp. 221–225,

1 I am grateful to Neil Wallace for bringing my attention to the data. All errors are mine.
Appendix C: The Index of World Production of Gold, 1493–1972).\(^2\) Because the data describe world production of gold, we view our demand function as applying to the world as a whole.

The main challenge, of course, is modeling the expected return. Our approach is simple – perhaps too simple. Measurement error aside, we assume that there are two exogenous random processes. One is a process for gold production and the other is a latent (unobserved by us) process for a scale variable such as total income or consumption. We assume that the processes and the current state are known to the agents and that an expected return is formed based on that information and on the true demand function.\(^3\)

It turns out that our model is rejected by the data in the following senses: our estimates imply that the real value of gold varies a great deal relative to the expected return and depends on it negatively, rather than positively. We hope that our effort will inspire others to consider alternative models of these time series.

### 2. The data

The gold production data are shown in Figure 1. The data prior to 1851 are averages: 20-year averages before 1811 and 10-year averages during 1811–1850. As described below, we use those averages and part of the model to interpolate the missing annual data on gold production.

\[\text{Figure 1. The index of world production of gold, 1492–1972}\]

In Figure 2 we plot the logarithm of the purchasing power of gold; that is, the logarithm of the price of gold. Notice that, in contrast to gold production, there does

---

\(^2\) Jastram describes how he came to produce the volume from which we take the data: “My interest in gold began in 1936 for a pragmatic reason. As the most junior member of the Stanford University Department of Economics, I was chosen to volunteer to do some research commissioned by Mr. C.O.G. Miller, an industrialist and gentleman scholar” (Jastram, 1977, p. vii).

\(^3\) Our model is therefore part of a large literature on the “rational expectations” specifications of the Cagan model. See, for example, Christiano (1987), Engsted (1993), Goodfriend (1982), Salemi and Sargent (1979), Sargent (1977) and Taylor (1991).
not seem to be a trend in the purchasing power of gold. As Jastram says, the title of his book refers to the absence of such a trend.

**Figure 2.** Logarithm of the purchasing power of gold, 1561–1913

![Graph of logarithm of purchasing power of gold, 1561-1913](image)

### 3. The model

Previous attempts to estimate Cagan demand functions use data from observed episodes of extremely high inflation (mainly post-WWI and post-WWII European hyperinflations). That choice of data is largely motivated by Cagan’s view that during periods of high inflation, the rate of return on money becomes the primary determinant of money demand. This is a convenient view, because it permits simple ordinary least squares (OLS) estimation of the rate-of-return elasticity, even if data on other money demand determinants such as real income or rates of return on other assets are unavailable. However, as we now explain, we cannot adopt such a simple estimation procedure.

Our Cagan demand function, which is essentially the same as that of Goodfriend (1982) and others, is

\[
\ln G_t + \ln p_t = \ln y_t + \alpha [E_t \ln p_{t+1} - \ln p_t],
\]

where \( G_t \) is the stock of gold, \( p_t \) is the price of gold, \( y_t \) is a latent scale variable (income), \( \alpha \) is the return elasticity, and \( E_t \) denotes mathematical expectation conditional on information through date \( t \).

The rational expectations hypothesis implies that the future price \( p_{t+1} \) can be represented as

\[
\ln p_{t+1} = E_t \ln p_{t+1} + v_{t+1},
\]

where \( v_{t+1} \) is uncorrelated with contemporaneous and past gold quantities, prices, and income.

Substitution of (2) into (1) yields

\[
\ln p_{t+1} = \frac{1}{\alpha} \ln G_t + \frac{1 + \alpha}{\alpha} \ln p_t + u_{t+1},
\]
where

\[ u_{t+1} \equiv -\frac{1}{\alpha} \ln y_t + v_{t+1}. \] (4)

It follows that (3) can be consistently estimated using OLS, provided that \( \ln p_t \) is uncorrelated with \( u_{t+1} \). Given the processes for \( G_t \) and \( y_t \), the fundamental solution to (1) implies that

\[ \ln p_t = \frac{1}{1 + \alpha} \sum_{i=0}^{\infty} \left( \frac{\alpha}{1 + \alpha} \right)^i E_t[\ln y_{t+i} - \ln G_{t+i}]. \] (5)

OLS estimation of (3) is therefore justified if \( G_t \) is an exogenous process and if \( y_t \) is nonrandom – for example, if \( y_t \) is constant. Both assumptions may seem reasonable for data from post-WWI hyperinflations in Austria, Germany, Greece, Hungary, Poland, and Russia, but the second assumption is not justified in the context of our long time series.

In Jastram’s data, the stock of gold exhibits an increasing trend, but the price of gold does not. The obvious way to reconcile the two is to account for the trend in \( y_t \). In particular, we assume that \( p_t \) is stationary. Then, because the processes for the gold stock \( G_t \) and the scale variable \( y_t \) appear to be nonstationary, equation (5) implies that there should be a cointegrating relationship between \( G_t \) and \( y_t \).

We assume that \( G_t \) is an exogenous process of the form

\[ \ln G_t - \ln y_t = \ln \mu_t + \ln G_{t-1} - \ln y_{t-1}, \] (6)

where \( y_t \) (the transitory shock) and \( \mu_t \) (the permanent shock) are realizations of independent finite-state Markov processes with positive supports. Our model for the cointegrating relationship between \( G_t \) and \( y_t \) is

\[ \ln G_t - \ln y_t - \ln y_t = \ln \varsigma_t, \] (7)

where \( \varsigma_t \) is a realization of an independent finite-state Markov process with a positive support. That is,

<table>
<thead>
<tr>
<th>Random variable</th>
<th>Support</th>
<th>Transition probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_t )</td>
<td>((y^1, y^2, \ldots, y^{M_y}))</td>
<td>(\pi_{yj}^{y})</td>
</tr>
<tr>
<td>( \mu_t )</td>
<td>((\mu^1, \mu^2, \ldots, \mu^{M_{\mu}}))</td>
<td>(\pi_{kj}^{\mu})</td>
</tr>
<tr>
<td>( \varsigma_t )</td>
<td>((\varsigma^1, \varsigma^2, \ldots, \varsigma^{M_{\varsigma}}))</td>
<td>(\pi_{ij}^{\varsigma})</td>
</tr>
</tbody>
</table>

(8)

where the supports for \( \mu_t, y_t \) and \( \varsigma_t \) are equally spaced and the support for \( y_t \) is also symmetric around unity. We assume that the agents know these processes and observe \( (y_t, \mu_t, \varsigma_t) \) before deciding on their gold holdings.

---

4 The augmented Dickey-Fuller test performed for the purchasing power of gold logarithm over the 1561–1913 sample rejects the null of the unit root at 0.1% significance level.
The process for $G_t$ and the Markov property of $\gamma_t$ imply that the effect of $\gamma_t$ on $G_t$ dies out with time (provided that $\gamma_t$ is asymptotically stable). In contrast, the effect of $\mu_t$ on $G_t$ is permanent. This is what motivates our use of the labels 'transitory' and 'permanent' for $\gamma_t$ and $\mu_t$, respectively. An alternative interpretation is that the process for gold stock $G_t$ has a stochastic trend $\mu_t$ and a stochastic cyclical component $\gamma_t$ around that trend.

Substitution of (6) and (7) in (1) leads to an equation of the same form as (3); namely,

$$\ln p_{t+1} = \frac{1 + \alpha}{\alpha} \ln p_t + u_{t+1}',$$

where

$$u_{t+1}' = \frac{1}{\alpha} (\ln \gamma_t + \ln \zeta_t) + \nu_{t+1}.$$  

Therefore, OLS estimation of (9) is justified if $\gamma_t$ and $\zeta_t$ are not random, an assumption that is too extreme in our context. We therefore proceed as follows.

Using (6)–(7), we can rewrite (1) as

$$\ln p_t = -\frac{1}{1 + \alpha} (\ln \zeta_t + \ln \gamma_t) + \frac{\alpha}{1 + \alpha} E_t \ln p_{t+1}.$$  

Then, our analogue of (3) is the equilibrium condition in the following definition.

**Definition 1.** A function $p : R^{M_\gamma} \times R^{M_\zeta} \rightarrow R_{++}$ (with generic element $p_{hl}$, which denotes the price when $(\gamma_t, \zeta_t) = (\gamma^h, \zeta^l)$) is a stationary equilibrium if it satisfies

$$\ln p_{hl} = -\frac{1}{1 + \alpha} (\ln \zeta^l + \ln \gamma^h) + \frac{\alpha}{1 + \alpha} \sum_{i=1}^{M_\gamma} \sum_{j=1}^{M_\zeta} \pi^\gamma_{hi} \pi^\zeta_{lj} \ln p_{ij}$$  

for each $(h, l) \in \{1, 2, ..., M_\gamma\} \times \{1, 2, ..., M_\zeta\}$.

This system of linear equations can be written as $x = a_0 + a_1 \pi x$, where $x$ is an $M_\gamma M_\zeta \times 1$ vector, $a_1 = \frac{\alpha}{1 + \alpha}$ and $\pi$ is the Kronecker product of $\pi^\gamma$ and $\pi^\zeta$, the transition matrices for $\gamma$ and $\zeta$, respectively. Provided that the matrix $I - a_1 \pi$ is nonsingular, the equilibrium exists and is unique. Obviously, that is the case if $\alpha \geq 0$. In any case, nonsingularity of the matrix $I - a_1 \pi$ is generic.

Our basic approach to estimation follows Cosslett and Lee (1985) and is consistent with our assumption that agents see $(\gamma_t, \mu_t, \zeta_t)$ before deciding on their gold holdings. That assumption forces us to estimate not only the processes for $(\gamma_t, \mu_t, \zeta_t)$, but also the realizations. We specify magnitudes for $M_\gamma, M_\mu$ and $M_\zeta$ and assume that the data on the stock of gold and its price are measured with multiplicative errors. Our version of the estimation procedure has two stages.\(^5\)

\(^5\) See Appendix 2 for a description of how we would jointly estimate the model and for a discussion of why we chose not to do that.
First, we use only the data on the stock of gold to estimate the processes and realizations for \((\gamma_t, \mu_t)\), the measurement error for the stock of gold production, and the initial stock of gold. Second, taking those as given, we use the price data to estimate the rest of the model: the process and realization for \(\zeta_t\), the measurement error in \(p_t\), and \(\alpha\) – the main parameter of interest.

4. Estimating the process for the stock of gold

Our model of the stock of gold\(^6\) for \(t = 1, 2, ..., T\) is

\[
G_t = G \left( \prod_{i=1}^{t} \mu_i \right) \gamma_t \exp(\varepsilon_t^G),
\]

(13)

where \(G\), a parameter to be estimated, is the stock of gold at \(t = 0\) and \(\varepsilon_t^G \sim N(0, \sigma_G^2)\), the measurement error, is independent and identically distributed (i.i.d.) and is independent of \(\gamma_t, \mu_t\) and \(\zeta_t\).

As noted above, we estimate some features of the Markov processes for \(\gamma_t\) and \(\mu_t\) and impose others. Because scaling the support of \(\gamma_t\) by one factor and scaling the support of \(\mu_t\) by its inverse leaves the true process for the stock of gold unaffected, we normalize \(\gamma_t\) by assuming that the support of \(\gamma_t\) is symmetric around unity. We do not estimate the number of elements in the supports. We use \(M_{\gamma} = 3\) and \(M_{\mu} = 5\), which yield a reasonably good fit.\(^7\) And, finally, for both supports, we assume equally spaced elements; that is, \(\gamma_j+1 = \gamma_j + \Delta_{\gamma}\) and \(\mu_j+1 = \mu_j + \Delta_{\mu}\). Given the normalization imposed on the support of \(\gamma_t\), that leaves us to estimate only \(\Delta_{\gamma}\) for the support of \(\gamma_t\). For the support of the \(\mu_t\) process, we estimate the lower endpoint of the support, \(\mu_1\) and \(\Delta_{\mu}\). To estimate \(\pi^\gamma\) and \(\pi^\mu\), we use a logit representation for each row (distribution) of the transition matrices, i.e.:

\[
\pi_{ij} = \begin{cases} 
\frac{e^{wij}}{1 + \sum_{i} e^{wij}} & \text{if } i \neq j, \\
1 & \text{if } i = j.
\end{cases}
\]

(14)

We impose additional bound constraints on \(w_{ij}\), which ensure that the estimated transition matrices are ergodic. The latter helps us to avoid the inconvenience of having to deal with the multiple stationary distributions implied by \(\pi^\gamma\) and \(\pi^\mu\) during the course of estimation. Thus, \(\kappa = (G, \Delta_{\gamma}, \pi^\gamma, \mu_1, \Delta_{\mu}, \pi^\mu, \sigma_G)\) are the parameters to be estimated for this part of the model.

---

\(^6\) An equivalent alternative is to model gold production.

\(^7\) We arrived at these choices as follows. We began with \(M_{\gamma} = 3\) and \(M_{\mu} = 1\), which were a poor fit. We further found that increasing \(M_{\gamma}\) while maintaining \(M_{\mu} = 1\) did not substantially improve the fit. Then we tried \(M_{\gamma} = 3\) and \(M_{\mu} = 3\) and \(M_{\gamma} = 3\) and \(M_{\mu} = 5\). The latter fit substantially better than the former; as we show later, the implied measurement error \(\varepsilon_t^G\) is less than 1% of the gold stock \(\bar{G}_t\).
Letting $\gamma = \{\gamma_t\}_{t=1}^T$ and $\mu = \{\mu_t\}_{t=1}^T$ denote possible realizations for the $\gamma_t$ and $\mu_t$ processes, the likelihood function is:

$$L_1 = \prod_{t=1}^T \Psi \left[ \ln G_t - \ln G - \sum_{i=1}^t \ln \mu_i - \ln \gamma_t ; \sigma_G \right] P(\gamma)P(\mu), \quad (15)$$

where $\Psi(x; \sigma_G)$ is the density of the normal distribution,

$$G_t = G + \sum_{i=1}^t Z_{i,t} \quad (16)$$

where $Z_i$ is the date $i$ data for gold production, and where $P(\gamma)$ and $P(\mu)$ are the probabilities of the sequences $\gamma$ and $\mu$ implied by the transition matrices $\pi^\gamma$ and $\pi^\mu$.

Because the number of $\gamma$ and $\mu$ sequences is large and the state space is discrete, we use a genetic algorithm as part of our procedure for maximizing $L_1$. In particular, we proceed as follows.

1. Generate a population of pairs of sequences which determine $\gamma$ and $\mu$, but only by their order in the respective domains. That is, the sequences corresponding to $\gamma$ are drawn from the set $\{1, 2, 3\}^T$ and those for $\mu$ are drawn from the set $\{1, 2, 3, 4, 5\}^T$.

2. For each pair of sequences in the step 1 population, find the parameters $\kappa$ that maximize the objective $L_1$. (Notice that for given parameters that complete the description of the domains for $\gamma_t$ and $\mu_t$ – $\Delta^\gamma, \mu^1, \Delta^\mu$ – a pair of sequences in the step 1 population determine $\gamma$ and $\mu$. Those realizations and the remaining parameters in $\kappa = G, \pi^\gamma, \pi^\mu, \sigma_G$ – determine a magnitude for $L_1$. Given the logit representation of the transition matrices $\pi^\gamma$ and $\pi^\mu$, the maximization problem is a standard constrained maximization problem with bound constraints. However, the objective is not concave, so there may be many local maxima.)

3. Apply standard genetic operators (such as simple crossover and mutation) to amend the population of step 1 sequences.

4. Repeat step 2 until the best pair $\gamma, \mu$ is found.

5. Compute confidence intervals for the estimated parameters, $\hat{G}, \hat{\Delta}^\gamma, \hat{\mu}^1, \hat{\Delta}^\mu, \hat{\sigma}_G$, using a Monte Carlo procedure.

Because our concern about the post-1913 data does not apply to gold production, we use the entire data set, 1561 to 1972, for gold production. However, prior to 1851, the gold production data reported in Jastram (1977) (and in the original source) are averages: 20-year averages prior to 1811 and 10-year averages during 1811–1850. We therefore use an interpolation procedure which is consistent with the maximum likelihood estimation procedure that we carry out. Given a vector $\kappa$ of parameters and a $\gamma$ and $\mu$ sequences, the likelihood function (15) is concave with respect to the gold production data $Z_{i,t}$. Consequently, if some annual data are missing, then maximum likelihood
interpolation of the missing data implies that the data should be interpolated in order to keep the terms,

\[ \ln G_t - \ln G - \sum_{i=0}^{t} \ln \mu_i - \ln \gamma_t, \]

in the likelihood function (15) constant over all sample periods for which we must interpolate. This requirement implies an interpolation procedure that makes the interpolated terms dependent on the \( \gamma \) and \( \mu \) realizations and on the parameters. Each evaluation of the likelihood function therefore has its own interpolation of the missing data. The details appear in Appendix 1.

**Figure 3.** Gold production: interpolated up to 1850, actual after 1850

Figure 3 contains the interpolated production series (before 1851) and the actual series (after 1851). Given the sparse parametrization (three points in the support of \( \gamma_t \) and five points in the support of \( \mu_t \)) a change in the state gives rise to large production changes. Moreover, because our interpolation procedure is sensitive to both permanent and transitory components (see Appendix 1, expression (22)), a change in the state creates spikes in the interpolated gold production series.

Some of the spikes, in particular the negative production (loss) of gold, implied by interpolation seem implausible. However, these spikes are consistent with maximization of the likelihood function. We could have eliminated the spikes – for example, by using the averages reported by Jastram (1977) or some other smoothing device. However, given that the data rejects the model even allowing for the spikes, eliminating them would only reinforce our negative result.

The estimated parameters for the gold process are given in Table 1. The estimated initial stock of gold (in 1560) equals 28.5 times gold production in 1930. Measured as percentages, the support of transitory shock is approximately \( \{-2.5, 0, 2.5\} \). The support of the permanent component is roughly \( \{-0.1, 0.3, 0.7, 1.1, 1.5\} \), so that gold stock growth rates range from –0.1% to 1.5% per year. Given our model for
the gold stock (13), $\varepsilon^G_t$ measures the percentage deviation of the gold stock implied by the data from that implied by the model.

**Table 1. Estimated parameters for the gold process**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>5% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower end</td>
</tr>
<tr>
<td>$G$</td>
<td>28.5639</td>
<td>28.5085</td>
</tr>
<tr>
<td>$\Delta \gamma$</td>
<td>0.024643</td>
<td>0.024313</td>
</tr>
<tr>
<td>$\mu^i$</td>
<td>0.999139</td>
<td>0.999137</td>
</tr>
<tr>
<td>$\Delta \mu$</td>
<td>0.004043</td>
<td>0.004014</td>
</tr>
<tr>
<td>$\sigma_G$</td>
<td>0.002328</td>
<td>0.002151</td>
</tr>
<tr>
<td>$L_i$</td>
<td>2048.33</td>
<td></td>
</tr>
</tbody>
</table>

Table 1

The estimate $\hat{\sigma}_G = 0.002328$ means that the standard deviation of the discrepancy is about one quarter of 1%. In fact, the difference between gold stock data and the model is less than 1% for almost the entire sample, and less than 1.3% for the entire sample. However, the errors measured in terms of gold production are substantially larger. Relative to gold production, errors of 30–50% are not uncommon and for some years (in the earlier part of sample) the errors exceed 100% of (implied) gold production. We show the plot of $\hat{\varepsilon}^G_t$ in Figure 4. Notice that large spikes in interpolated production data before 1851 are consistent with small errors $\hat{\varepsilon}^G_t$ during that period. In addition, because the likelihood function is concave with respect to the interpolated data, the implied errors are constant over each 20-year (10-year) interpolation subperiod before 1851.

**Figure 4.** Estimated gold production measurement error $\hat{\varepsilon}^G_t$, 1561–1972

We use the following Monte Carlo procedure to obtain the confidence intervals in Table 1. First, we use $\hat{\sigma}_G$ to generate a sequence of simulated errors $\hat{\varepsilon}^G_t \sim N(0, \hat{\sigma}^2_G)$. After that, we use $\hat{\gamma}$, $\hat{\mu}$ and $\hat{G}$ to compute a simulated gold stock series; namely,
\( \hat{G}_t = \hat{G} \left( \prod_{i=1}^{t} \hat{\mu}_i \right) \hat{\gamma}_t \exp(\tilde{\epsilon}_t^G). \) (18)

Then, we treat \( \hat{G}_t \) as 'data' and obtain new estimates of \( \gamma, \mu, G \) and \( \sigma_G \). In doing this we keep constant the order of states in the estimated sequences of states for \( \gamma \) and \( \mu \) by order described in step 1 above.

A more complete procedure would reestimate the sequences of states for \( \gamma \) and \( \mu \) by order. Such a procedure would yield larger confidence intervals. However, our estimates of the ratios \( \hat{\Delta}_\gamma / \hat{\sigma}_G \approx 11 \) and \( \hat{\Delta}_\mu / \hat{\sigma}_G \approx 1.7 \) (see Table 1) imply that only a small part of the simulated data would differ from the actual data enough to produce changes in the sequences for \( \gamma \) and \( \mu \) by order. Given (18), the ratios \( \hat{\Delta}_\gamma / \hat{\sigma}_G \) and \( \hat{\Delta}_\mu / \hat{\sigma}_G \) are effectively the t-ratios for the null hypothesis that the data distinguish between the two adjoining points in the supports of \( \gamma \) and \( \mu \), respectively. The ratio \( \hat{\Delta}_\mu / \hat{\sigma}_G \), approximately equal to 1.7, implies that under the more complete procedure only about 10% of the sequence for \( \mu \) by order would differ from the estimated sequence for \( \mu \).

Thus, it did not seem worthwhile to undertake the more complete procedure, which would require a large amount of additional computational time.\(^8\)

The 5% confidence intervals are reported in the two rightmost columns of Table 1. Notice that the estimates \( \hat{G}, \hat{\gamma}, \hat{\mu}, \hat{\sigma}_G \) are not midpoints of those intervals. Given our procedure, the true gold stock series \( G_t \) can be viewed as implied by the sequence of measurement errors, \( \tilde{\epsilon}_t^G \), which is drawn from the normal distribution with zero mean and variance \( \sigma^2_G \). There is no prior reason to expect that that drawing yields the estimates \( \hat{G}, \hat{\gamma}, \hat{\mu}, \hat{\sigma}_G \) which fall exactly in the middle of their 5% confidence intervals. And, as one can see, that is not the case.

The estimated transition matrices are:

\[
\hat{\pi}^\gamma = \begin{bmatrix} 0.9749 & 0.0251 & 0 \\ 0.1140 & 0.7170 & 0.1690 \\ 0 & 0.0223 & 0.9777 \end{bmatrix}
\]

and

\[
\hat{\pi}^\mu = \begin{bmatrix} 0.9264 & 0.0736 & 0 & 0 & 0 \\ 0.1074 & 0.8406 & 0.0520 & 0 & 0 \\ 0.0273 & 0.1131 & 0.7612 & 0.0984 & 0 \\ 0 & 0 & 0.1047 & 0.7398 & 0.1555 \\ 0 & 0 & 0 & 0.0814 & 0.9186 \end{bmatrix}.
\]

The plots of the estimated sequences of \( \hat{\gamma} \) and \( \hat{\mu} \) are given in Figures 5 and 6. The estimates are consistent with high persistence in the gold stock process, so that the most likely state next year is the current state. However, when the

---

\(^8\) A limited investigation of the consequences for confidence intervals of varying the sequences for \( \gamma \) and \( \mu \) is reported in Appendix 3.
transition occurs, the state does not change much; almost all changes are changes to an adjoining state. Furthermore, consistent with a considerable increase in gold production during the course of history (see Figure 1), the estimated sequence $\hat{\mu}$ starts out low and transits to the upper end of the support.

![Figure 5](image1.jpg)

**Figure 5.** Estimated sequence for the permanent component of the gold stock, $\hat{\mu}$, 1561–1972

![Figure 6](image2.jpg)

**Figure 6.** Estimated sequence for the temporary component of the gold stock, $\hat{\gamma}$, 1561–1972

5. **Estimating the rest of the model**

Our model of the gold price data is

$$p_t = p(\varsigma_t, \gamma_t) \exp(\varepsilon_t^p),$$

(19)

where $p(\cdot, \cdot)$ is the equilibrium price function and where $\varepsilon_t^p \sim N(0, \sigma_{\varepsilon_t^p}^2)$ is i.i.d. and is independent of $\gamma_t, \mu_t, \varsigma_t$, and of $\varepsilon_t^G$. As above, we interpret $\varepsilon_t^p$ as measurement error.
We take $M_\varsigma = 3$ and assume an equally spaced support for $\varsigma_t$ ($\varsigma_t^{j+1} = \varsigma_t^j + \Delta_\varsigma$).

We also treat as known the estimated stage one parameters and the realizations for the $\gamma_t$ and $\mu_t$ processes (denoted $\hat{\kappa}$, $\hat{\gamma}$ and $\hat{\mu}$). Our choice of equally spaced support for $\varsigma_t$ and a relatively small $M_\varsigma$ (as well as adoption of the two-stage estimation procedure in general) is dictated by the size of the computing problem. By using the stage one estimates, we can increase the number of price states from $M_\varsigma = 3$ to $M_\gamma M_\varsigma = 9$ without increasing the computational burden. The remaining stage two parameters are:

$$\rho = (\alpha, \varsigma^1, \Delta_\varsigma, \pi_\varsigma, \sigma_p).$$

Letting $\varsigma = \{\varsigma_t\}_{t=1}^T$ denote a realization for the $\varsigma_t$ process, the likelihood function is:

$$L_2 = \prod_{t=1}^T \Psi[\ln p_t - \ln(p(\varsigma_t, \hat{\gamma}; \rho, \hat{\kappa})); \sigma_p] P(\varsigma),$$

where $\Psi(x; \sigma_p)$ is the destiny of the normal distribution, $p(\cdot; \rho, \hat{\kappa})$ is the solution for the equilibrium price function corresponding to the parameters $(\hat{\kappa}, \rho)$, and $P(\varsigma)$ is the probability of the sequence $\varsigma$ implied by the transition probabilities $\pi_\varsigma$.

Our procedure is similar to the one we used when estimating the production process.

1. Generate a population of sequences which determine $\varsigma$, but only by order in the respective domain. That is, the sequences corresponding to $\varsigma$ are drawn from the set $\{1, 2, 3\}^T$.

2. For each sequence in the step 1 population, find the parameters $\rho$ that maximize the objective $L_2$. This involves the following steps. Pick $\rho$. This $\rho$ and a stage one sequence imply a corresponding sequence $\varsigma$. Solve for the equilibrium prices. Together, these imply a magnitude for $L_2$. Search over values of $\rho$. Given a logit representation for the transition probabilities in $\pi_\varsigma$, search over $\rho$ is a standard constrained maximization problem with bound constraints.

3. Apply standard genetic operators (such as simple crossover and mutation) to amend the population of step 1 sequences.

4. Repeat step 2 until the best $\varsigma$ is found.

5. Compute confidence intervals using a Monte Carlo procedure.

As noted above, here we use the sample period from 1561 to 1913. The estimates $\hat{\alpha}$, $\hat{\varsigma}^1$, $\hat{\Delta}_\varsigma$, $\hat{\sigma}_p$ are given in Table 2 and the estimation transition matrix is

$$\hat{\Pi}_\varsigma = \begin{bmatrix} 0.9922 & 0.0040 & 0.0038 \\ 0.0032 & 0.9930 & 0.0038 \\ 0.0038 & 0.0037 & 0.9925 \end{bmatrix}.$$
during Monte Carlo simulation of the confidence intervals. Because the change in the equilibrium price function associated with a change in the discrete order sequence for $\varsigma$ is about 21%, i.e. roughly $2\hat{\sigma}_p$, only a small part of the simulated price data would differ from the actual series enough to produce changes in the discrete sequence for $\varsigma$ if we let the sequence by order change in the course of simulations. Thus, as above, it did not seem worthwhile to undertake the more complete procedure.\footnote{Again, see Appendix 3 for further details.}

### Table 2. Estimated parameters for the rest of the model

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>5% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>-90.791</td>
<td>-90.907 -88.881</td>
</tr>
<tr>
<td>$\varsigma^1$</td>
<td>$8.9507 \cdot 10^{-3}$</td>
<td>$8.8387 \cdot 10^{-3}$ - $9.0606 \cdot 10^{-3}$</td>
</tr>
<tr>
<td>$\Delta \varsigma$</td>
<td>$1.7431 \cdot 10^{-7}$</td>
<td>$6.3120 \cdot 10^{-8}$ - $2.9184 \cdot 10^{-7}$</td>
</tr>
<tr>
<td>$\sigma_p$</td>
<td>0.11244</td>
<td>0.10323 - 0.12014</td>
</tr>
<tr>
<td>$L$</td>
<td>557.68</td>
<td></td>
</tr>
</tbody>
</table>

The estimated $\alpha$ is large, significant, and has the wrong sign. Interestingly, this holds true if we reestimate the price process for various subsamples within the period for which we have data. We report the estimates of the price process parameters for the periods of the Napoleonic Wars, pre- and post-World-War gold standards, and Bretton Woods monetary system in Appendix 4. Because the number of states $M_\varsigma$ is relatively small, we have not obtained a close fit of the price data; the standard deviation $\hat{\sigma}_p$ of the error is quite large (about 11%). We show the actual and fitted prices in Figure 7.

### Figure 7. Purchasing power of gold: actual and fitted, 1561–1913
The estimated sequence \( \varsigma \) is persistent, so that the implied price \( p_t \) is also persistent. Persistence means that the most likely price tomorrow is the current price. In other words, high persistence implies that the expected rate of return on gold is often zero.

We present the plot of the net expected rate of return on gold in Figure 8, along with the actual return from the data, the first difference of the (logarithm of the) series in Figure 2. At no time does the net expected rate of return implied by the model exceed 0.3% in absolute value. Given the erratic pattern of actual returns, it is, perhaps, not surprising that our model gives rise to little variation in the expected return.

Figure 8. Actual and expected rates of return on gold, 1562–1913

In Figures 9 and 10, we present two scatter plots. Figure 9 is the data on the value of the stock of gold (except that we use the interpolated stock [see Figure 3]
for the gold stock prior to 1850) and the return on gold. Figure 10 is the analogue using the model’s predictions. It is evident from Figure 10 that the model implies that the value of the gold stock is highly sensitive to the rate of return, a sensitivity which happens to be of the wrong sign. However, even if it were the right sign, its magnitude would be implausible.

6. Concluding remarks

Cagan, of course, fitted his demand function to periods of hyperinflation, when there were large ‘predictable’ variations in the return on money – variations which, he argued, would swamp any changes in a scale variable such as total income or consumption, and any changes in the yields on alternative assets such as the real return on capital. We cannot make that argument. Instead, we use his approach mainly because we do not have access to data on a scale variable or on the yields of alternative assets.

Appendices are available at http://rjmf.econs.online/en;
http://dx.doi.org/10.31477/rjmf.201903.122

References


XXI April International Academic Conference on Economic and Social Development

CALL FOR PAPERS

On 6–10 April 2020 in Moscow, the National Research University Higher School of Economics (HSE University), with the support of the World Bank, will be hosting the XXI April International Academic Conference on Economic and Social Development.

The committee will be chaired by Professor Evgeny Yasin, HSE University’s academic supervisor.

Detailed information will be published on the Conference website conf.hse.ru

Papers presented at the Conference should contain the results of original Research using an up-to-date research methodology. The Conference programme will be developed based on accepted proposals.

• Submit the proposal through HSE University’s online system from 9 September to 15 November 2019 (the link will become available later).
• Online registration to attend the Conference (without a presentation) will be open until 20 March 2019.
• A group of authors, each individually registered on the Conference system, may request permission from the Programme Committee to present their reports in one session. To do so, they must complete the form on the Conference website by 15 November 2019.

The committee will be chaired by Professor Evgeny Yasin, HSE University’s academic supervisor.

Information about previous conferences can be viewed here: https://conf.hse.ru/2019/

Information about participation fees, payment deadlines and procedures will be available in the respective section of the Conference website.

Conference Organizing Committee
(Contact: interconf@hse.ru)
CONTENTS

Macroprudential Policy and Financial (In)Stability Analysis in the Russian Federation
  Mikhail Andreev, Udara Peiris, Aleksandr Shirobokov, Dimitrios Tsomocos

Commodity and Financial Cycles in Resource-based Economies
  Marina Tiunova

The Impact of Inflation Anchor Strength and Monetary Policy Transparency on Inflation During the Period of Emerging Market Volatility in Summer 2018
  Tatiana Evdokimova, Grigory Zhirnov, Inge Klaver

Review of Bank of Russia Conference on 'Macroprudential Policy Effectiveness: Theory and Practice'
  Nadezhda Ivanova, Mikhail Andreev, Andrey Sinyakov, Ivan Shevchuk

Estimating a Cagan-type Demand Function for Gold: 1561–1913
  Alexei Deviatov