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A Semi-Structural Model with Household Debt for Israel*

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Abstract

We propose a semi-structural DSGE model for the Israeli economy, as a small open economy, which contains a financial friction in the household sector credit market. Such a friction is reflected in a positive relationship between households' leverage ratio and their interest rate (credit spread) on debt, as evident in the Israeli data. Our main purpose is to evaluate the implications of such a friction on the implementation of monetary policy and macroprudential policy. Our two main findings are: First, it is important that the monetary policy will react also to developments in the credit market, such as credit spread widening, to increase effectiveness in achieving its main goals of stabilizing inflation and real activity. Second, macroprudential policy may increase the sensitivity of households' credit spread to their leverage. Thus, this policy can mitigate or even prevent over-borrowing and reduce the risk of a debt deleveraging crisis. Moreover, in a case of demand weakness and debt deleveraging, in addition to accommodative monetary policy, the macroprudential policy may contribute to stimulating demand due to a corresponding reduction in credit spread.

JEL Classifications: E44, E52, G21, G51
Keywords: Monetary Policy, Household Finance, Financial Friction, Macroprudential Policy, Leaning Against the Wind (LAW)

מודל סמי-מבני הכולל חוב משקי בית עבור המשק הישראלי

אלכס אילק ונמרוד כהן

תקציר

אנו מציגים מודל סמי-מבני של שיווי משקל כללי עבור המשק הישראלי, כמשק קטן ופתוח. המודל כולל חיכוך פיננסי בשוק האשראי למשקי הבית, אשר מתבטא בקשר חיובי בין מינוף משקי הבית לבין שיעור הריבית (מרווח האשראי) על החוב שלהם, כפי שנצפה בנתוני המשק הישראלי. המטרה העיקרית שלנו היא להעריך את ההשפעה של חיכוך כזה על יישום של מדיניות מוניטרית ושל מדיניות מאקרו יציבותית. שני הממצאים העיקריים הם: ראשית, חשוב שהמדיניות המוניטרית תגיב גם להתפתחויות בשוק האשראי, כגון התרחבות במרווח האשראי, כדי להגדיל את האפקטיביות בהשגת היעדים המרכזים שלה – ייצוב של האינפלציה והפעילות. שנית, מדיניות מאקרו יציבותית יכולה להגדיל רגישות של מרווח האשראי של משקי הבית ביחס למינוף שלהם. לכן, מדיניות זו יכולה למתן או אפילו למנוע מינוף ייתר, ולהקטין את הסיכון למשבר כתוצאה מרצון של משקי בית להקטין בצורה חדה את המינוף שלהם. בנוסף, במקרה של חולשה בביקוש המצרפי במשק וירידה בהיקף האשראי של משקי בית, בנוסף למדיניות מוניטארית מרחיבה, המדיניות המאקרו יציבותית יכולה לתרום לעידוד הביקוש הודות לצמצום של מרווח האשראי.

1 Introduction

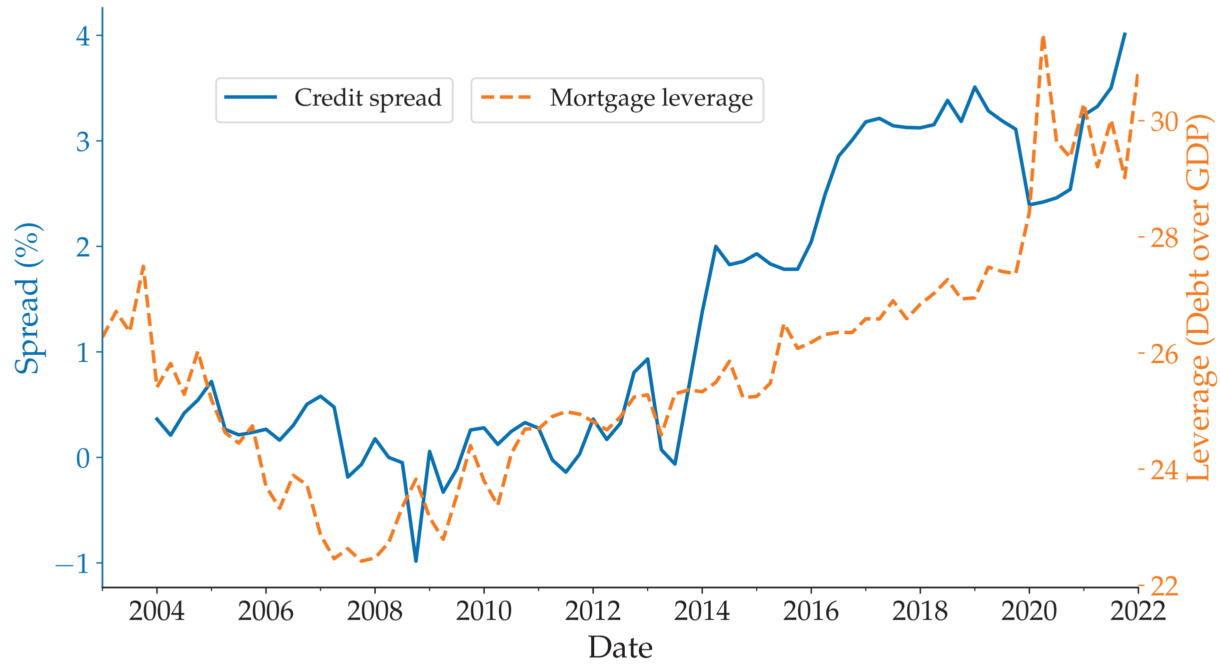
We propose a simple empirical – semi-structural[1] – DSGE model for Israel, as a small open economy (henceforth, SOE), that incorporates financial friction in the household sector credit market. We specify and calibrate the model based on stylized facts and empirical evidence for the Israeli household sector credit market. Our model incorporates two main blocks. The first block is a standard model for SOE based on Laxton et al. (2006), in which financial friction is absent, but it contains all the key features of SOE.

The second block contains household sector credit market with financial friction (for a closed economy). We adopt the type of financial friction model introduced by Benigno et al. (2020) and Cúrdia and Woodford (2016), which is reflected in a positive relationship between households' debt leverage level and their credit interest rate spread. One possible interpretation for such a relationship is that a higher leverage leads to higher risk of default perceived by the financial intermediaries, and therefore requires compensation in the form of spread over a risk-free interest rate. An alternative interpretation is that providing credit is costly for the financial intermediaries, and the spread compensates them.

Stylized Facts. We will discuss here about stylized facts and evidence of financial friction in the household sector credit market in Israel. First, the ratio of borrowers in Israel is about 40% (according to Shami (2019)), which motivates a model with heterogeneous households – two types of agents – borrowers and lenders. Second, the Israeli household sector credit market is closed to abroad, and just a minute percent of the households can borrow from abroad. Moreover, their dominant credit is mortgage, which is around two-thirds of their total debt, on average, over time. Finally, to justify integration of the type of financial friction we describe above into our model, we empirically validate the existence of a positive relationship between the interest rate spread and leverage ratio (as we will define below) in the Israeli mortgage market. Note that the Israeli data on household's non-housing debt interest rates are too short (started

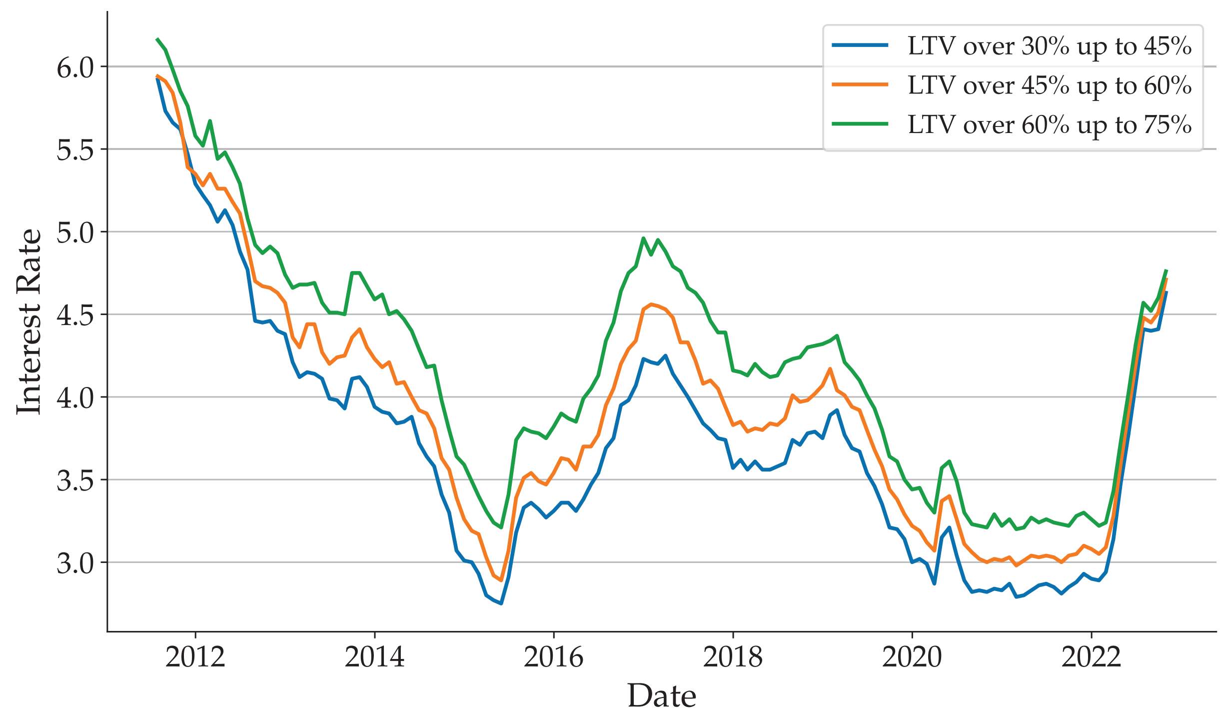
[1]A semi-structural general equilibrium model where the structure of the equations follows economic reasoning, but several economic restrictions are relaxed to improve the empirical fit and allow for an intuitive use of the model, as Laxton et al. (2006).

Figure 1: Mortgage leverage vs. spread over time in Israel (2004-2022)



Notes: Orange line: leverage defined as mortgage stock over output, Blue line: spread defined as the mortgage weighted interest rate over capital market long term bonds (10 years). (Source: Bank of Israel)

Figure 2: Average mortgage nominal fixed interest rate over time in Israel (2011-2022)



Notes: Average Mortgage Nominal Fixed Interest Rate, for various LTV groups. We can see a positive relationship between credit spread and leverage. (Source: Bank of Israel) only in 2016) such that we cannot draw a conclusion about their credit spread–leverage relation. Fig. 1 presents the leverage in the Israeli mortgage market defined as mortgage stock over output (orange line), and the corresponding credit spread defined as the mortgage weighted interest rate over capital market long term bonds (10 years), in the blue line. We can clearly see a positive relationship between the two – mortgage leverage and credit spread – over time (2004-2022). Another indication for a positive relationship can be observed in Fig. 2, which presents the average mortgage nominal fixed interest rate over time, for various LTV groups. As expected, we can see that as LTV is higher the spread is higher. In summary, these enlightening figures support the existence of financial frictions in Israel's credit market. Formal analyses can be seen in Section 3.2.1 and Appendix A.

We will now elaborate on the details of the financial friction modeling framework. In Benigno et al. (2020) and Cúrdia and Woodford (2016), the leverage ratio is defined by current aggregate households' debt over the *steady state output*. We will adjust this definition to be households' debt over their income (which in turn is related to the current *output gap*), as we think that this definition is more suitable in practice.[2] Moreover, with this definition, our model can produce either a financial accelerator or financial decelerator dynamic, depends on the parameters' calibration. We will elaborate on this in Section 4.1.1 (and Appendix D), and we will validate that the current model may fit well to the Israeli case in Section 4.1.2.

In fact, the definition of leverage we use is closely related to the definition in Bernanke et al. (1999), Gertler and Karadi (2011) and Iacoviello (2005) in the sense that the numéraire of the leverage takes into account the value of economic unit or value of asset. In Bernanke et al. (1999) and Gertler and Karadi (2011) the numéraire is a firm's (bank's) net worth (value of assets). At Iacoviello (2005) the numéraire is the value of house, which is a collateral for the lenders. In our framework, the numéraire is the household's income that captures to some extent the present (or even expected) income of the borrowers. An increase in the household's income, ceteris paribus, reduces risk of default

[2] Practically, it is common that when a borrower applies to receive a mortgage, the bank requires an income report at least to evaluate the ability of the borrower to repay monthly payments and minimize the probability of default.

and should reduce the cost of borrowing. Thus, increase in debt does not necessarily induce higher spread, unless income increases by a lower extent.

One of the most striking results in Benigno et al. (2020), which we inherit in our model, is that the natural rate of interest (henceforth, NRI) is negatively affected by households' debt (or by interest rate spread). Thus, the NRI is partially affected by policy because the households' debt, as well as interest rate spread, are policy dependent. Since the NRI is included in the aggregate demand equation (IS), a higher spread leads to lower aggregate activity. Thus, the model links negatively financial conditions and real activity. A negative effect of financial conditions on real activity was also presented (for a closed economy) by Adrian et al. (2020)[3], and by Cúrdia and Woodford (2016)[4].

It should be noted that Benigno et al. (2020) obtained this relationship from microfoundations, therefore the NRI in their model is a real interest rate that would have been obtained under price flexibility. Since our model is not fully microfounded, we cannot necessarily treat the NRI here according to the same definition as in Benigno et al. (2020). Nevertheless, we can still treat it as **a benchmark real interest rate** for the central bank (henceforth, CB). Only for the sake of simplicity, from now on we will call the benchmark interest rate NRI.

Furthermore, the NRI in our model for SOE is also affected by the expected growth of potential output in the domestic economy, the expected growth abroad (see Clarida et al. (2002)), and the demand of borrowers for credit (because of shocks to their preference).

Given our model, we will ask three main questions: (1) What are the implications of the financial friction – in the household sector credit market – on the Israeli economy under various types of shocks? (2) Should monetary policy react to financial variables, like credit spread or leverage? What are the costs, in terms of efficiency of monetary policy to achieve its main goals – price and real activity stability, if the monetary policy ignores the financial sector? (3) What are the implications of macroprudential policy that seeks to mitigate excess lending?

[3] In Adrian et al. (2020) which is not microfounded, the negative relationship is between a financial condition index and output gap, but the main economic essence is the same.

[4] Although in their model the negative effect stems from the expected flow of future spreads rather than from a one-period spread. To be precise, the expected future flow of spreads at period t negatively affects the output, but the expected future flow of spreads at period $t+1$ positively affects output gap.

These questions are closely related to a still open debate in the economic literature – the *Leaning Against the Wind* debate – which intensified after the global financial crisis in 2008, asking whether monetary policy should respond to financial variables or not (Boissay et al. (2022) and Gourio et al. (2018)). On one side, economists suggest the need for tighter monetary policy for financial stability purposes – Leaning Against the Wind policy (henceforth, LAW) – see Borio (2014)[5], Cúrdia and Woodford (2016), Cúrdia and Woodford (2010) and Adrian et al. (2020). Based on the idea that high level of borrowing significantly increases the probability of future default and may have a potential disastrous effect on the economy, this calls for policy intervention to control the financial risk. Monetary policy may mitigate to some extent the excess borrowing by increasing the interest rate. However, attaining financial stability with monetary policy may contradict achieving stability of inflation and real activity. This is why on the other side, some economists claims that each policy – monetary policy and macroprudential policy – should be conducted separately, with its separate goals and instruments (the *separation principle* of Svensson (2018)[6]). Thus, only macroprudential policy can deal directly with financial stability issues.

The rest of the paper is organized as follows. Section 2 presents the main equations of the model, Section 3 describes the data used for validating the existence of the financial friction in Israel, and presents the calibration of the model's parameters, which is most relevant for the financial sector, Section 4 shows the implication of the financial friction on the economy, and also shows the implications of macroprudential policy. Section 5 presents the analysis of monetary policy, and Section 6 concludes the main results.

2 The Model

Our model consists of domestic and foreign parts. The foreign part introduces the world economy model which has a New-Keynesian standard specification for a closed economy. The domestic part is presented by the SOE economy with a financial sector for households' credit, as discussed above. Moreover, in the current model, the SOE has

[5] and Juselius et al. (2016), Borio et al. (2018).
[6] and Svensson (2014), Svensson (2017).

two types of households – borrowers and lenders – in contrast to Laxton et al. (2006) where the SOE model is a representative agent model without a financial sector. Note that in our accomplished model we do not explicitly include lenders equations, since the model explicitly presents the aggregate activity and the borrowers' activity, therefore lenders' activity is redundant.

The main model advantage is that although it is parsimonious and empirically oriented (for the Israeli economy), it is capable of answering basic economic questions regarding the implications of financial friction on aggregate activity and other macroeconomic variables in Israel. However, since the model is not microfounded, it is limited in its ability to provide exact answers to all kinds of questions, especially related to implications of changing deep parameters of the model.

Since our model is for SOE, attention should be given to foreign forces affecting the domestic economy. First, as we saw above, domestic households in Israel cannot borrow from abroad, so their credit is entirely domestic, therefore the domestic spread and leverage are **only indirectly affected** by foreign economy (and foreign shocks). For instance, in Appendix C, we present the responses of the main macroeconomics variables - output gap and inflation - to foreign monetary shocks, and it is clear that the responses are not sensitive for change in the domestic households' financial friction. Second, the possibility for households to invest (and save) abroad has existed in Israel for many decades, mostly through financial intermediaries. But this is costly, so the domestic and foreign assets are not complete substitutes, and thus savers should be indifferent between receiving a higher interest rate abroad subject to transaction costs or a lower interest rate in the domestic economy. This incomplete substitutability between domestic and foreign assets gives rise in our model to a non-zero effect of domestic spread on the NRI (see Sec.3), and also to the existence of the risk premia in the UIP equation (as in Schmitt-Grohé and Uribe (2003)).

2.1 The SOE model equations

The main equations of the non financial block are similar to Laxton et al. (2006), although we modified some of them. The financial block equations are based on microfounded equations from Benigno et al. (2020) and Cohen (2022). Subscripts $t+1$ and $t+4$ in the equations below denote expectation for the next quarter and over the next four quarters, respectively. We consider three foreign shocks: monetary shock, inflation shock and potential output growth shock abroad. We also consider six domestic shocks: demand (preference of the borrowers) and supply financial shocks, monetary shock, inflation shock, potential output growth shock, and exchange rate shock.

Below we provide a brief explanation of the model equations.

1. Phillips curve. The inflation rate is determined by past and expected inflation (for last year and next year, respectively, as $\pi_t^{4q} = \frac{1}{4}(\pi_t + \pi_{t-1} + \pi_{t-2} + \pi_{t-3})$ is four quarters inflation), output gap, real depreciation of the shekel, and oil prices. ε_t^{π} is a cost-push shock (inflation shock).

$$\begin{aligned} \pi_t &= A_{ld}^{\pi}\pi_{t+4}^{4q} + (1 - A_{ld}^{\pi})\pi_{t-1}^{4q} + A^y\widehat{y}_{t-1} \\ &\quad + A_z^{\pi}\Delta z_t + A_{oil}^{\pi}\pi_t^{oil} + A_{oil,lag}^{\pi}\pi_{t-1}^{oil} + \varepsilon_t^{\pi} \end{aligned} \tag{1}$$

2. Uncovered Interest Rate Parity equation (henceforth, UIP) for real exchange rate of the shekel (henceforth, RER). It is determined by expected and past RER, interest rate spread between domestic and foreign riskless real interest rates, and country risk premia.

$$z_t = D_{zld}^z z_{t+1} + (1 - D_{zld}^z) z_{t-1} - (r_t - r_t^* - \Delta_t^{fx}) \tag{2}$$

3. The country risk premia in the UIP is determined by the change in the natural RER, z_t^n, and the gap between the domestic and world NRI. ε_t^{fx} is a shock to country risk premia (see, for example Schmitt-Grohé and Uribe (2003)).

$$\Delta_t^{fx} = \Delta z_t^n + (r_t^n - r_t^{nw}) + \varepsilon_t^{fx} \tag{3}$$

4. Aggregate IS equation. The output gap is determined by expected and past output gap, monetary stance, $\widehat{r}_t$, which is a gap between the real interest rate and the natural real interest rate ($\widehat{r}_t = r_t - r_t^n$, where $r_t = i_t - E_t\pi_{t+1}$ is Fisher equation), real exchange rate gap ($\widehat{z}_t = z_t - z_t^n$), and output gap abroad.

$$\hat{y}_t = \beta_{yld}^y \widehat{y}_{t+1} + (1 - \beta_{yld}^y)\widehat{y}_{t-1} - \beta_r^y \widehat{r}_{t-1} + \beta_z^y \widehat{z}_{t-1} + \beta_{y^w}^y \widehat{y}_t^w \tag{4}$$

This equation represents the dynamic of the aggregate output gap that has the following composition. First, note that the model is without investment and capital dynamics. Second, **net export,** in line with Laxton et al. (2006), can be split into quantity dynamic represented by $\widehat{y}^{w}_{t}$ and relative prices dynamic represented by $\widehat{z}_{t-1}$. Finally, exluding the above (two right elements in Eq. 4) we remain with the Euler equation for the aggregate consumption (the joint consumption of two type of agents – borrowers and lenders – in line with Benigno et al. (2020)). This explanation is important for the implementation of the next equation (NRI).

5. The NRI. Our specification of the NRI is completely different from Laxton et al. (2006) and Chen Zion (2021), who modeled the NRI and the growth rate of potential output as two independent stationary processes. Here the NRI consists of four components, as follows. The first two components are the expected growth of potential output of the SOE and the expected growth abroad (actual). This specification was introduced by Clarida et al. (2002) for an open economy without financial friction. The last two components capture the effect of the financial sector on the aggregate activity (through the NRI). Specifically, the third component is the domestic interest rate spread reflecting financial friction, as was introduced by Benigno et al. (2020). The minus sign reflects contractionary effect, since higher spread leads to lower aggregate activity, in line with the literature (Adrian et al. (2020) and Cúrdia and Woodford (2016)). Moreover, Benigno et al. (2020) considered only supply shocks to credit stemming from financial intermediaries, so in the fourth component we also consider demand shocks for credit, caused by preference shock of the borrowers[7].

$$r^{n}_{t} = \alpha + \alpha^{NRI}_{g} g^{n}_{t+1} + \alpha^{NRI}_{g^{w}} g^{w}_{t+1} - \alpha^{NRI}_{\Delta} \widehat{\Delta}_{t} - \alpha^{NRI}_{cb} \Delta\varepsilon^{cb}_{t+1} \tag{5}$$

6. Central bank policy rule. The monetary interest rate is determined by a Taylor-type rule with interest rate inertia. It reacts to the NRI, inflation environment, which is

[7] It can be shown that adding preference shocks for the borrowers in the model of Benigno et al. (2020) results in an additional component in the NRI, which is the expected change in the preference shocks of the borrowers multiplied by their relative share in the population.

a weighted average of deviation from the target of the expected inflation over the next year and actual inflation in the past year, and output gap. ε_t^i is a monetary shock.

$$\begin{aligned} i_t &= G_{lag}^i i_{t-1} + \\ & (1 - G_{lag}^i)(r_t^n + \overline{\pi} + G_\pi^i \begin{pmatrix} w(\pi_{t+4}^{4q} - \overline{\pi}) + \\ (1-w)(\pi_t^{4q} - \overline{\pi}) \end{pmatrix} + G_y^i \widehat{y}_t) + \varepsilon_t^i \end{aligned} \tag{6}$$

7. The growth rate of the potential output is determined by past growth of potential output, depreciation of the shekel in terms of the natural RER, and growth of actual output abroad. Inclusion of the two variables into Eq. 7 is also an extension of Laxton et al. (2006), and reflects the world demand for domestic output under price flexibility. The potential output growth is also affected by shocks (ε_t^g), such as technology shocks or fiscal shocks[8]. In steady state (henceforth, SS), the growth of potential output is positive, $g^n > 0$, reflecting long-run technological growth of the economy.

$$g_t^n = (1 - \theta_1 - \theta_3) g^n + \theta_1 g_{t-1}^n + \theta_2 \Delta z_t^n + \theta_3 g_t^w + \varepsilon_t^g \tag{7}$$

The equations listed below describe the financial sector of the model.

1. Leverage ratio gap, $\widehat{lev}_t$. First, let us define b_t and y_t as levels of household debt and output, respectively. Define $lev_t = \frac{b_t}{y_t}$ as a debt-output leverage ratio. We assume that in SS, output and debt grow at their potential rates, g^n, therefore the leverage ratio is constant and equal to $lev = \frac{b}{y}$. Any deviation of debt and/or output from their "natural" level leads to a deviation of the leverage ratio from its SS value. Therefore, we present the leverage ratio deviation from SS as a difference between debt gap and output gap.

$$\widehat{lev}_t = \widehat{b}_t - \widehat{y}_t \tag{8}$$

[8] Since the presented model is not microfounded, it is impossible to differentiate between all shocks that affect the potential output growth.

2. Credit spread (Identity) on the households' debt is the interest rate spread between the interest rate for borrowers and lenders

$$\Delta_t = i_t^b - i_t \tag{9}$$

3. Credit spread (supply side). Assume that the credit spread is a function of the leverage ratio, $\Delta_t = \beta_{lev}^{\Delta} lev_t + \varepsilon_t^{\Delta}$, where $\beta_{lev}^{\Delta} > 0$. ε_t^{Δ} is a financial shock which either presents changes in the perceived level of "safe" debt by financial intermediates or changes in costs associated with credit provision by financial intermediates. In SS, the spread is positive, $\Delta > 0$. For further purposes it is convenient to represent the relationship in terms of gaps, namely deviations from SS values.

$$\widehat{\Delta}_t = \beta_{lev}^{\Delta} \widehat{lev}_t + \varepsilon_t^{\Delta} \tag{10}$$

One can decompose the total elasticity of the spread with respect to leverage as $\beta_{lev}^{\Delta} = \beta_{lev}^{inter} + \beta_{lev}^{MP}$, where β_{lev}^{inter} captures only private banks' considerations of penalizing higher debt, taking into account their own revenues from the interest rate and risk of default. If for the policymakers β_{lev}^{inter} of banks is perceived to be too low, that is, the financial risks are undervalued, the intervention can be in place, by increasing the total elasticity by β_{lev}^{MP}. This can be done by intervention that makes the credit more expensive, causes an increase in the elasticity of the spread to leverage. For example, by increasing the capital requirements on loans provided by banks, as was implemented in Israel in 2010, where capital requirements for risky loans were set (see detailed description in Benchimol et al. (2022)).

4. **Borrowers** Euler equation. Their consumption is determined by expected and past consumption, real interest rate for borrowers, leverage ratio, and expected growth of potential output. All variables here are expressed in gaps (i.e. $\widehat{g}_t^n = g_t^n - g^n$). ε_t^{cb} is a consumption preference shock of the borrowers which represents demand shock to credit.

$$\begin{aligned} \widehat{c}_t^b &= \beta_{ld}^{cb} \widehat{c}_{t+1}^b + (1 - \beta_{ld}^{cb}) \widehat{c}_{t-1}^b - \beta_r^{cb} (\hat{R}_t^b - (\pi_{t+1} - \overline{\pi}) + v\, \widehat{lev}_t - \widehat{g}_{t+1}^n) \\ &\quad - \Delta \varepsilon_{t+1}^{cb} \end{aligned} \tag{11}$$

5. **Borrowers** budget constraint (in real terms). The left hand side of the equation is the amount of credit at period t needed to finance several components on the right hand side: (1) repayment of old credit from period $t-1$ and the interest rate payment on debt in period t. Since the debt is nominal, high inflation in the past erodes the old debt in real terms reducing required $\hat{b}_t$; the growth rate ($\widehat{g}_t^n$) is a by-product of stationarization[9];(2) a gap between consumption and income gaps (we assume that $\beta_b^{c^b} = \beta_b^y$).

$$\widehat{b}_t = \widehat{R}_t^b + \beta_{lag}^b \left(\widehat{b}_{t-1} - (\pi_t - \overline{\pi}) - \widehat{g}_t^n \right) + \beta_b^{c^b} \widehat{c}_t^b - \beta_b^y \widehat{y}_t \tag{12}$$

This is consistent with the stylized fact discussed before – The source of credit for households is only domestic and it comes from the domestic lenders (through financial intermediates).

2.2 The world economy equations

Most equations of the world economy are from Laxton et al. (2006). The only modification we made here is concerning the specification on the NRI in Eq. 15 according to Clarida et al. (2002).

1. Inflation equation (Phillips curve)

$$\pi_t^w = \alpha^w E_t \pi_{t+4}^{4qw} + (1-\alpha^w)\pi_{t-1}^{4qw} + k^w \hat{y}_{t-1}^w + \varepsilon_t^{\pi^w} \tag{13}$$

2. IS equation

$$\hat{y}_t^w = \delta_1^w E_t \hat{y}_{t+1}^w + \delta_2^w \hat{y}_{t-1}^w - \delta_2^w \widehat{r}_{t-1}^w \tag{14}$$

where monetary stance abroad is $\widehat{r}_t^w = r_t^w - r_t^{wn}$, and Fisher equation $r_t^w = i_t^w - E_t \pi_{t+1}^w$.

3. Natural rate of interest

$$r_t^{nw} = c_0^w + c_1^w g_{t+1}^{nw} \tag{15}$$

[9]The original borrowers budget constraint is $\frac{b_t}{R_t^b} = c_t^b + \frac{b_{t-1}}{\Pi_t} - \frac{\omega}{\chi} y_t$. Dividing by y_t yields $\frac{b_t}{R_t^b y_t} = \frac{c_t^b}{y_t} + \frac{b_{t-1}}{\Pi_t y_t} \frac{y_{t-1}}{y_{t-1}} - \frac{\omega}{\chi}$, where now the third term is divided by the growth rate $\frac{b_t^y}{R_t^b} = \frac{c_t^b}{y_t} + \frac{b_{t-1}^y}{\Pi_t \Delta y_t} - \frac{\omega}{\chi}$.

4. Policy rule of the CB

$$i_t^w = \gamma^w i_{t-1}^w + (1-\gamma^w)\left(r_t^{nw} + \overline{\pi}^w + \beta_1^w(\pi_{t+4}^{4qw} - \overline{\pi}^w) + \beta_2^w \hat{y}_t^w\right) + \varepsilon_t^{rw} \tag{16}$$

5. Growth rate of the potential output

$$g_t^{nw} = (1-\theta^w)g^{nw} + \theta^w g_{t-1}^{nw} + \varepsilon_t^{gw} \tag{17}$$

3 Calibration

3.1 Data

The data regarding credit volume is based on the commercial banks' financial reports and Bank of Israel process. The credit spread is based on a monthly report of the commercial bank to the Banking Supervision Department at the Bank of Israel.

3.2 Calibration stages

We summarize the main model parameters in Table 1. Most of the parameters in the non-financial block are based on Chen Zion (2021) who estimated the model of Laxton et al. (2006) for Israel. As we showed in Section 2, the effect of the financial friction on aggregate activity is through the NRI in Eq. 4. Therefore, in order to correctly assess the implications of the financial friction on aggregate activity, three parameters require special attention: (1) the elasticity of the interest rate spread to debt-GDP ratio, β_{lev}^{Δ}, in Eq. 10; (2) the elasticity of NRI to the spread (up to minus sign), α_{Δ}^{NRI}, in Eq. 5; and (3) the elasticity of the output gap to the NRI, β_r^y, in Eq. 4. Now we explain how we calibrated these parameters.

3.2.1 The elasticity of the spread to Debt-GDP ratio

The parameter β_{lev}^{Δ} in Eq. 10 captures the degree of the financial friction in the model. If $\beta_{lev}^{\Delta} = 0$, we return to the standard model in which the volume of debt does not matter. In Appendix A, we empirically validate the existence of such a financial friction in Israel. Specifically, we find a positive relationship between the interest rate spread and debt to GDP ratio in the Israeli mortgage market.

We are aware that the estimated elasticity we found also reflects the macroprudential steps applied in Israel during the last decade (see Benchimol et al. (2022)), therefore the estimated parameter is probably upward biased regarding the pure parameter of the banking system. Thus, in Appendix A we apply several tests by considering the macroprudential steps. We find that even under accounting these macroprudential steps, the basic parameter is still positive and significant, and we find some support for the upward biasedness of the estimated parameter.

More specifically, we estimate the following regression (in quarterly sample 2004:Q1-2021:Q3):

$$spread_t^H = c + \beta Lev_t^H + \alpha_0 \pi_t^H + \alpha_1 \pi_{t-1}^H + \alpha_2 \pi_{t-2}^H + \alpha_3 \pi_{t-3}^H + u_t \tag{18}$$

Where the debt to GDP ratio defined as $Lev_t^H = \frac{B_t^H}{Y_t}$, B_t^H is the stock of mortgages and Y_t is the GDP (with seasonal adjustment), π_t^H is housing prices. We choose this specification to be close to our model Eq. 10 and Benigno et al. (2020), where the spread is determined by the leverage in the same period. Our purpose is to obtain an adequate estimator of the parameter β for model calibration, and not to obtain the best fit of Eq. 18 with respect to R^2. The inclusion of housing prices π_t^H is expected to capture a collateral effect on the spread, and it is very significant in all regressions examined, while it helps in identification of the true supply-side shocks to the spread u_t.

Under some assumption in the non-mortgage credit market, elaborated in Appendix B, we calibrate the model-consistent parameter regarding to the total household credit market, β_{lev}^{Δ} to be 0.031. This parameter is close to the parameter in Cúrdia and Woodford (2010) (of 0.1), but much higher than obtained in Benigno et al. (2020) for the US (of 0.0078).

3.2.2 The elasticity of the NRI to spread

Benigno et al. (2020) obtained that the elasticity of the NRI to spread for the US is -2.5. We assert that for a SOE, this elasticity should be lower in magnitude, due to the possibility of the savers to substitute part of domestic saving with foreign saving (they face higher transaction costs when investing abroad). Here the NRI rate will decline when a positive shock to the spread hits the borrowers, but this decline will be moderate compared to the closed economy. Based on these considerations, we calibrated the elasticity of the NRI to the spread to -0.5 ($\alpha_{\Delta}^{NRI} = 0.5$).

Concerning the NRI in Eq. 5, we also modeled it as a function of expected growth of domestic potential output and the expected growth of actual output abroad following Clarida et al. (2002). The estimated elasticities for Israel of both variables were taken from Ilek and Segal (2022). Another justification for a lower parameter here compared to Benigno et al. (2020) is that here the effect is on the output gap and not only on aggregate consumption as in Benigno et al. (2020).

3.2.3 The elasticity of the output gap to NRI

The elasticity of the output gap with respect to NRI (parameter β_r^y in Eq. 4) is equal to the elasticity of the output gap with respect to the short real interest rate of the CB. Several estimates of this parameter exist for Israel. Chen Zion (2021) obtained β_r^y of -0.02, which is falls far below all the others. Ilek and Segal (2022) estimate is -0.1, Benchimol (2016) estimate is -0.5, Argov and Elkayam (2009) estimate lies between -0.42 and -0.82, and Argov et al. (2012) estimate is close to -0.1.[10] We adopt a conservative approach in calibrating parameter β_r^y in Eq. 4, setting it to -0.1, which is a left tail of all estimates for Israel, except the estimate in Chen Zion (2021).

3.2.4 Borrowers' debt aversion

Concerning other parameters in the financial block, the highest uncertainty is about the parameter v in Eq. 11, that economically reflects the degree of aversion to deviations of the leverage from its SS value. Low values of v induce high volatility of debt and leverage and vice versa. Benigno et al. (2020) set $v = 0.025$ for the US. No estimates or any assessments exist for Israel. One way to calibrate v is to match debt volatility from the model to the data. Measuring debt gap from the data using HP filter results in SE of

[10]This model is presented in a non-linear form, therefore it is hard to obtain this elasticity directly. We applied the following procedure to derive it indirectly. In the first stage, we generated 1,000 observation using stochastic simulation of the DSGE model. In the second stage, we regressed the output gap on real interest rate, and other explanatory variables like specification of IS equation in Laxton et al. (2006). We obtained estimated elasticity of the output gap to the real interest rate between -0.1 and -0.15.

about 4%. To obtain this volatility, high v is required in the model, $v = 1.25$. However, HP filter is a very conservative approach of deriving gaps, because the HP trend closely tracks the actual data by construction (the standard assumption of smoothing parameter is $\lambda = 1,600$). In contrast, deriving gaps from linear trend induces remarkably high volatility of debt gap (under linear trend λ is very big). Measuring debt gap from the data using linear trend results in SE of 13%. To obtain such SE from the model, low parameter of v is needed as in Benigno et al. (2020), of about $v = 0.0225$. Given the very high uncertainty regarding to true volatility of debt gap in the data, we examine two polar cases of this parameter, baseline case with $v = 0.0225$ as in Benigno et al. (2020) and alternative case with $v = 1.25$ which is higher by 50.

3.2.5 Other parameters

The parameter α_{cb}^{NRI} in Eq. 5 is calibrated to -0.4, capturing the share of borrowers in the population (according to Shami (2019)). Parameters in Eq. 12 are obtained from linearization of the equation. Finally, we calibrate $\beta_r^{c^b}$ to be 5 times bigger than β_r^y, economically meaning that the consumption of the borrowers is more sensitive to the interest rate than the lenders' (as in Cúrdia and Woodford (2016)).

4 Implications of Financial Friction and Macroprudential Policy

In this section, we show the implications of financial friction and macroprudential policy on the economy. To that end, we compare the responses of the main variables to various shocks in a model under three cases, as described below:

- **A model without financial friction**. In this case, commercial banks do not take into account the possibility of default and don't penalize borrowers for higher leverage. That means that the spread for the borrowers does not depend on their leverage ratio ($\beta_{lev}^{\Delta} = 0$ in Eq. 10) and it is completely exogenous.
- **A model with financial friction**. The banks penalize borrowers for higher debt, as a result of internal risk management, so they require higher credit spread for

Table 1: The parameters of the financial block of the model

Parameter		Value	Source or Target
Elasticity of the Spread to Debt-GDP	β_{lev}^{Δ}	0.031	Appendix B
Elasticity of the NRI to			
1. Spread	α_{Δ}^{NRI}	0.5	Benigno et al. (2020) and authors' considerations
2. Domestic expected potential growth	α_{g}^{NRI}	0.4	Ilek and Segal (2022)
3. Actual growth abroad	$\alpha_{g^*}^{NRI}$	0.6	Ilek and Segal (2022)
4. Preference shock	α_{cb}^{NRI}	0.4	Share of borrowers
Elasticity of the Output Gap to NRI	β_{r}^{y}	-0.1	Argov et al. (2012), Ilek and Segal (2022)
Euler equation of borrowers			
	v	0.0225-1.25	Benigno et al. (2020) and authors considerations
	$\beta_{r}^{c^b}$	$\beta_{r}^{y} \times 5$	Cúrdia and Woodford (2016) and authors considerations

higher leverage ratio ($\beta^{\Delta}_{lev} = 0.031$, as under the basic calibration, see Table 1).

- **A model with macroprudential policy**. Here the banks influenced significantly by regulation of macroprudential policy, resulting in a higher credit spread sensitivity to borrowers' leverage ($\beta^{\Delta}_{lev} = 0.1 > 0.031$). As discussed earlier, in Eq. 10, macroprudential policy should try to prevent excess borrowing. One possible tool is to impose stringent regulations on the borrowers, such as maximum level of leverage (LTV) or maximum payment-to-income ratio (PTI). Another common tool is by controlling the commercial banks' capital requirements, which can make borrowing more costly. However, we do not analyze here how each tool affects the spread sensitivity to borrowers' leverage, β^{Δ}_{lev}. Our purpose is to illustrate how an increase in this sensitivity affects the economy.

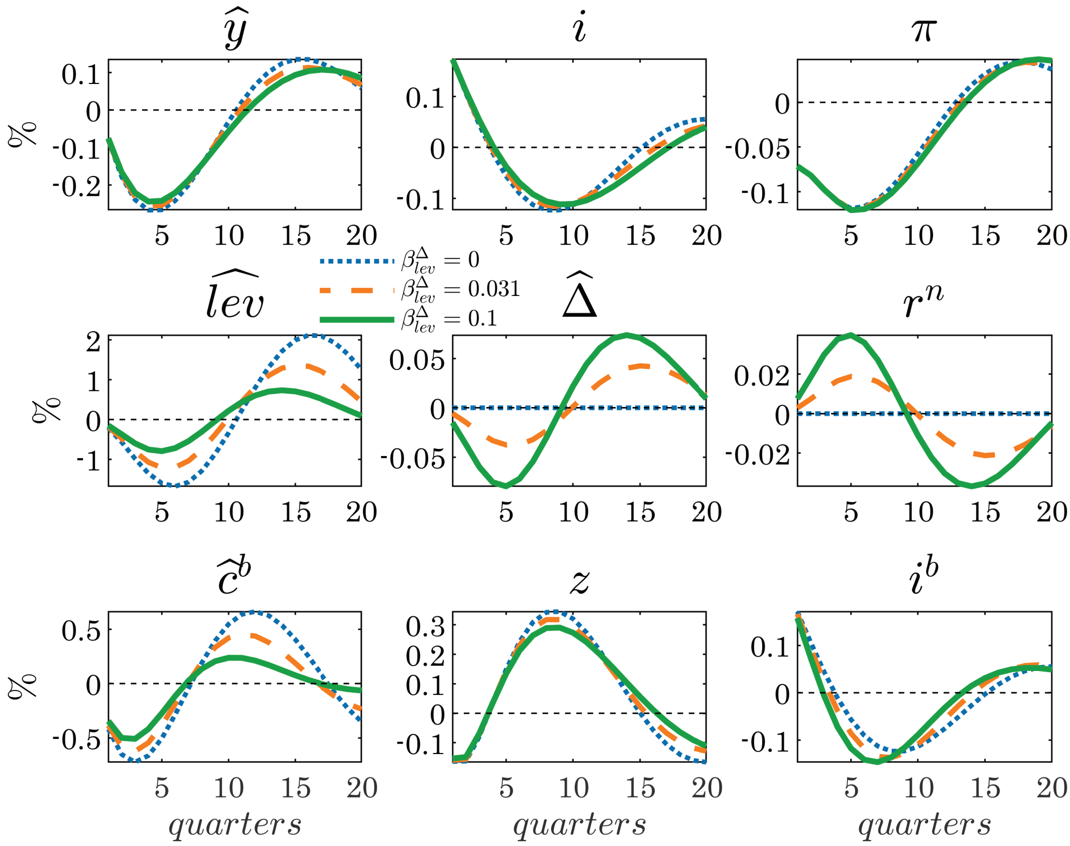
4.1 Implication of financial friction and macroprudential policy under monetary policy shock

Fig. 3 shows the impulse response function (henceforth, IRF) to monetary policy shock of nine variables - output gap, central bank interest rate, inflation, leverage ratio, credit spread, natural rate of interest, borrowers' consumption, real exchange rate and borrowers' risky interest rate. The blue dotted line presents the case without financial friction, $\beta^{\Delta}_{lev} = 0$. The orange line represents the baseline case with financial friction, $\beta^{\Delta}_{lev} = 0.031$, but without distinctive macroprudential policy. Finally, the green line represents the case with tight macroprudential policy describe above, result in total elasticity of $\beta_{lev} = 0.1$.

The contractionary monetary policy shock reduces consumption demand through the financial decision channel, since higher interest rate drives all households – borrowers and savers – to reduce debt or increase saving, accordingly. As a result, we get a decline in output and inflation. We can see that under monetary policy shock the role of the financial friction and macroprudential policy is not significant, and we obtain quite a similar dynamic of the main variables – output and inflation – in all three cases.

In the case without financial friction (blue dotted line), the borrowers' spread is not influenced by their leverage level, and it is constant. While in the case with financial

Figure 3: IRF to positive monetary policy shock



Notes: Shock of 1 standard deviation. Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). Green line: represents the case with macroprudential policy. (elasticity of spread to leverage is 0.1). All simulations are under specification of low borowers' aversion to leverage, v=0.0225 friction (orange line), the reduction in borrowers' leverage gives a relief in the credit conditions and we obtain a small decline in the credit spread. This has a minor positive contribution to borrowers' demand. Finally, under macroprudential policy, we get much higher reduction in the spread, with lower decline in leverage and consumption of borrowers. This behavior of a slightly smoother output path with higher financial friction is elaborated on the next section.

4.1.1 Financial Accelerator or Financial Decelerator?

The sign of the response of credit spread to monetary shock is unequivocal in the literature, even when considering the same country and the same methodology. For example, Brzoza-Brzezina et al. (2013) show, based on a VAR model for the US economy, that a positive monetary shock reduces spread, at least for one year. In contrast, Cesa-Bianchi and Anderson (2020) and Gertler and Karadi (2015) also consider the US economy but show that spreads rise.

The main result we obtained previously is that a positive monetary shock reduces leverage, and therefore reduces the spread. The reduction in the spread partially mitigates the negative effect of the monetary shock on consumption of borrowers and output. So, the financial friction in our model calibration generates a **financial decelerator** rather than financial accelerator. We will now elaborate on this result, starting by referring to the literature, where one can find that there are few types of financial frictions modeling approaches (Brzoza-Brzezina et al. (2013) among others).

Our point is that for all type of models, the spread increases with leverage, but the leverage is defined differently, therefore its reaction to shocks may be different. This is the reason why in different models the impact of shocks is different – it amplifies or mitigates with respect to the case without financial friction. The reaction is depends critically on the question of whether the leverage increases or decreases in response to shocks – which depends on the relative reaction of leverage numerator (debt) and leverage denominator (net worth, house value, etc.).Specifically:

1. In Bernanke et al. (1999) the financial friction is reflected by the (negative) depen-

dence of the credit spread on borrowers' (firms') net worth.[11] In this framework the financial friction induces that shocks are amplified; hence it is named a financial accelerator. After a (positive) monetary shock, the leverage increases because the value of firms/banks assets (leverage denominator) decreases more than the volume of credit (leverage numerator). This induces increase in credit spread and causes amplification of the monetary shock.

2. In Kiyotaki and Moore (1997) and Iacoviello (2005) the friction is reflected in existence of collateral constraint on borrowing, so leverage is defined as Loan to Value (LTV). In this framework, the financial friction induces financial accelerator for some types of shocks and financial decelerator for others.

3. In Cúrdia and Woodford (2016) and Benigno et al. (2020) the leverage denominator is the SS level of debt and output, respectively. So, in this case, the leverage decreases as a result of (positive) monetary shock, because debt decreases along with constant denominator in the leverage.

In our model, as we show previously, the denominator is a time-variant output gap (which is related to households' income). As such, our model can be viewed as a generalization of Cúrdia and Woodford (2016) and Benigno et al. (2020), thus can function as financial accelerator or decelerator, depending on calibration. In our model calibration (Table 1) the debt decreases more than the output, therefore the leverage and the spread decrease, and we get deceleration (which was validated empirically in Section 4.1.2). If under some parameterization a positive monetary shock reduces output more than debt, then the leverage will rise and consequently the spread will increase, which will cause acceleration (see Appendix D), but these parameters are not reasonable for Israel.

4.1.2 The case of Israel

Now we will validate the existence of a financial decelerator in Israel empirically. To that end, we assess the sign (and the size) of elasticity of the spread to monetary shock. If

[11] In Gertler and Karadi (2011) the financial spread depends on the lender's net worth (financial intermediates).

positive monetary shock induces higher (lower) spread, it indicates existence of financial accelerator (decelerator). To evaluate the sign of the effect of monetary shock on spread in Israeli mortgage market we estimate the following regression:

$$spread_t^H = \alpha\epsilon_t^{mon} + \beta X_{t-1} + \gamma Z_t + u_t \quad (19)$$

where ϵ_t^{mon} is a monetary shock based on projections for the Bank of Israel (henceforth, BOI) interest rate by the professional forecasters in Israel. X_t is a vector of explanatory variables containing the leverage (debt over GDP), changes in the houses prices, changes in the unemployment rate and the spread. Vector Z_t contains exogenous variables including a dummy variable representing macroprudential policy measures of the BOI in the housing market (based on calculation of Benchimol et al. (2022)), and the VIX index in the US representing uncertainty. u_t are residuals.

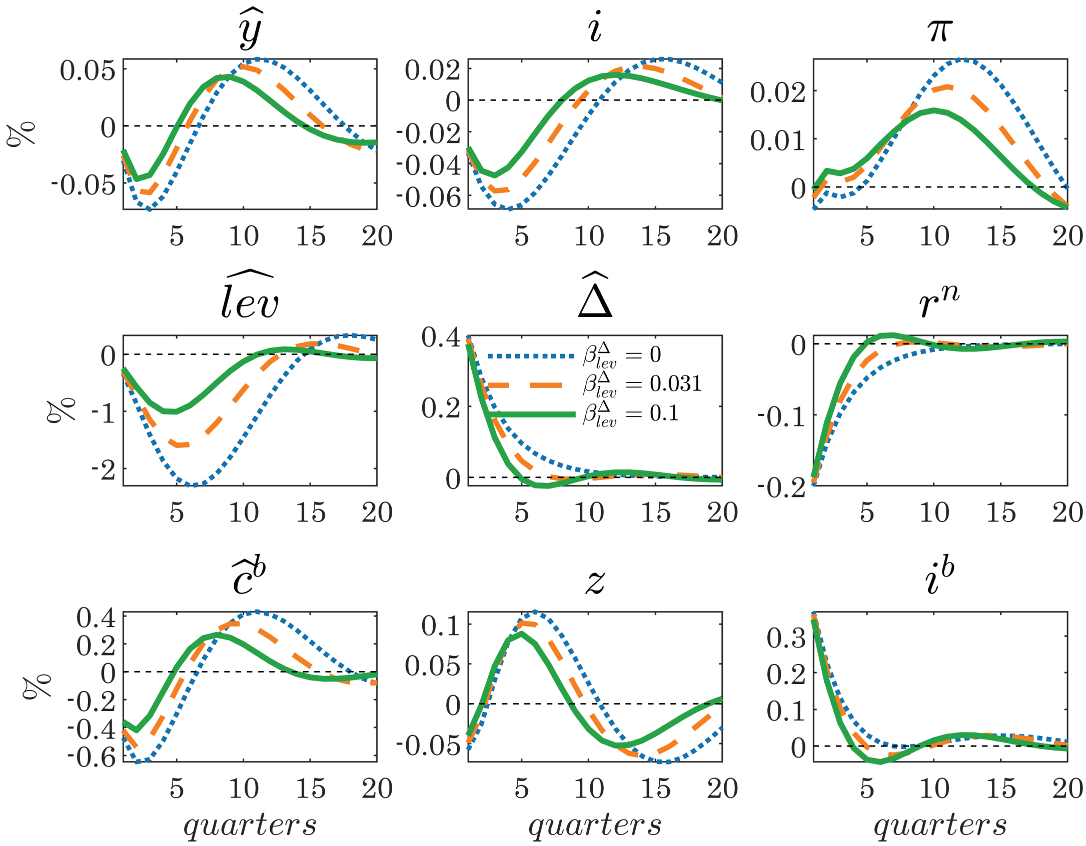
When the spread in Eq. 19 is defined relative to the real rate of commercial banks, we obtain $\alpha = -0.74$ ($pvalue = 0.045$), and when it is defined relative to real return of government bonds we obtain $\alpha = -0.77$ ($pvalue = 0.06$). The negative sign of α is robust to other specifications of Eq. 19, while its size can exceed -1 in some cases.[12] So, we obtained empirical support that the financial friction in the mortgage credit market in Israel induces financial decelerator, similar to Cúrdia and Woodford (2016) and Benigno et al. (2020). This result gives support for the IRF of credit spread to positive monetary shock in Fig. 3.

4.2 Implication of financial friction and macroprudential policy under credit supply shock

Fig. 4 shows the IRF to positive credit spread shock which represents a negative credit supply shock. In the case *without* financial friction ($\beta_{lev}^{\Delta} = 0$, blue line) the spread is exogenous and independent of the borrowers' leverage ratio. Since borrowers have a higher effective interest rate, their debt is more expensive, and they prefer to deleverage. This requires reduction in the borrowers' expenditure for consumption. Simultaneously, the increase in the spread induces a decline in the NRI and a reduction in the output

[12]In Cesa-Bianchi and Anderson (2020) the estimated elasticity also exceeds 1 for some tests. However, in contrast to our result the elasticity in Cesa-Bianchi and Anderson (2020) is positive.

Figure 4: IRF to negative credit supply shock



Notes: Positive shock to spread of 1 standard deviation.Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). Green line: represents the case with macroprudential policy. (elasticity of spread to leverage is 0.1). All simulations are under specification of low borowers aversion to leverage, v=0.0225 gap. In the case *with* financial friction (orange line) the spread has an endogenous part, so as the borrowers deleverage, it helps to reduce their credit spread. In turn they keep deleveraging and reduce consumption, but much softer than in the first case. Under macroprudential policy (ex-post policy) deleveraging process contributes much more to the reduction of the spread, and thus the deleveraging process is much more moderate, and we have a smoother path for all variables, which is good policy outcome.

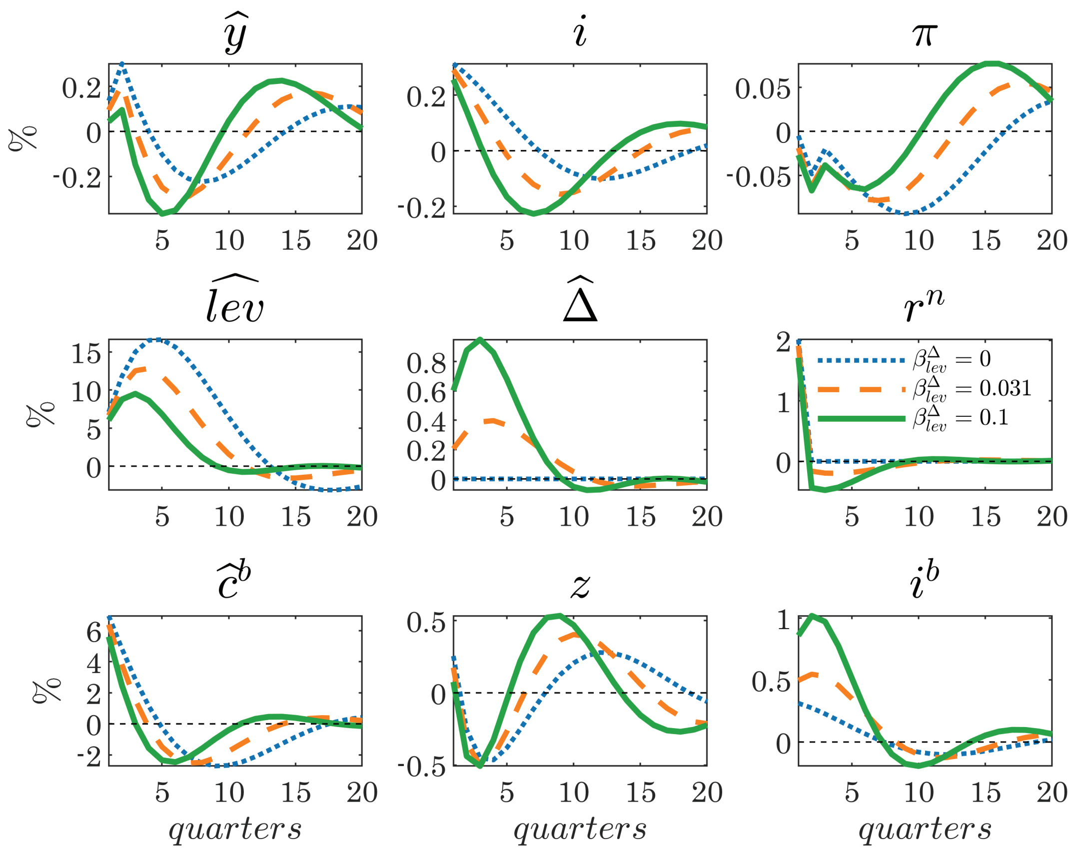
Note that a negative credit shock (which is a mirror image of the IRF's described above in Fig. 4) represents credit market easing which results in economic expansion. In these circumstances, the macroprudential policy (ex-ante policy) acts to limit excess leverage buildup and reduces the likelihood of a financial default.

Looking at the second-year response (quarters 5 to 8) we can see that borrowers' consumption and aggregate activity are high. This can be explained by the real depreciation along the first year (increasing z_t) which supports modest inflation in the first year and accumulates to high yearly inflation. Due to high inflationary inertia, as can be seen in Eq. 1, we get high inflation rate along the second year. This inflationary path with smoothing (inertial) interest rate policy has the consequences of lowering the real interest rate and has expansionary impact of high activity. In other words, the monetary policy is not contractionary enough (due to smoothing) and unintentionally causes an expansionary effect. This mechanism based on the interaction between spread (financial market) and real exchange rate does not exist in close economic models.

4.3 Implication of financial friction and macroprudential policy under credit demand shock

In Fig. 5 we induce a positive preference shock only to the borrowers (ε_t^{cb}), which is translated into a higher demand for borrowers consumption, as can be seen in Eq. 11, and thus a higher demand for credit (see Eq. 12). Accordingly, we call this shock a credit demand shock. On impact, this shock increases the NRI (see Eq. 5), which induces output gap increase, which is consistent with the borrowers' consumption increase. This is pronounced in the case without financial friction ($\beta_{lev}^{\Delta} = 0$) as the leverage rises sharply, while the spread does not move. While in the case with financial friction, especially

Figure 5: IRF of positive credit demand shock (borrowers with low aversion to leverage)



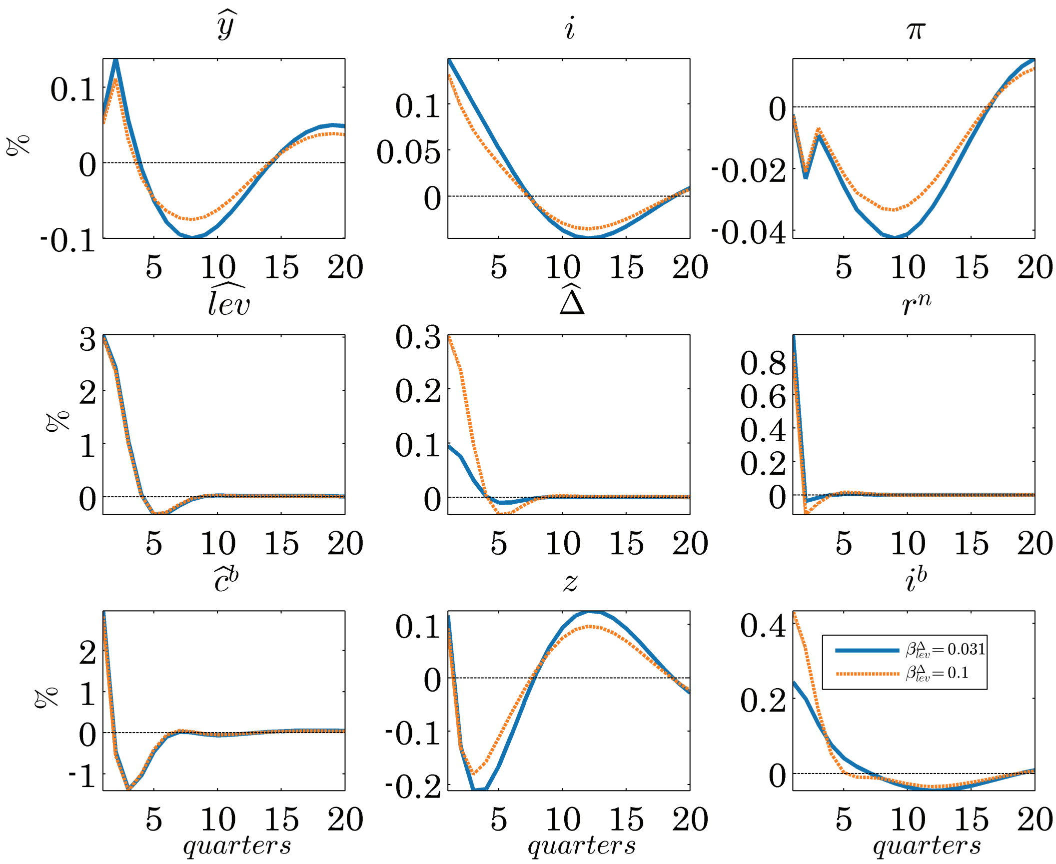
Notes: Positive preferences shock of 1 standard deviation. Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). Green line: represents the case with macroprudential policy. (elasticity of spread to leverage is 0.1). All simulations are under specification of low borowers' aversion to leverage, v=0.0225 when the macroprudential policy is at place ($\beta_{lev}^{\Delta} = 0.1$), after credit demand shock the leverage increases, and the spread increases dramatically, which in turn lower NRI and a have negative effect on aggregate activity. In this case, the substantial increase in credit spread mitigates the excess borrowers demand and leveraging, by increasing borrowing costs. In summary, there is *trade-off* in implementation of macroprudential policy, since as macroprudential policy is more solid (higher β_{lev}) the spread increases significantly, and thus the policy succeeds in mitigating increase in the leverage, which is *beneficial* for financial stability (ex-ante prevention policy). But this is at the *cost* of higher spread which lowers the NRI and deteriorates aggregate real activity, which is a bad outcome. We will discuss this further in Section 5.

Debt Aversion. The effectiveness of macroprudential policy depends very much on the degree of aversion of the borrowers with respect to deviation of debt from its normal value (see Eq. 11). To show this, Fig. 5 and Fig. 6 present the IRFs with low ($v = 0.0225$) and high ($v = 1.25$) debt aversion parameter. It can be seen that for the same demand shock, households with low risk aversion are much more affected by the macroprudential policy than households with high degree of aversion. This is reflected in significant reduction of the leverage to increase in the parameter β_{lev}^{Δ} in a case with low risk aversion (Fig. 5). However, in a case with high risk aversion, Fig. 6, we can see it just barely react to the macroprudential policy. The reason for this result is that households with high aversion are very conservative from the beginning, and they are reluctant to deviate from normal leverage. This can be seen in moderate increase of their leverage by 3% in Fig. 6 as opposed to 15% in Fig. 5. Therefore, making the borrowing costs more expensive (higher β_{lev}^{Δ}) does not matter very much for borrowers with high aversion. In contrast, households that do not care very much about the volume of their debt from the beginning are more sensitive to the cost of borrowing, making macroprudential policy more efficient.

5 Monetary policy analysis

In this section, we examine the implications of financial friction in the household sector credit market on monetary policy. Our goal is not to derive an optimal monetary policy

Figure 6: IRF of positive preferences shock (borrowers with high aversion to leverage)



Notes: Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). Green line: represents the case with macroprudential policy. (elasticity of spread to leverage is 0.1). All simulations are under specification of high borowers' aversion to leverage, v=1.25

rule, but to analyze quantitatively the consequences on the economy when the monetary policy ignores the financial sector and responds only to standard variables, such as inflation and real activity.

Cúrdia and Woodford (2010) (and Cúrdia and Woodford (2016)) examine optimal reaction of monetary policy to credit spread. They show that if the financial shock is dominant in the economy, a (negative) reaction to spread (LAW policy) could be beneficial but the optimal size of the response depends very much on the persistence of the financial shock. They also show that reaction to financial spread is also beneficial to certain other types of shocks but not for all types. Moreover, the size and even their sign depend on the type of shock and on the degree of its persistence. So, it is hard to provide a robust recommendation on how optimally monetary policy should react to financial spread. This result is in line with McCulley and Toloui (2008), who proposed deducting the spread from the natural rate of interest. In this sense, our policy rule, which negatively reacts to the spread, is consistent with the above papers.

In our model, the financial spread is an integral part of the NRI. Thus, the only possibility we will consider here is monetary policy (see Eq. 6) that react to the spread vs. monetary policy that not react to the spread. It is important to note that all models' equations are the same, and just the policy rule, Eq. 6, will be different by taking misspecified NRI as we will elaborate below (Eq. 20) instead of the correct model NRI (Eq. 5). In details, in the following exercise we compare the IRF of the main economic variables to shocks under two policy rules: the first rule reacts to correctly specified NRI in Eq. 5 which takes into account the credit spread and preference shocks of the borrowers, in line with LAW policy (we will call it "FI" – Fully Informative). The alternative policy rule reacts to misspecified NRI, which corresponds to non-LAW policy (we will call it "PI" – Partially Informative), and defined as

$$r_t^{n,PI} = \alpha + \alpha_g^{NRI} g_{t+1}^n + \alpha_{g^w}^{NRI} g_{t+1}^w. \tag{20}$$

The only difference between Eq. 20 and Eq. 5 is that the former rule ignores the credit spread as well as preference shocks of the borrowers. The gap between the correct and misspecified NRI (exploiting Eq. 10) is

$$r_t^n - r_t^{n,PI} = \alpha_{\Delta}^{NRI}(\beta_{lev}^{\Delta}\widehat{lev}_t + \varepsilon_t^{\Delta}) + \chi_{cb}^{NRI}\Delta\varepsilon_{t+1}^{cb} \tag{21}$$

Thus, it is easy to see that the difference between the IRFs stems mainly and directly from two shocks, ε_t^{Δ} and $\Delta\varepsilon_{t+1}^{cb}$. While other shocks also have some indirect impact through effect on leverage ratio, $\widehat{lev}_t$, quantitatively the effect of leverage in our model is tiny, because according to our calibration, $\alpha_{\Delta}^{NRI} \cdot \beta_{lev}^{\Delta} = 0.016$. So, any reasonable change in the leverage ratio due to shocks in the economy has only a small impact on the difference between the IRF's under "FI" and "PI" rules. It comes out that the IRFs under the two policy rules are almost identical for all shocks except two, ε_t^{Δ} and $\Delta\varepsilon_{t+1}^{cb}$. Fig's 7 to 10 present the IRF to these two shocks, where "R-Correct" corresponds to the "FI" rule, whereas "R-Wrong" corresponds to the "PI" rule.

Below we consider two cases. In Case 1, the households have low aversion to deviations of the leverage from its SS value (v in Eq. 11 is low), and in Case 2 they have high aversion (v is high).

5.1 Case 1: Households with low aversion to leverage deviations

Fig. 7 shows the IRF to a positive spread shock (of 0.4 p.p). Higher spread makes debt more expensive, therefore the leverage ratio ($\widehat{lev}_t$) declines by about 2 p.p (after 5 periods). The reduction in debt forces borrowers to reduce consumption ($\hat{c}_t^b$). Looking now at the aggregate economy, the NRI declines by 0.2 p.p (see Eq. 5) pushing the output gap downward (see Eq. 4). Under the "FI" rule, the CB immediately cuts the interest rate following reduction in the NRI. This "on-time" reaction of the CB mitigates the fall in the output gap and inflation. It also mitigates the fall in the borrower's consumption. The picture is different under the "PI" rule. The CB does not react to the spread, because its perceived NRI is misspecified (see Eq. 20). As a result, the output gap noticeably falls and inflation as well (compared to the "FI" rule). The reaction of the CB is delayed and stronger compared to the "FI" rule, because in the former case the policy reacts only to the (noticeable) fall in the output gap and inflation. Overall, due to reaction of the CB to the correct NRI, it manages to stabilize the economy more efficiently than under incorrect NRI - a result which is reflected in more moderate IRFs of output and inflation.

If the Monetary Committee will decide not to react to the spread, eventually it will be forced to react strongly in the future.

Fig. 8 shows the IRF to a positive demand shock of the borrowers.[13] The consumption of the borrowers increases by 6%, as well as their leverage ratio by about 10 p.p.. As a result, the spread increases by 0.2-0.4 p.p. (Fig. 8). The preference shock also pushes the NRI upward (see Eq. 5) (note that there is also indirect impact of the shock on the NRI through the spread, but it is small). Overall, the deviations of output gap and of inflation are slightly more moderate under "FI" than under "PI" rule, so the policy is more effective. One can argue that the preference shocks of the borrowers are hard to identify in practice, because they are unobserved. Therefore, once these shocks are in place the assumption of the "FI" rule is highly unreasonable. Note, however, that preference (demand) shocks are reflected in the observed leverage ratio and debt volume in the same direction (see Fig. 8). In other words, the CB can optimally react to both financial spread and leverage ratio and it is insufficient to react only to spread when credit demand shocks are in place.

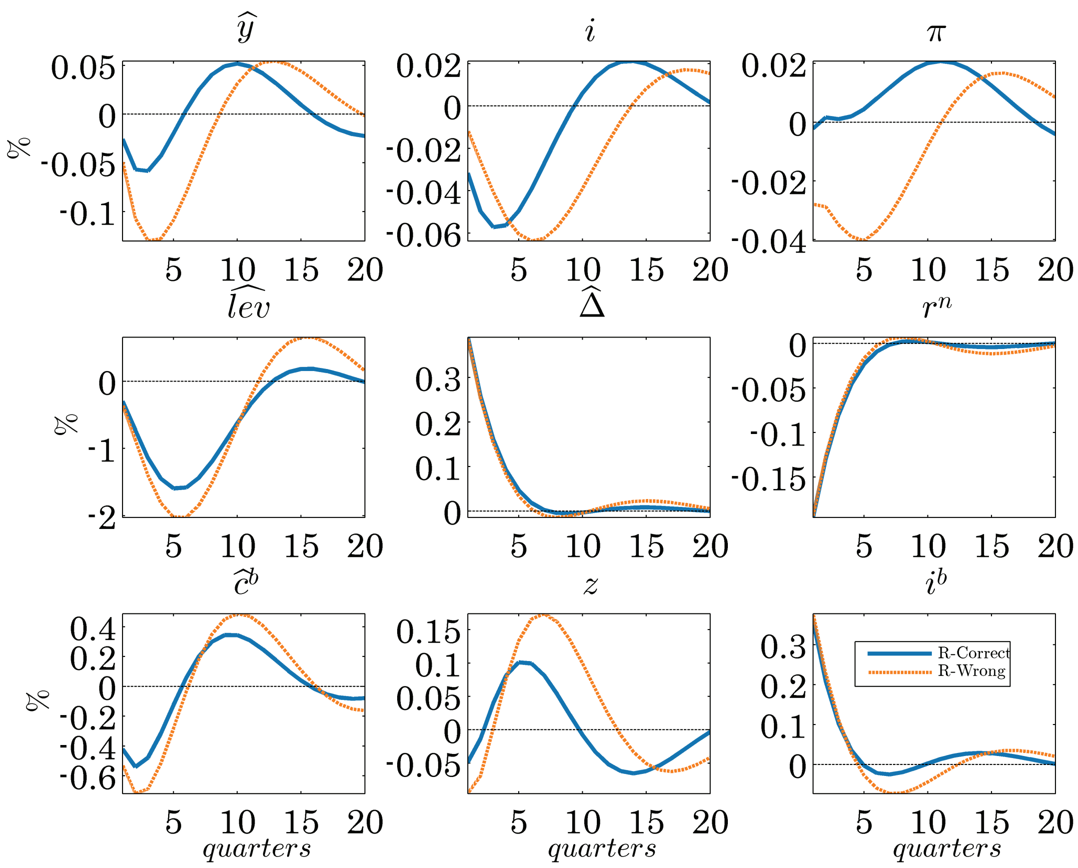
5.2 Case 2: households with high aversion to leverage deviations

Fig. 9 shows the IRF to the shock to interest rate spread when borrowers have high aversion to debt deviations. The sensitivity of the leverage to the spread shock here is much lower than in Fig. 7, which is reflected in a lower decline in consumption. The IRF of the output gap and inflation are similar to Fig. 7, because these variables are affected by the NRI, which declines at a similar rate as in Fig. 7.

Fig. 10 shows the IRF to the preference shock. Households with high aversion to debt increase their demand for consumption and credit only by 3% (as opposed to 6% and 15%, respectively, in Case 1). As a result of moderate increase in the leverage, the spread increases only by 0.1 p.p.. It is evident from Fig. 10 that the under the "FI" rule the CB is more efficient in stabilizing inflation and real activity.

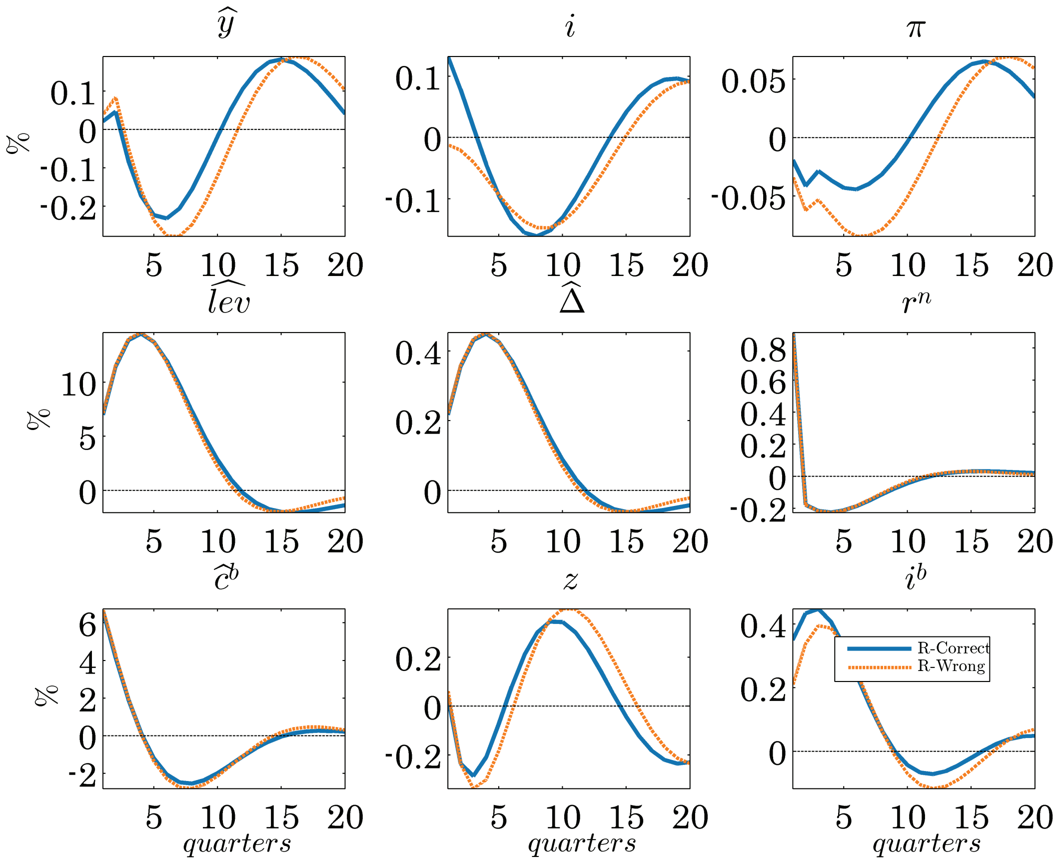
[13]The SE of preference shock is taken from Argov et al. (2012).

Figure 7: IRF to positive shock to spread of 1 SE, with low aversion to leverage



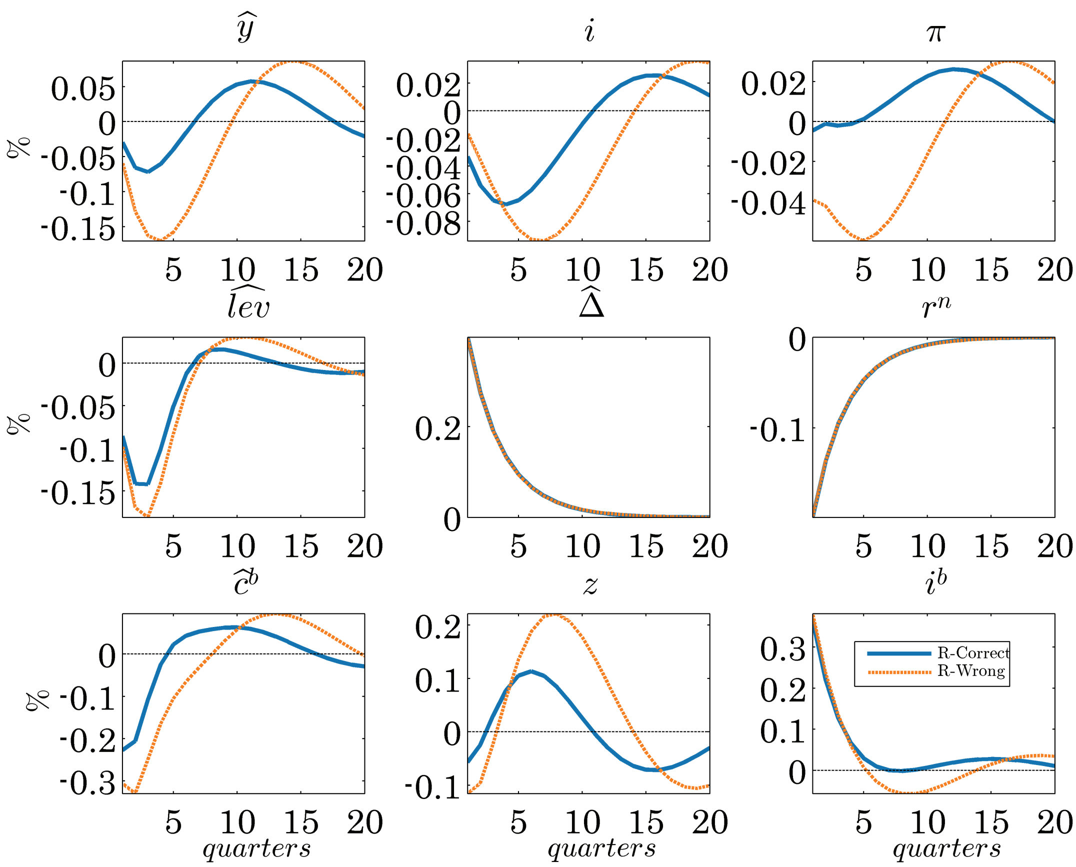
Notes: R-Correct: CB reacts to correct NRI. R-Wrong: CB reacts to wrong NRI. Low aversion to leverage is v=0.0225.

Figure 8: IRF to positive preference shock of the borrowers of 1 SE, with low aversion to leverage



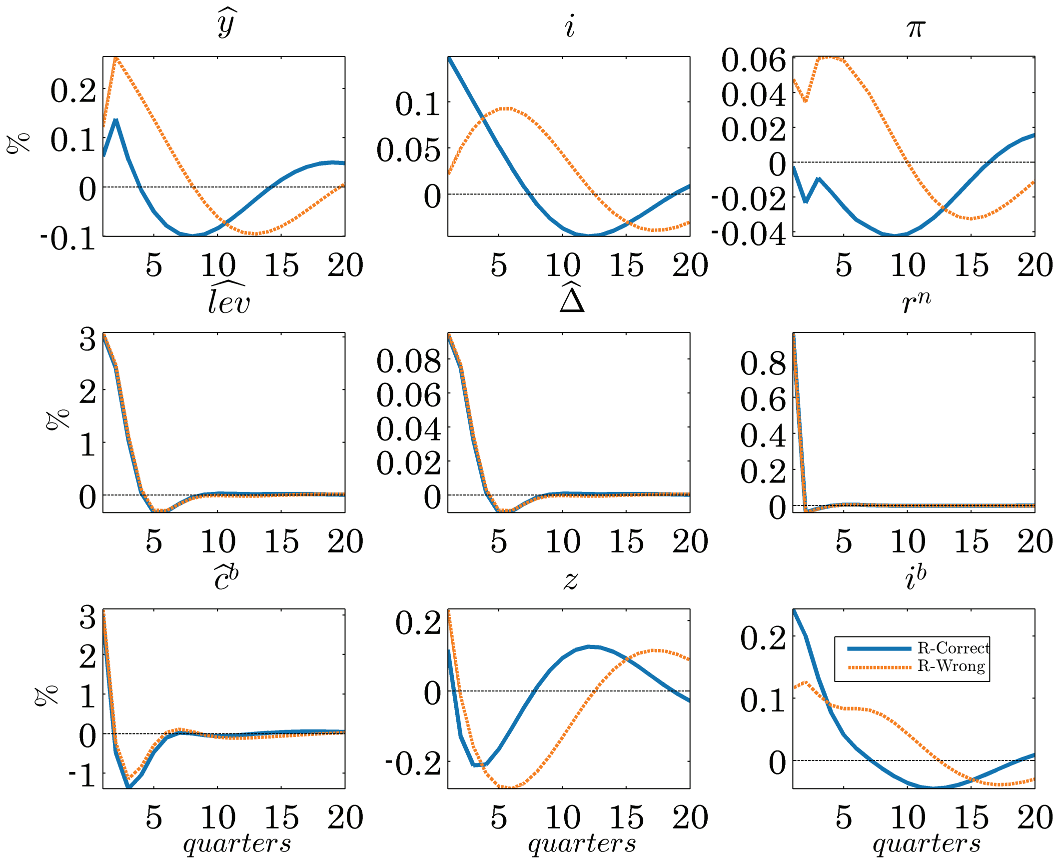
Notes: R-Correct: CB reacts to correct NRI. R-Wrong: CB reacts to wrong NRI low aversion to leverage, v=0.0225

Figure 9: IRF to positive shock to spread of 1 SE, with high aversion to leverage



Notes: R-Correct: CB reacts to correct NRI. R-Wrong: CB reacts to wrong NRI. high aversion to leverage: v=1.25

Figure 10: IRF to positive preference shock of the borrowers of 1 SE, with high aversion to leverage



Notes: R-Correct: CB reacts to correct NRI. R-Wrong: CB reacts to wrong NRI high aversion to leverage: v=1.25

5.3 Loss function analysis

The IRF's comparison shown above sheds first light on a loss function of the CB when it ignores the financial sector. To make loss function analysis more precise and formal, we make stochastic simulation with 10,000 periods and calculate the loss function under two policy rules, "FI", and "PI". In the simulations we activate only two shocks–credit demand and supply–because as we explained previously, other shocks barely make any difference between the IRFs under these two rules. We consider four versions of the loss function as shown in Eq. 22. Our purpose is to choose the loss function that characterizes best the preference of the Monetary Committee according to the BOI Law. The first version of the loss function (Version 1) is based on the variances of inflation and output gap, which reflects two main goals–price stability and stabilization of real activity. This loss function was considered for Israel by Benchimol (2022). We also consider another version of the loss function (Version 2), which may also match the preferences of the Monetary Committee in Israel. The only difference is that the variance of the output gap is replaced by the variance of *changes* in the output gap–which is the gap between actual and potential output growth. The third version (Version 3) also includes the variance of *changes* in the BOI interest rate. This specification is consistent with Segal (2007), who examined this loss function for Israel in sample 1999-2007. Finally (Version 4) is like (Version 3), but here the variance of *changes* in the output gap is included instead of variance of output gap.

Unfortunately, no up-to-date estimates for α and β exist for Israel in Eq. 22. Segal (2007) considered a wide range of α between zero and 1.5 and an even larger range for β, between zero and 16. Benchimol (2022) calibrated α between zero and 1 but he assumed $\beta = 0$. We calibrate $\alpha = 0.5$ (middle of range from Segal (2007) and Benchimol (2022)), and $\beta = 6$ (relevant for Versions 1 and 2 of the loss function). Segal (2007) showed that for $\beta = 6$ (and $\alpha = 0.5$) the derived interest rate replicates quite well the actual interest rate in the sample 1999-2007, and this result is robust for any $\beta < 16$ and $0 < \alpha < 1.5$.

Table 2: The loss of the CB under Cases 1 and 2

Loss	Case 1:FI	Case 2: PI	Ratio
Version 1	0.08	0.24	3.12
Version 2	0.26	0.56	2.18
Version 3	0.25	0.28	1.13
Version 4	0.43	0.60	1.40

$$\begin{aligned} &\text{Version 1:} \quad var(\pi_t - \pi) + \alpha \cdot var(\hat{y}_t) \\ &\text{Version 2:} \quad var(\pi_t - \pi) + \alpha \cdot var(\Delta y_t - g_t^n) \\ &\text{Version 3:} \quad var(\pi_t - \pi) + \alpha \cdot var(\hat{y}_t) + \beta \cdot var(\Delta i_t) \\ &\text{Version 4:} \quad var(\pi_t - \pi) + \alpha \cdot var(\Delta y_t - g_t^n) + \beta \cdot var(\Delta i_t) \end{aligned} \tag{22}$$

Table 2 reports the calculation of the loss function under the "FI" and "PI" rules and the ratio between them. The loss function was calculated by assuming moderate aversion of households to debt, that is, the parameter v is equal to 0.64 (middle of range in Table 2). It can be seen that under all versions of the loss function, under "PI" rule the loss is always larger (the ratio lies between 1.13-3.12). The ratio under Versions 3-4 is lower than under Versions 1-2, so the "FI" is less beneficial that the "PI". The reason for that result is that under Versions 3-4 the change of the BOI interest rate is also included into the loss function. Although the "FI" policy rule is more efficient in stabilizing inflation and real activity, the BOI interest rate is more volatile because it reacts to correct but more volatile NRI (see Eq. 5 versus Eq. 20).

6 Conclusions

There is still an open debate in the literature concerning the question of whether central banks should react to financial variables, like spread or credit, and if and how macroprudential policy can prevent future crises. We built an empirical model for Israel which incorporates the credit market of households, aiming to analyze the impacts of monetary policy and macroprudential policy.

Investigating the stylized facts of Israeli households' credit market, we find that the relationship between the credit spread and the debt leverage is positive, but seems to be weak. This is reflected in low elasticity of spread to LTV and to debt-GDP ratio. The upward continuous trend in the LTV and in the debt-to-GDP ratio observed in recent years in Israel probably indicate that the costs of borrowing are not high enough to mitigate this trend. Another important fact is that the households in Israel hold only domestic debt (the foreign debt is negligible).

Relying on this empirical evidence, we specify and calibrate a semi-structural DSGE model for the Israeli economy with household's credit market. As mentioned, since the households cannot borrow from abroad, the credit spread is determined only by the domestic financial intermediares, and also may be affected by macroprudential policy. If higher debt does not increase the costs of borrowing very much, households have an incentive to keep increasing their debt further. This boosts a probability of default in the future and may have disastrous effects on the economy if default materializes. Thus, in our model macroprudential policy aims to mitigate excess borrowing by imposing regulations on the financial intermediares. Such measures are eventually translated into a higher elasticity of credit spread to credit leverage, mitigating incentive to borrow. The effectiveness of this policy depends also on the degree of aversion of households to high debt, since if households are conservative, they internally will not over-borrow, and the policy effectiveness will be low. But if households have low degree of aversion to high debt, such that they barely internalize the effects of their borrowing decisions on credit spread and therefore face a low effective interest rate in consumption decision, they may seek to increase their borrowing very much. In this case macroprudential policy is crucial and also effective. However, the direct cost of mitigating excess borrowing is reflected in shrinking of real activity.

Analyzing the model, we provide the following findings. First, if monetary policy does not react to credit spread, but reacts only to standard variables, such as inflation and output gap, it loses the effectiveness to achieve its main goals, which are stabilizing inflation and real activity. Effectiveness deteriorates even more, if the central bank completely ignores developments in the credit market, which can be induced, for example, by shocks in preference of the borrowers. Second, as macroprudential policy may increase the elasticity of credit spread to households' leverage, it can mitigate or even prevent over-borrowing and reduce deleveraging crises risk. In addition, in case of demand weakness, and deleveraging, this policy may contribute to expansionary efforts, due to corresponding reduction in credit spread.

This paper focuses on the qualitative analysis of a model with households' credit and policy implications, adjusted for the Israeli economy. Even though the model has been adjusted and calibrated to fit the Israeli data, its purpose is to give qualitative reasonable conclusions. However, we leave for future work the model estimation which can be useful to more adequately examine the impact of financial frictions of forecasting performance. Estimation also can be useful also in analyzing historical decomposition of shocks, scenario analyses, and qualitative stress tests of the credit market. Furthermore, one can expand the empirical analysis using time series methods (such as VAR, Local Projections) or using loan level data (mortgage database). Lastly, the model can be analyzed in the presense of the effective lower bound of the policy interest rate, where in this case we may get much higher amplification due to the limitation of the monetary policy to mitigate demand shocks (we analyzed this case but did not put it in here). This topic is discussed in Benigno et al. (2020) and Cohen (2022) among others.

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Part I
Appendix

A Empirical evidence of financial friction in the mortgage market in Israel

As discussed in 3.2.1, here we will validate empirically our assumption in the model that there is a financial friction in the mortgage market in Israel, which is reflected in a positive relationship between the interest rate spread and the leverage ratio. We apply three tests to validate the positive relationship mentioned above.

A.1 Test 1

In the first version of Eq. 18 explained in 3.2.1 we use a spread, $spread_t^H = r^{m\_w} - r^{10\_bond}$, where r^{m_w} is a weighted average (real) interest rate on mortgages[14] and r^{10_bond} is a real yield on government bonds for 10 years to maturity. In the second version we

[14]It is calculated by the Information and Statistics Department at the BOI. The calculation takes into account both interest rate on indexed and non-indexed mortgages and different maturities.

use a spread, $spread^H_t = r^m - r^{bank}$, where r^m is a fixed real interest rate on mortgages and r^{bank} is a real yield on bonds of commercial banks. In the last version we use a spread,$spread^H_t = i^m - i^{bank}$, where i^m is a fixed nominal interest rate on mortgages and i^{bank} is a nominal yield on bonds of commercial banks. The estimation results are shown below:

Version 1:[15]

$$\begin{aligned} spread^H_t &= \underset{(0.00)}{-5.89} + \underset{(0.00)}{0.07}\,Lev^H_t - \underset{(0.00)}{0.16}\,\pi^H_t - \underset{(0.15)}{0.06}\,\pi^H_{t-1} - \underset{(0.06)}{0.07}\,\pi^H_{t-2} - \underset{(0.10)}{0.06}\,\pi^H_{t-3}, \\ R^2 &= 0.74,\ DW = 0.59 \end{aligned} \tag{A.1}$$

Version 2:

$$\begin{aligned} spread^H_t &= \underset{(0.00)}{-11.15} + \underset{(0.00)}{0.13}\,Lev^H_t + \underset{(0.92)}{0.005}\pi^H_t - \underset{(0.13)}{0.08}\,\pi^H_{t-1} - \underset{(0.23)}{0.05}\,\pi^H_{t-2} \underset{(0.61)}{+0.03}\,\pi^H_{t-3}, \\ R^2 &= 0.66,\ DW = 0.36 \end{aligned} \tag{A.2}$$

Version 3:

$$\begin{aligned} spread^H_t &= \underset{(0.06)}{-3.13} + \underset{(0.00)}{0.05}\,Lev^H_t - \underset{(0.15)}{0.10}\,\pi^H_t - \underset{(0.66)}{0.02}\,\pi^H_{t-1} - \underset{(0.08)}{0.10}\,\pi^H_{t-2} \underset{(0.39)}{+0.09}\,\pi^H_{t-3}, \\ R^2 &= 0.31,\ DW = 0.30 \end{aligned} \tag{A.3}$$

We can see from Eq's A.1–A.3 that the effect of the leverage ratio on various spreads lies between 0.05 to 0.13 and is always highly significant. As expected, the collateral effect of home prices, $\pi^H_t ... \pi^H_{t-3}$, on the spread is negative (and significant) in most cases.

As we mentioned previously, the estimated parameter β can be upward biased because macroprudential steps applied during the sample period could increase the elasticity of spread to leverage. To see how the basic parameter β changes, we add to the regression additional explanatory variable $\gamma Lev^H_t \cdot dum_t$, where dum_t is a dummy variable capturing the macroprudential measures. Under this specification the elasticity of the spread to the leverage is $\beta + \gamma \cdot dum_t$. We consider three types of variable dum_t (all of them are taken from Benchimol et al. (2022)). The first type of the dummy variables is in a form of 'steps', so when a new macroprudential measure was implemented in

[15]The reported p-values in all equations of Appendix A are based on the S.E. of the parameters corrected by the Newey-West methodology.

the credit housing market, the new 'step' in the dummy variable is added. The second type of the dummy variable is based on the same macroprudential measures as before, but now the dummy receives 1 when a new measure was implemented in some quarter and 0 otherwise. This dummy is less reasonable and barely significant in estimation, because it assumes only very transitory effect on the elasticity and the spread. The third type of the dummy variable is based on general macroprudential measurers constructed by Benchimol et al. (2022). We obtain that for all three versions of the dummy variable the parameter γ is positive but it is significant only for the first dummy, which to some extent validates our concern of upward bias of β. Most importantly, we find no evidence that inclusion of $\gamma Lev_t^H \cdot dum_t$ wipes out the parameter β. It is still positive and indeed smaller in some cases than in the original estimation.

A.2 Test 2

Now we use an alternative measure of the leverage ratio $\overline{Lev}_t^H = \frac{B_t^{H\_new}}{Y_t}$, where $B_t^{H\_new}$ is a volume of new mortgages in quarter t (instead of stock of mortgages) and Y_t is a GDP (with seasonal adjustment) in quarter t (sample 2004Q1-2021Q3):

$$spread_t^H = c + \beta \overline{Lev}_t^H + \alpha_0 \pi_t^H + \alpha_1 \pi_{t-1}^H + \alpha_2 \pi_{t-2}^H + \alpha_3 \pi_{t-3}^H \tag{A.4}$$

The estimation results of three versions of spread measure are shown below.

Version 1:

$$\begin{aligned} spread_t^H &= \underset{(0.03)}{-0.84} + \underset{(0.00)}{0.47}\,\overline{Lev}_t^H - \underset{(0.00)}{0.32}\,\pi_t^H - \underset{(0.00)}{0.11}\,\pi_{t-1}^H - \underset{(0.07)}{0.08}\,\pi_{t-2}^H - \underset{(0.01)}{0.10}\,\pi_{t-3}^H, \\ R^2 &= 0.66,\ DW = 0.78 \end{aligned} \tag{A.5}$$

Version 2:

$$\begin{aligned} spread_t^H &= \underset{(0.00)}{-1.76} + \underset{(0.00)}{0.88}\,\overline{Lev}_t^H - \underset{(0.00)}{0.30}\,\pi_t^H - \underset{(0.00)}{0.19}\,\pi_{t-1}^H - \underset{(0.29)}{0.07}\,\pi_{t-2}^H - \underset{(0.49)}{0.05}\,\pi_{t-3}^H, \\ R^2 &= 0.52,\ DW = 0.46 \end{aligned} \tag{A.6}$$

Version 3:

$$\begin{aligned} spread_t^H &= \underset{(0.67)}{0.26} + \underset{(0.00)}{0.39}\,\overline{Lev}_t^H - \underset{(0.00)}{0.23}\,\pi_t^H - \underset{(0.17)}{0.07}\,\pi_{t-1}^H - \underset{(0.08)}{0.11}\,\pi_{t-2}^H + \underset{(0.52)}{0.06}\,\pi_{t-3}^H, \\ R^2 &= 0.32,\ DW = 0.41 \end{aligned} \tag{A.7}$$

We see from Eq's (A.5)-(A.7) that the effect on new loans to GDP is much higher than in Test 1 as expected. The collateral effect of home prices on spreads is still at place.

A.3 Test 3

We also tested the relationship between the mortgage interest rate and LTV ratio, where $LTV_t = \frac{B_t^{H\_new}}{P_t^H}$ ($B_t^{H\_new}$ is a volume of new mortgages, P_t^H is a home price). We compared the average nominal (and real) interest rate of loans with LTV of 30-45%, 45-60% and 60-75% in sample 2011M7-2021M11. We found that the average nominal (and real) interest rate of loans with LTV of 45-60% is higher by 0.3 p.p. compared to the loans with LTV of 45-60% and a similar gap exists between the LTV of 60-75% and LTV of 45-60%. That means, broadly speaking, that increase in LTV by 15% increases the interest rate by 0.3 p.p., implying elasticity of the mortgage interest rate with respect to LTV of about 0.02. We notice, however, that higher LTV is associated with longer maturity of loans in the data, therefore it could be that the higher maturity induces higher interest rates and not necessarily higher LTV. We assert, however, that higher maturity is also a part of the risk for the banks (lenders) because higher maturity increases a probability of default of the borrowers during the maturity period.[16] In summary, it is unimportant for our purposes to identify whether higher interest rate is due to higher LTV or due to higher maturity. Both factors reflect risk of the borrowers and therefore induce a positive relationship between interest rate and risk factors, which is a heart of financial friction we consider in our paper.

B Deriving elasticity for our model

The last step is to translate the estimated elasticity in the mortgage market to elasticity in terms of total debt of the households which contains both mortgages and non-mortgage credit. For that we need to examine spread-leverage ratio in non-mortgage credit market as well. Unfortunately no reliable examination is feasible since the data is very limited. We adopt a conservative approach and assume that the spread-leverage relationship in

[16]Clearly, say, an NIS 1 million loan for 10 years is riskier than the same loan for 1 year, given the same leverage ratio of the borrower.

non-mortgage credit market is close to null. For the housing market we use elasticity from Eq. A.1 which is most suitable to our model.

Notice that by definition the total debt is a sum of a mortgage and non-mortgage debt

$$B_t = B_t^H + B_t^{N\_H} \tag{B.8}$$

The interest rate payment on the total debt is a sum of interest rate payments of mortgage and non-mortgage debt

$$(R_t + spread_t)B_t = (R_t + spread_t^H)B_t^H + (R_t + spread_t^{N\_H})B_t^{N\_H} \tag{B.9}$$

where R_t is a riskless interest rate, $spread_t$ is a spread on total credit, $spread_t^H$ is a spread on mortgage credit and $spread_t^{N\_H}$ is a spread on non-mortgage credit. Exploiting Eq's B.8 and B.9 we get

$$spread_t = spread_t^H \frac{B_t^H}{B_t} + spread_t^{N\_H} \frac{B_t^{N\_H}}{B_t}$$

Using the fact that in Israel a weight of mortgages in total credit of households is 2/3, and assuming elasticity from Eq. A.1 we rewrite the previous equation

$$spread_t = (spread^H + \underbrace{\beta^H}_{0.07} \tilde{Lev_t^H}) \underbrace{\frac{B_t^H}{B_t}}_{2/3} + (spread^{N\_H} + \underbrace{\beta^{N\_H}}_{\tilde{}0} \tilde{Lev_t^{N\_H}}) \underbrace{\frac{B_t^{N\_H}}{B_t}}_{1/3} \tag{B.10}$$

where $spread^H$ and $spread^H$ are SS values of spread on mortgage credit and non-mortgage credit, respectively. $\tilde{Lev_t^H}$ is a deviation of spread on mortgage credit from its SS value. After some simplification on Eq. B.10 we get

$$spread_t = \frac{2}{3}(spread^H + 0.07\tilde{Lev_t^H}) + \frac{1}{3}(spread^{N\_H}) \tag{B.11}$$

Note that

$$Lev_t^H = \frac{B_t^H}{Y_t}\frac{B_t}{B_t} = \frac{2}{3}Lev_t$$

where $Lev_t = \frac{B_t}{Y_t}$. Therefore the following condition also holds (since in SS, $Lev^H = \frac{2}{3}Lev$)

$$\tilde{Lev_t^H} = \frac{2}{3}\tilde{Lev_t} \tag{B.12}$$

Substituting Eq. B.12 into Eq. B.11 we get

$$spread_t = \frac{2}{3}(spread^H + 0.07(\frac{2}{3})\tilde{Lev_t}) + \frac{1}{3}(spread^{N\_H})$$

From Eq. B.10 we see that in SS, $spread = \frac{2}{3}(spread^H) + \frac{1}{3}(spread^{N\_H})$, therefore

$$spread_t = spread + 0.07(\frac{2}{3})^2\tilde{Lev_t}$$

Finally, we obtain the relationship between the interest rate spread gap and leverage gap as appears in the model.

$$\tilde{spread_t} = 0.031\tilde{Lev_t} \tag{B.13}$$

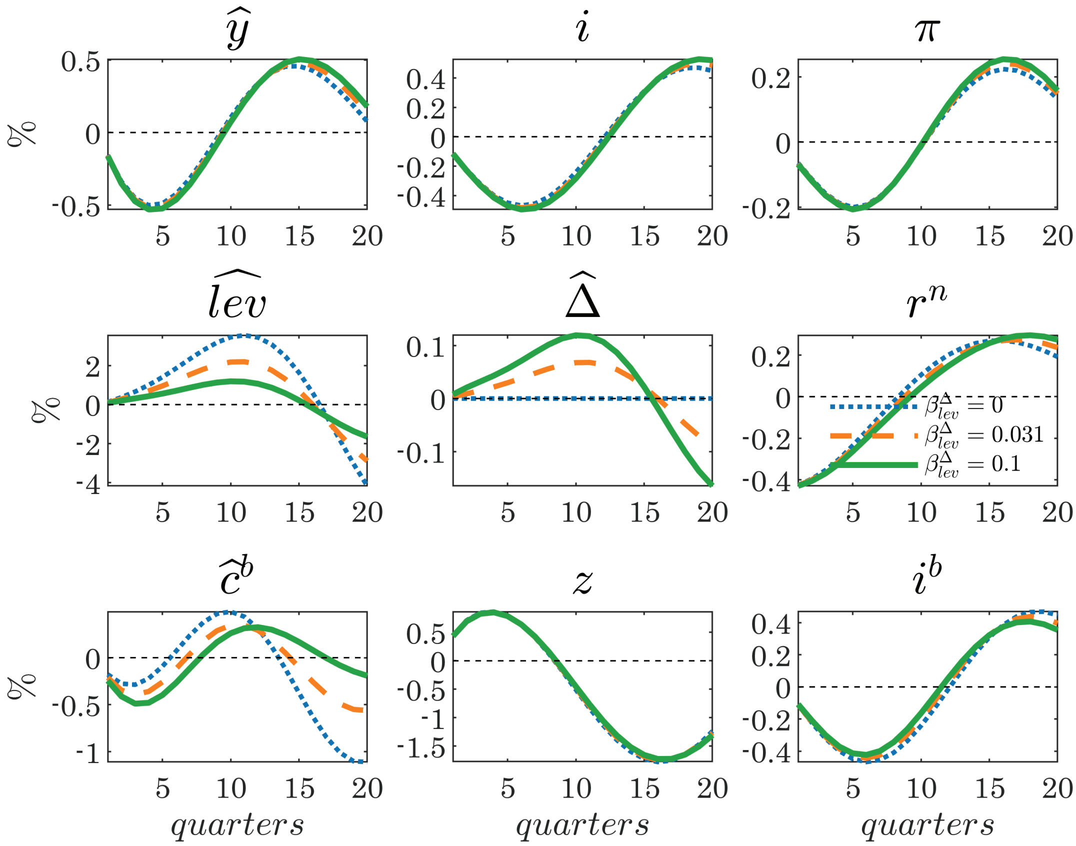
C Foreign shock IRF

Foreign monetary shock see Fig. 11.

D IRF under Financial Accelerator Calibration

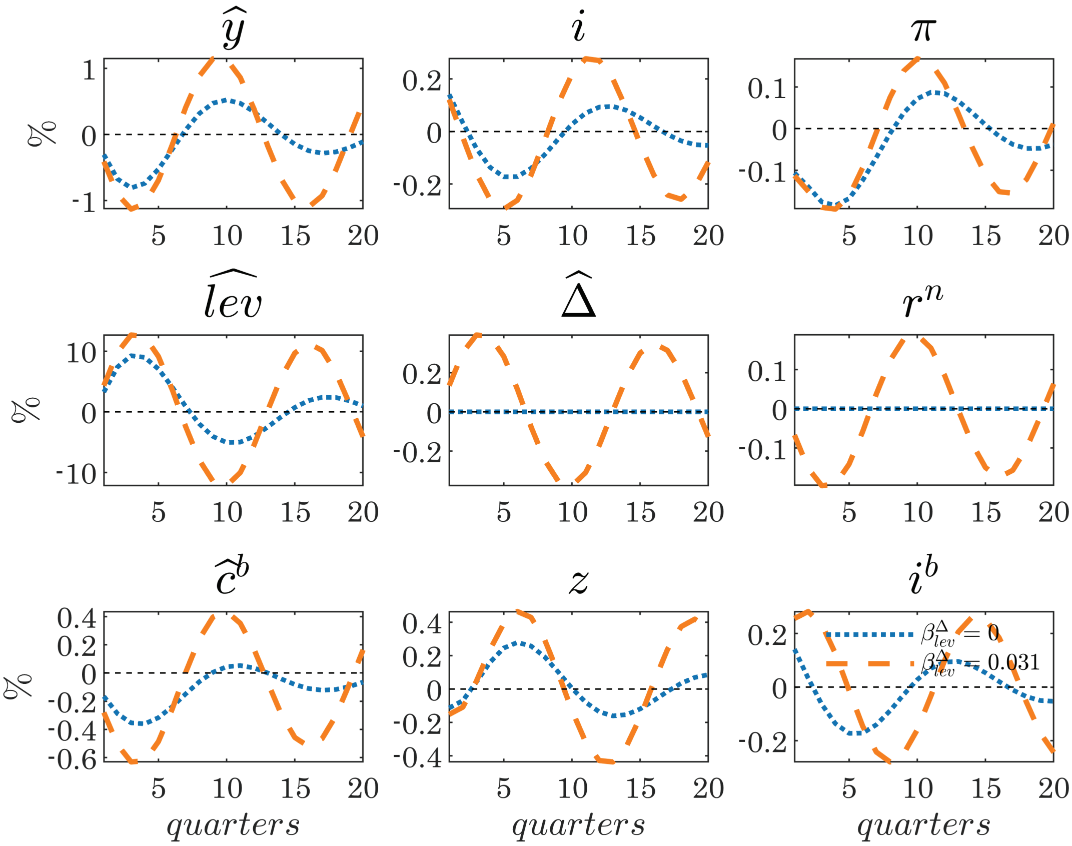
As can be seen in Fig. 12 it is possible to have financial accelerator dynamic under some model calibration. This includes calibration of the elasticity of the output gap to NRI: $\beta_r^y = -0.5$ (see Eq. 4), which is in the upper range of several estimates of this parameter exists for Israel. But we also need to calibrate $\beta_r^{c^b} = 0.2$ (instead of 5) which is much smaller from any value acceptable for Israel economy (economically meaning that the consumption of the borrowers is less sensitive to the interest rate than the lenders, in opposite to Cúrdia and Woodford (2016)). In summery, the model may give a financial acelerator dynamic, but not for a reasonable parameters for Israel.

Figure 11: IRF to positive shock to foreign monetary policy of 1 SE



Notes: Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). Green line: represents the case with macroprudential policy. (elasticity of spread to leverage is 0.1). All simulations are under specification of low borowers' aversion to leverage, v=0.0225

Figure 12: IRF to positive shock to monetary policy of 1 SE



Notes: Variables as deviation from steady state: output gap, inflation, interest rate, leverage, credit spread, borowers consumption, real exchange rate and borowers' interest rate. Blue dotted line: represents the case without financial friction. Orange line: represents the baseline case with financial friction, but without macroprudential policy (Elasticity of spread to leverage is 0.031). All simulations are under specification of low borowers' aversion to leverage, v=0.0225