Research Proposal

Role of Banking Sector in Defining Liquidity and Structure of Ukrainian Government Debt Market

Financial Intermediation and General Equilibrium

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Contents

Research Proposal ................................................................. 1
  1.1 Introduction .............................................................. 1
  1.2 Objectives ............................................................... 2
  1.3 Practical contribution of the research ............................. 3
    1.3.1 Investment banking and underwriting: the mechanism of financial
          intermediation ....................................................... 3
    1.3.2 Primary and secondary market dealership in Ukraine and the world .... 4
  1.4 Hypothesis ............................................................... 6
  1.5 Literature review ........................................................ 8
  1.6 Methodology ............................................................ 10
    1.6.1 Theoretical model: Savings-investment intermediation model ............ 10
    1.6.2 Government ......................................................... 13
    1.6.3 Estimation and empirical testing .................................. 14
    1.6.4 Data ............................................................... 14
    1.6.5 Expected research output .......................................... 15

References ................................................................. 17

A The structure of the investment banking industry ................. 22

B Trading Strategy ........................................................... 23
C Theoretical model: Savings-investment intermediation model .... 24
  C.0.6 Consumer problem ........................................... 24
  C.0.7 Bank profit optimization problem ................................ 27

D Estimation and empirical testing ........................................ 31

E Participants and Project Timetable ....................................... 34
  E.1 Participants .......................................................... 34
  E.2 Alternative/additional sources of funding ............................ 34
  E.3 Project timetable ...................................................... 34
Research Proposal

1.1 Introduction

Ukrainian market for government domestic bonds has been traditionally underdeveloped with very low liquidity. Both primary and secondary markets for government debt trading activity remains weak with only few key players as for example, Ukrainian Exchange, representing the role of financial intermediary.

The low liquidity in the market for government bonds and lack of efficient financial intermediation or investment banks has a negative impact on the development of Ukrainian stock exchange and on economic environment in general. The cost of domestic borrowings incorporates high risk premia due to the low liquidity that makes the placement of bonds in the primary market more expensive. Besides, lack of risk-free state security in hryvnia creates portfolio diversification problems for banks, insurance companies and suspend the development of private pension funds.

At the same time, illiquid domestic bond markets can hinder the adoption of flexible exchange rate system that in its turn suspends the implementation of an active monetary policy. Therefore, illiquid and inefficient government bonds market in Ukraine creates obstacles for the development of the banking system and creates substantial borrowings constrains for the government.

Models with financial market frictions, such as borrowing constraints or limited insurance are not widely used for macro policy analysis. The recent financial crisis starting in the fall of 2007 demonstrated that financial intermediaries play a critical role in economic activity. Such models would provide their users with explicit guidance about appropriate interventions into financial markets. The innovation of the suggested research is at least two-dimensional. First of all, it suggests the new general equilibrium theoretical model that contains the primary and secondary market dealerships for the government debt. Second, the model will be calibrated for the latest decade Ukrainian financial and real sector
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Table 1.1. Secondary Market Turnover of Domestic Government Bonds in Selected Countries

Data. Finally, the cost structure of the Ukrainian government debt market is revealed on the basis of the empirical evaluation of the model that allows to develop appropriate policy recommendations.

1.2 Objectives

The underdeveloped and illiquid government bond market in Ukraine rises the cost of the financial services for investors, creates impediments for the development of the banking sector, hinders the development of the stock exchange with the respective development and diversification of financial instruments, prevents the implementation of the flexible exchange rate regime and consequently the active monetary policy and rises the cost of the government borrowings that has a negative impact on the economic development.

Table 1.1 provides an overview of the market for Ukraine and few Central and Eastern European Countries. In 2011, the yearly secondary market turnover of domestic government bonds in Ukraine was only 7.7 % of GDP, compared to 22.5% in Romania (in 2004) and 156.7% in Hungary (in 2006).

The proposed research is aimed at identifying the key pitfalls of Ukrainian investment banking structure that creates problems for the bond market liquidity and size and increases the cost of government debt. The proposed theoretical general equilibrium model that
incorporates the cost of financial intermediation will be tested with Ukrainian historical data. The relevant policy recommendations will follow.

1.3 Practical contribution of the research

1.3.1 Investment banking and underwriting: the mechanism of financial intermediation

Raising funds by the company or the government is conducted via issuing and selling new securities, such as stocks or bonds. Direct sale of the securities to the public is in general more costly than using the investment bank; therefore, investment banks are usually involved into the debt issuing process by the corporation or the government. The key role of the investment bank is connecting the need for money with the source of money.

An investment bank helps an organization, which may be a company, or a government or one of its agencies, in the issuance and sale of new securities. It is usually a division of a brokerage firm, because many of their activities are related (see Appendix A). If the investment bank and company reach an agreement to do an underwriting and the investment bank buys the new securities at an agreed price, and then resells the securities to the public at a mark-up that includes all the expenses associated with the sale. With the mechanism of underwriting the investment bank becomes a broker-dealer, or market maker, in the new security and the company that issued the security in its turn gets the guaranteed funds even if the investment bank does not sell all of the securities. Therefore, the investment bank takes a significant risk in a debt commitment and might incur the losses in case it does not sell the underwritten security.

The profit of the investment bank is generated from selling the new securities at a mark-up from what they paid for it, known as the underwriting discount, or underwriting spread. The underwriting discount is set by bidding and negotiation, but is influenced by the size of the new issue, whether it is stocks or bonds, and the perceived difficulty of selling the new issue, with more speculative issues requiring a larger underwriting spread
for the increased risk. The amount of spread varies widely, depending on the size of the issue, the financial strength of the issuer, the type of security involved (stock, bonds, rights), the status of the security (senior, junior, secured, unsecured), and the type of commitment made by the investment bankers. The range may be from a fraction of 1% for a bond issue of a big utility company to 25% for the Initial Public Offering of a small company.

The underwriting firm or, in other words, the primary dealer frequently becomes a market maker in the new security, keeping an inventory and providing a firm bid and offer price for the new security to provide a secondary market so that investors can buy or sell the new securities after the primary sale. Providing liquidity for investors increases the value of the primary offering, since few investors would buy the new security if they couldn’t sell it at will.

1.3.2 Primary and secondary market dealership in Ukraine and the world

The investment banking in Ukraine is underdeveloped both on the primary and secondary (retail) levels of dealership. There is no legislation that clearly establishes the primary market state debt underwriting procedure that negatively affects the state and size of secondary market operations. While the primary dealers underwrite the new issued debt as a wholesale purchase, the secondary market deals mainly with retail private investors who are willing to invest at smaller size at usually lower interest rate thus higher then primary market wholesale price.

In the last decades primary underwriters have become a popular institution worldwide. By 2006, more than 40 countries already established such a system, with the number growing constantly. Primary dealers for government debt exist in different countries with the number of them varying from a low 5 (for example, Mexico, Mauritius, Slovenia) to more than 20 (for example, Czech Republic, Korea, Brazil). In the developed countries such as, for example, United States, primary dealership has existed for almost a century. In

the US government debt had to be fully financed but local citizens from 1917 through both higher taxes and purchases of war bonds.

The so called ‘Liberty bonds’ were sold at subscription where officials created coupon price and then sold it at par value. In the late-1920’s the situation of constant undervaluation of the government debt ended up in the reselling of the purchased government debt instruments to another market participant at a higher price. This could be called the first prototype of the nowadays primary and secondary market operations.²

The primary market underwriters create certain advantages for the financial sector such as:

- Increased liquidity and lower cost of debt.
- Better placement of the domestic debt.
- More facilitated open market operations.
- Improved dialogue between the government sector and financial sector.
- Higher transparency of the financial system.

The well developed and liquid government debt market will play the following roles both in Ukrainian domestic and international financial markets:

- Benchmarks for pricing and quotation in domestic and international bond markets.
- Important component of global bond indexes used by portfolio managers.
- Major instrument for hedging fixed-income positions in Ukrainian hryvnia and international markets.

- Collateral for domestic and international financial transactions.
- Main tool for liquidity management by private sector, especially by banks.
- Large share of foreign exchange reserves held by other governments.
- Main monetary intervention vehicle used by the National Bank of Ukraine.
- Domestic and international safe-haven.

I develop and calibrate with Ukrainian data the new general equilibrium model, where investment bank that underwrites government debt plays the role of financial intermediary. Such financial intermediation approach would allow to analyze the economic determinants

and the role of investment bank, its productivity level and the behavior of the underwriting spread itself that is the bank’s fee for providing its underwriting service. Effectively, the investment bank provides the liquidity for the newly issued government debt, thus the underwriting spread is the direct costs for the issuer, which is inversely related to the quality of the issued securities. As soon as the role of the investment bank in Ukrainian case is not explicitly outlined, the appropriate data proxies will be used to evaluate the cost of state securities transactions as well as primary and secondary market yields.

1.4 Hypothesis

The current dynamic stochastic general equilibrium is set up in a way of Gillman and Kejak (2010) and Gillman (2010) when the credit is extended to intertemporal credit. I assume that the government has an access to the financial intermediary’s intertemporally produced credit, from which it can borrow at the specific interest rate that incorporates the cost of the financial transaction incurred by the financial intermediary or the prototype of the financial intermediary as in the case of Ukraine. The key difference with previous general equilibrium literature is that consumer can buy government bonds only through the intermediary (bank) that underwrites the sovereign debt.

The underwriting spread derived from the financial decentralization model incorporates the cost of the credit production by the bank to the government and proportional to the ratio of shadow cost of banking to the marginal return of banking.

For the purpose of testing the theoretical prediction of the general equilibrium model I use data series for Ukraine of 2000-2010 (upon the availability) and attempt to explain the behavior of the investment banking and government debt market activity of Ukrainian economy. Primary and secondary market government bond yields data would allow to analyze the behavior of the gross spreads and the fundamentals during the sub-prime mortgage crisis of 2007.

Though some data series are not expected to be continuous, it is still possible to find good proxies for the purpose of current analysis that is discussed further in more details.
The **main hypothesis** that will be tested within the proposed model is:

*Out of the three underlying shocks of the model that are the total factor productivity shock, banking technology shock and government expenditure shock, what is the main contributor to the cost of banking technology or, in other words, to the gross spread that is directly linked to the financial market solvency and liquidity.*

**The expected result:**

*Most probably low level of banking technology along with low total factor productivity are the two key contributors to the inefficient and illiquid structure of Ukrainian government debt market.*

**The policy recommendations** follow:

- Banking sector and, in particular, the investment banking sector must be further developed and become more competitive.

- The particular attention must be paid to the development of primary and secondary market dealership as well as to the procedure of underwriting that will substantially reduce the cost of banking.

- The underwriting procedure of the primary issued debt should be properly worked out and well documented with the appropriate legislation.

- The government should issue more diversified short-terms borrowing instruments that will secure the guarantees to the domestic investors, attract more cash into the economy, stimulate the economic development and will make government expenditure policy more transparent.

- Development of the ‘plain vanilla’ borrowing instruments will stimulate the development of the Ukrainian stock market, would allow for more diversified portfolio structures, reduce the exchange rate risks and will make domestic monetary policy more proactive.
1.5 Literature review

There are two strands of literature involved. First one relates to the state of Ukrainian financial market and banking sector. The second one serves as theoretical background for the development of general equilibrium model with the primary and secondary market dealers and financial market frictions.

On the Ukrainian side Trebesch, Giucci and Kravchuk (2007) analyze the situation of the Ukrainian government debt market and claim that it exhibits only limited liquidity. This lack of liquidity reduces demand and increases the cost of local borrowing for the government that creates serious problems for the economy and especially for the financial industry. They develop policy recommendations for primary dealer system and advise on the procedure of underwriting of the newly issued debt. Giucci, Kirchner and de la Rubia (2009) review the international experience of the retail debt dealership and comment on the legislation adopted by the Cabinet of Ministers in Ukraine. They advocate that retail bonds can decrease funding costs and stabilize the funding basis. In particular, they can reduce the dependency from foreign investors and lessen the vulnerability to exchange rate fluctuations and contribute towards developing capital markets.

The development of the general equilibrium literature that outlines the banking sector role has been a slow process over time. Hicks (1935) mentions the banking sector role while making his suggestions for the simplifying theory of money. He considers bank as a safe investments that act as a substitute for money, and therefore diminish the demand for money. The banking credit creation acts as a measure of restoration the liquidity position of the lenders that has been affected by the expansionary affect of the loan. Pesek and Saving (1968) further develop the idea of the banking role in macroeconomics. They reject the conventional wisdom and deny that deposits embody liability characteristics. By so doing, they advanced the earlier attempts in the literature to offset the elementary fallacies of balance-sheet (Patinkin (1965), Gurley and Shaw (1960), and Leijonhufvud (1968)) and provide a direct and explicit basis for recognizing that bank-money issue adds to net wealth. The distinguishing feature of Pesek and Saving is their boldness in attacking the central accounting paradigm. The financial intermediation approach to banking was
suggested by Sealey and Lindley (1977), which views the bank as employing labor, physical capital, and borrowed funds to produce earning assets and most commonly used in the conventional bank cost function literature. From the latest literature on the financial intermediation Goodfriend and McCallum (2007) reconsider the role of money and banking in monetary policy analysis by including a banking sector and money in an optimizing model. Using production function for credit use in exchange they calibrate the model for US data and provide endogenous explanation for different types of interest differentials.

Models with financial market frictions, such as borrowing constraints or limited insurance are not widely used for macro policy analysis. This practice should change. The recent financial crisis starting in the fall of 2007 demonstrated that financial intermediaries play a critical role in economic activity. Adverse banking sector shocks increase the borrowing costs, reduce their net worth, resulting in a widening of spreads in the credit market (Hirakata et al. (2010)). From August 2007 through late 2008, credit markets tightened (in the sense that spreads spiked and trading volume fell). These changes led - at least in a statistical sense - to sharp declines in output. As it was recently argued by Kocherlakota (2010) understanding these changes in spreads and their connection to output declines can only be done via models with financial market frictions. Such models would provide their users with explicit guidance about appropriate interventions into financial markets.

The general macroeconomic theory suggests that bond yields can tell very good story about the economy so do the spreads. Government securities are free from corporate risks and, therefore, has long been considered to be very good predictor of the state of the economy. Recent post-2007 crisis literature proves that underwriting spreads can be a very good predictor of the economic trends. Parra (2008) argues that underwriting spreads of the government securities can be a good predictor of the sovereign debt crisis. Indeed the investment banks tend to price the risk well before the crisis and before investors and charge higher underwriting spreads to the countries presenting default vulnerabilities. The major policy implication of this finding is that underwriting spreads should be closely followed by policy makers and actors of the capital markets. In the earlier empirical studies (Altman (1998), Sy (2004), Pescatori and Sy (2007)) sovereign bond spreads could be employed as
an indicator of sovereign bond crises. By contrast, at the entry of the crisis, underwriting spread increases and the sovereign bond spreads decrease.

As it is suggested in the financial literature (e.g. Kim, Palia, and Saunders (2003)) government bonds price is dependent on the government bonds market movements and it responds promptly to economic changes. For example, in the US Treasury Bills prices are determined by Treasury Bills actions and also by the secondary market.

The current dynamic stochastic general equilibrium uses the framework and assumptions of the models that contain the financial intermediary and explicitly derive the cost of banking suggested by Gillman and Kejak (2010) and Gillman (2010) when the credit is extended to intertemporal credit.

1.6 Methodology

1.6.1 Theoretical model: Savings-investment intermediation model

Consumer problem

Financial intermediary is needed when consumer cannot directly invest savings into capital Gillman (2010). In this case consumer cannot directly invest into sovereign debt market due to the underwriting procedure and risks of the bank been undertaken while buying government bonds.

The utility function with non-separable preferences in consumption has the general form:

$$E_o \sum_{t=0}^{\infty} \beta^t \frac{(c_t x_t^\varphi)^{1-\theta}}{1-\theta}$$  \hspace{1cm} (1.1)

Consumer owns the bank, therefore, the dividend income $R^d_t d_t$ is added to the labour income, and the net increase invested in deposits at the bank, of $d_{t+1} - d_t$, is the investment subtracted from the income. Agent supplies labour to both goods sector producer $l_G$ and to
the bank $l_B$. The government conducts annual transfers to the consumer in the form of the transfers $G_t$. Consumer also pays tax $\tau_c$ to the government.

Current income from labour, physical capital, dividends, money balances and government transfers is spent on consumption, new physical and financial capital formation $(1 + \gamma_d)i_t$ and the accumulation of real balances. The consumer’s budget constraint is given by:

$$c_t(1 + \tau_c) + i_t + \frac{M_{t+1}}{P_t} + d_{t+1} - d_t \leq w_t(1 - x_t) + d_t R^d_t + \frac{M_t}{P_t} + G_t + R^d_t k_t \quad (1.2)$$

The second constraint is the allocation of time constraint whereby time working in the goods and bank sector, plus leisure, equal the endowment of one:

$$l_{Bt} + l_{Gt} + x_t = 1 \quad (1.3)$$

Cash-in-advance constraint:

$$P_t c_t = M_t \quad (1.4)$$

The consumer chooses consumption, leisure, capital stock, investment, money and deposits $\{c_t, x_t, k_{t+1}, i_t, d_{t+1}, M_{t+1}\}$ to maximize lifetime utility 1.1 subject to the representative agent budget constraint 1.2, time constraint 1.3 and cash-in-advance constraint 1.4. See Appendix C for technical derivations.

The Euler equation takes the form:

$$\left\{ \frac{1}{\pi_t} U''_{ct} \right\} = \beta E_t \left\{ \frac{1}{\pi_{t+1}} U''_{ct+1} - \frac{R^d_{t+1} + Q_{t+1}[(1 - \delta_k) - (\phi'(\frac{i_{t+1}}{k_{t+1}}) - \phi''(\frac{i_{t+1}}{k_{t+1}})(\frac{i_{t+1}}{k_{t+1}}))]}{Q_t} \right\} \quad (1.5)$$

Where $U''_{ct} = (c_t x_t^\varphi)^{-\theta} x_t^\varphi$. Define function $Q_t[1 - \phi''(\frac{i_t}{k_t})] = 1$ that means that Tobin’s $Q$ is defined as: $Q_t = [1 - \phi''(\frac{i_t}{k_t})]^{-1}$.

The intra-temporal consumption-labour equation is:

$$\frac{\varphi c_t(1 + \tau_c + R^d_t)}{x_t} = w_t \quad (1.6)$$
Goods producer problem

The goods producer competitively hires labour and capital for use in its Cobb-Douglas CRS production function subject to technology shock $z_t$ to produce output $y_t$. Given $A_G \in (0, \infty), \alpha \in [0, 1]$,

$$y_t = A_Ge^{z_t}(k_t)^\alpha(l_{Gt})^{1-\alpha} \quad (1.7)$$

Technology shock follows the stochastic process:

$$z_t = \varphi_z z_{t-1} + \varepsilon_{zt}, \varepsilon_{zt} \sim N(0, \sigma_{\varepsilon z}^2), 0 < \varphi_z < 1 \quad (1.8)$$

The goods producer time $t$ profit, denoted by $\Pi_t$, with $R_t^q$ denoting the price of physical capital rented from the consumer who owns it, and $w_t$, real wage, is given by:

$$\Pi_t = A_Ge^{z_t}(k_t)^\alpha(l_{Gt})^{1-\alpha} - w_t l_{Gt} - (R_t^q + \delta_k)k_t \quad (1.9)$$

The goods producer maximization problem with respect to $k_t$ and $l_{Gt}$ is given by:

$$\max_{k_t, l_{Gt}} \Pi_t = A_Ge^{z_t}(k_t)^\alpha(l_{Gt})^{1-\alpha} - w_t l_{Gt} - (R_t^q + \delta_k)k_t \quad (1.10)$$

The marginal product of capital then just equals the interest rate $R_t^q$ plus the depreciation rate $\delta_k$:

$$R_t^q + \delta_k = \alpha A_Ge^{z_t}(\frac{l_{Gt}}{k_t})^{1-\alpha} \quad (1.11)$$

The marginal product of labour equals the real wage:

$$w_t = (1 - \alpha)A_Ge^{z_t}(\frac{k_t}{l_{Gt}})^\alpha \quad (1.12)$$

Bank profit optimization problem

The bank underwrites newly issued government real debt $b_{t+1}$ and receives back $(1 + R_t)b_t$ at time $t$ that is its source of the revenues. $R_t$ is the risk-free primary market real interest rate that is paid by the government on its borrowings. The bank uses savings deposits from the consumer $d_{t+1}$ and pays back $(1 + R_t^d)d_t$, where $R_t^d$ represents the interest
on the deposit or the residual profit per unit of deposits that the bank makes, leaving it with zero profit after the dividend payout. The interest paid on the deposits in the secondary market is smaller than the risk-free rate paid by the government to the financial intermediary $R_t^d < R_t$.

By investing into government bonds the financial intermediary produces credits to the government $b_t$.

To produce credit to the government bank uses a CRS credit production technology that involves labour $l_{Bt}$ and deposits $d_t$ as inputs. With $A_B \in (0, \infty)$ and $\gamma \in [0, 1]$ real government bond production function is given by:

$$b_t = A_B e^{u_t} (l_{Bt})^\gamma (d_t)^{1-\gamma}$$

(1.13)

Where banking technology shock, $v_t$, follows the stochastic process:

$$v_t = \varphi_v v_{t-1} + \varepsilon_{v_t} \varepsilon_{v_t}^{-\gamma} N(0, \sigma_v^2), \ 0 < \varphi_v < 1$$

(1.14)

See Appendix C for details. Optimization problem produce the following two equilibrium conditions for the underwriting spread 1.15 and marginal product of labour 1.16:

$$E_t(R_{t+1}) - E_t(R_{t+1}^d) = E_t\{x_{t+1}'(1 - (1 - \gamma) b_{t+1}^{d_t+1})\}$$

(1.15)

$$w_t = x_{t}' \gamma b_t$$

(1.16)

1.6.2 Government

It is assumed that government expenditure constitutes a constant share of GDP $\gamma_g$ (following Barro (1990), Turnovsky (2000) and Funke and Strulik (2006) who suggest that government spending is a constant fraction of income, rather than exogenous and independent of income):

$$G_t = (\gamma_g)^{u_t} y_t$$

(1.17)

Share $\gamma_g$ is subject to random shocks $u_t$, which follow the autoregressive process:

$$u_t = \varphi_u u_{t-1} + \varepsilon_{u_t} \varepsilon_{u_t}^{-\gamma} N(0, \sigma_u^2), \ 0 < \varphi_u < 1$$

(1.18)
Government expenditures are financed from the real government borrowings $b_{t+1} - b_t(1 + R_t)$ and consumption tax revenues $\tau_tC_t$. Nominal money balances change is endogenously defined by $M_{t+1} - M_t$.

The government budget constraint in nominal terms takes the form:

$$P_tG_t = P_tb_{t+1} - P_tb_t(1 + R_t) + M_{t+1} - M_t + P_t\tau c_t$$  \hspace{1cm} (1.19)

### 1.6.3 Estimation and empirical testing

#### Empirical evaluation

The empirical evaluation of the model is conducted on the basis of procedure suggested by Gillman, Kejak and Benk (2005), Benk, Gillman and Kejak (2008) and Ingram, Kocherlakota and Savin (1994). The procedure is developed in order to check for the robustness of the proposed DSGE model with the existing data. The three underlying shocks to TFP in the goods and banking sector and shock to government expenditure are constructed using this procedure and compared to their conventional counterparts that are derived on the basis of traditional estimation procedures. To get a deeper insight into the dynamic of the shocks I plot the extracted shocks against the traditionally derived counterparts. I also plot the derived shocks against the underwriting spread and trace the dynamics of those shocks against the behavior of the spread and analyze variance decomposition results. The technical description of the procedure of construction of shocks is provided in the Appendix D.

### 1.6.4 Data

The primary market short-term interest rates are available from the mentioned sources. There are few proxies for the secondary market government debt yields. I can use the over-the-counter interest rates, the deposit rate or, alternatively, repo rates.³

1.6.5 Expected research output

The expected research output can be summarized as following:

- The theoretical model will be calibrated for the Ukrainian latest decade data. The proposed theoretical model incorporates the recent theory of investment banking and general equilibrium financial intermediation literature to build up a convex structure of the banking cost function that is linked to the primary and secondary market government debt yields.

- The impulse responses functions will be produced and analyzed.

- On the basis of the theoretical model and empirical tests I will analyze the activity of government debt market and how it relates to the state of the economy in general and state of banking sector in particular.

³ Deposit rate refers to the amount of money paid out in interest by a bank or financial institution on cash deposits. Banks pay the deposit rate on savings and other investment accounts.

Accordingly Certificate of Deposit (CD) is a negotiable coupon bearing security issued by a bank, replicating an interest-bearing time deposit of fixed maturity with the flexibility and potential of secondary market trading.

For example, a Deposit Rate will often be paid for cash deposited into savings and Money Market accounts. Savings accounts earn a rather low rate of interest, but cash deposited in certain other account types are also paid a Deposit Rate by banks and financial institutions. In essence, the Deposit Rate is the interest rate that a bank pays the depositor for the use of their money for the time period that the money is on deposit.

A Repo Rate is the gain in price between the two trades in a repo transaction (i.e. the difference between the sale and repurchase prices) as an annualized percentage of the sale price.

If you regard the transaction as a secured loan and repayment secured against a security (which is the economic effect it has), the repo rate is the interest rate on the loan.
• Historical and variance decomposition results will show the key contributors to the financial market frictions.

• The proposed model is an attempt to built in the financial intermediation into the general equilibrium model and using Ukrainian data to link the activity of the banking sector to the aggregate macroeconomic variables.
References


Parra, S. (2008) 'Sovereign Debt Crises through the Prism of Primary Bond Markets’, Institut d’Etudes Politiques de Paris (SciencesPo Paris) and Research Associate, OECD Development Centre.


References


Appendix A
The structure of the investment banking industry

(source: www.thisMatter.com)
Appendix B
Trading Strategy
Appendix C
Theoretical model: Savings-investment intermediation model

C.0.6 Consumer problem

Financial intermediary is needed when consumer cannot directly invest savings into capital. Gillman (2010). In this case consumer cannot directly invest into sovereign debt market due to the underwriting procedure and risks of the bank been undertaken while buying government bonds. To invest in government bonds consumer deposits $d_t$ and receives a return $(1 + R^d_t)d_t$ where $R^d_t$ is the dividend return. I assume that consumer owns the bank so he or she receives dividend $R^d_t d_t$, that is profit of the bank.

Consumer has two investment opportunities: either he invests directly into physical capital or alternatively into sovereign debt through the financial intermediary (bank).\(^4\)

I assume that $\gamma_d$ is the share of investment put by the consumer into bank deposits.\(^5\)

Defining $i^d_t$ as an investment into deposits $i^d_t = \gamma_d i_t$. Total investment is equal to the sum of investments into two different assets: physical capital, $i_t$ and government bond, $i^d_t$ done through the bank.

Total consumer investment accumulation equation has the following shape:

$$(1 + \gamma_d)i_t = k_{t+1} - (1 - \delta_k)k_t + \phi(\frac{i^d_t}{k_t})k_t + d_{t+1} - d_t$$  \hspace{1cm} (C.1)

The representative agent’s discounted utility stream depends on the consumption of goods $c_t$ and leisure $x_t$; with $\beta = \frac{1}{1 + \rho}, \beta \in (0, 1)$ and relative risk aversion parameter

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\(^4\) In the previous literature (e.g. Gillman (2010)) investment formulation problem that involves a bank when all the bank loans are invested into firm’s capital and, therefore, change in the bank loan production is equal to investment $i_t = k_{t+1} - k_t = q_{t+1} - q_t$ and loans therefore, $k_t = q_t$ that under zero bank capital requirement all deposits are used for loans production in the deterministic case $d_t - q_t = 0$, that defines the interest differential $R^d_t - R^d_t$ is just determined by the labour costs.

\(^5\) In the ‘calibration’ section I provide the rationale behind the size of the share, $\gamma_d$ that investor puts into deposits.
\( \theta > 0; \) if \( \theta = 1 \) the utility function transforms to a logarithmic utility function. \( \varphi \) is the leisure weight in the total utility.

The consumer chooses consumption, leisure, capital stock, investment, money and deposits \( \{c_t, x_t, k_{t+1}, i_t, d_{t+1}, M_{t+1}\} \) to maximize lifetime utility 1.1 subject to the representative agent budget constraint 1.2, time constraint 1.3 and cash-in-advance constraint 1.4:

\[
\begin{align*}
\max_{c_t,x_t,k_{t+1},i_t,d_{t+1},M_{t+1}} L_t = E_o \sum_{t=0}^{\infty} \beta^t \left\{ \frac{c_t x_t^\varphi}{1-\theta} + \lambda_t (w_t (1-x_t) + d_t (1+R^d_t) + \frac{M_t}{P_t} + G_t + R^I_t k_t \right. \\
- c_t (1+\tau_c) - i_t - \frac{M_{t+1}}{P_t} - d_{t+1}) + \mu_t \left( \frac{M_t}{P_t} - c_t \right) \\
+ \xi_t (i_t - k_{t+1} + (1-\delta_k) k_t - \phi \left( \frac{i_k}{k_t} \right) k_t) \right\}
\end{align*}
\]

The first order conditions with respect to \( c_t, x_t, k_{t+1}, i_t, d_{t+1}, M_{t+1} \) are given by C.2 through C.7:

\( c_t: \)

\[
\beta^t \left( c_t x_t^\varphi \right)^{-\theta} x_t^\varphi - \beta^t \lambda_t (1 + \tau_c) - \beta^t \mu_t = 0 
\] (C.2)

\( x_t: \)

\[
\beta^t \left( c_t x_t^\varphi \right)^{-\theta} \varphi c_t x_t^\varphi - \beta^t \lambda_t w_t = 0 
\] (C.3)

\( k_{t+1}: \)

\[
- \beta^t \xi_t + \beta^{t+1} E_t \left\{ \lambda_{t+1} R^q_{t+1} \right\} + \beta^{t+1} E_t \left\{ \xi_{t+1} [1-\delta_k] - \phi \left( \frac{i_{t+1}}{k_{t+1}} \right) + \phi' \left( \frac{i_{t+1}}{k_{t+1}} \right) \frac{i_{t+1}}{k_{t+1}} \right\} = 0
\] (C.4)

\( i_t: \)

\[
\beta^t \lambda_t = \beta^t \xi_t [1 - \phi' \left( \frac{i_t}{k_t} \right)] 
\] (C.5)

\( d_{t+1}: \)

\[
- \beta^t \lambda_t + \beta^{t+1} E_t \left\{ \lambda_{t+1} [1 + R^d_{t+1}] \right\} = 0
\] (C.6)

\( M_{t+1}: \)

\[
- \beta^t \lambda_t \frac{1}{P_t} + \beta^{t+1} E_t \left\{ \lambda_{t+1} \frac{1}{P_{t+1}} + \mu_{t+1} \frac{1}{P_{t+1}} \right\} = 0
\] (C.7)

Define function \( Q_t \left[ 1 - \phi' \left( \frac{i_t}{k_t} \right) \right] = 1 \) that means that Tobin’s \( Q \) is defined as:

\[
Q_t = \left[ 1 - \phi' \left( \frac{i_t}{k_t} \right) \right]^{-1}
\]

Therefore, the relative price of investment to consumption is the Tobin’s \( Q \) and equals to the ratio of the shadow price of investment to the relative price of consumption:
\[ Q_t = \frac{\xi_t}{\lambda_t} \]

Equation C.4 after dividing by \( \beta^t \lambda_t \) transforms to:

\[ \frac{\xi_t}{\lambda_t} = \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} R^q_{t+1} + \beta E_t \left\{ \frac{\lambda_{t+1}}{\lambda_t} \left[ (1 - \delta_k) - \phi(\frac{i_{t+1}}{k_{t+1}}) - \phi'(\frac{i_{t+1}}{k_{t+1}})(\frac{i_{t+1}}{k_{t+1}}) \right] \right\} \right\} (C.8) \]

Equations C.8 and C.6 establish the relationship between interest rates on physical capital and deposit rates that is the "risk premium":

\[ \frac{E_t \{ R^q_{t+1} + Q_{t+1} [(1 - \delta_k) - \phi(\frac{i_{t+1}}{k_{t+1}}) - \phi'(\frac{i_{t+1}}{k_{t+1}})(\frac{i_{t+1}}{k_{t+1}})] \}}{Q_t} = E_t [1 + R^d_{t+1}] \] (C.9)

The difference between the interest received by the consumer while investing into physical capital \( R^q_t \) and interest received on deposits \( R^d_t \) is defined by FOCs and are related through physical capital depreciation rate, Tobin’s \( Q \) and the investment adjustment cost function.

Further transformations allow to obtain the following relationship between physical capital interest, \( R^q_t \), and interest received on deposits, \( R^d_t \):

\[ E_t (R^q_{t+1}) - E_t (Q_t R^d_{t+1}) = Q_t - E_t [Q_{t+1} (1 - \delta_k)] + E_t \left\{ Q_{t+1} [\phi(\frac{i_{t+1}}{k_{t+1}}) - \phi'(\frac{i_{t+1}}{k_{t+1}})(\frac{i_{t+1}}{k_{t+1}})] \right\} \]

\[ \phi(\cdot) > 0, \phi'(\cdot) > 0, \phi''(\cdot) < 0 \]

If investment adjustment costs, \( \phi(\frac{i_{t+1}}{k_{t+1}}) \), increase, risk premium \( E_t (R^q_{t+1}) - E_t (Q_t R^d_{t+1}) \) also rises.

As installation of new capital goods becomes more disruptive, the higher compensation the investor requires for investing into risky assets that increases the required risk premium.

The Euler equation takes the form:

\[ \left\{ \frac{1}{\pi_t} U'_{cr} \right\} = \beta E_t \left\{ \frac{1}{\pi_{t+1}} U'_{cr+1} \left[ \frac{R^q_{t+1} + Q_{t+1} [(1 - \delta_k) - \phi(\frac{i_{t+1}}{k_{t+1}}) - \phi'(\frac{i_{t+1}}{k_{t+1}})(\frac{i_{t+1}}{k_{t+1}})]}{Q_t} \right] \right\} (C.11) \]

\(^6\) The simplifying assumption is that \( \text{cov}(\lambda_{t+1} R^q_{t+1}) = \text{cov}(\lambda_{t+1} R^d_{t+1}) = \text{cov}(\lambda_{t+1} \phi(\cdot)) = \text{cov}(\lambda_{t+1} \phi'(\cdot)) = 0\)
Where \( U_{ct}^t = (c_t x_t^\phi)^{-\theta} x_t^\phi \).

The intra-temporal consumption-labour equation is:

\[
\frac{\varphi c_t (1 + \tau_c + R_t^d)}{x_t} = w_t
\]

(C.12)

Adjustment costs in investment arise because installing new capital goods is disruptive, with the installation or adjustment costs increasing in the amount of new capital installed. Holding factor inputs fixed, the adjustment cost model assumes that the cost of the investment good in terms of the consumption good is increasing as the rate of investment increases.

Risk premium C.10 can be specified as:

\[
E_t(R_{t+1}^q) - E_t(Q t R_t^d) = Q_t - E_t[Q t+1 (1 - \delta_k)] - E_t \left\{ Q_{t+1} \left[ \frac{1}{2} \psi \left[ \left( \frac{i_{t+1}}{k_{t+1}} \right)^2 - \delta_k^2 \right] \right]\right\}
\]

(C.13)

There is an inverse relationship between expected investment to capital ratio \( E_t(\frac{i_t}{k_{t+1}}) \) and risk premium \( E_t(R_{t+1}^q) - E_t(Q t R_t^d) \) required by the investor to compensate for investing into physical capital instead of deposits. As the expected size of investment accumulation over physical capital rises, the smaller premium is required.

C.0.7 Bank profit optimization problem

Bank is needed when the consumer cannot invest directly into government bonds and, therefore, bank underwrites newly issued government bonds and resells the consumer in the secondary market at a higher price.

To buy government bonds from the bank consumer puts his deposits \( d_t \) into a bank and receives a return of \( d_t (1 + R_t^d) \) where \( R_t^d \) is the dividend return and also secondary market risk-free rate. The consumer owns the bank so the total dividends received are \( d_t R_t^d \) that is the profit of the bank.

The bank underwrites newly issued government real debt \( b_{t+1} \) and receives back \((1 + R_t)b_t \) at time \( t \) that is its source of the revenues. \( R_t \) is the risk-free primary market real interest rate that is paid by the government on its borrowings. The bank uses savings
deposits from the consumer $d_{t+1}$ and pays back $(1 + R^d_t) d_t$, where $R^d_t$ represents the interest on the deposit or the residual profit per unit of deposits that the bank makes, leaving it with zero profit after the dividend payout. The interest paid on the deposits in the secondary market is smaller than the risk-free rate paid by the government to the financial intermediary $R^d_t < R_t$.

By investing into government bonds the financial intermediary produces credits to the government $b_t$.

To produce credit to the government bank uses a CRS credit production technology that involves labour $l_{Bt}$ and deposits $d_t$ as inputs. With $A_B \in (0, \infty)$ and $\gamma \in [0, 1]$ real government bond production function is given by:

$$b_t = A_B e^{v_t} (l_{Bt})^{\gamma} (d_t)^{1-\gamma}$$

(C.14)

Where banking technology shock, $v_t$, follows the stochastic process:

$$v_t = \varphi_v v_{t-1} + \varepsilon_{vt}, \varepsilon_{vt} \sim N(0, \sigma^2_v), 0 < \varphi_v < 1$$

(C.15)

Due to the operational costs related to credit production process the amount of bonds produced is less (or equal) to the amount of the deposits $b_t \leq d_t$.

The bank profit maximization problem is dynamic in the variables $d_t$ and $b_t$ and takes the form:

$$\Pi_F(b_t, d_t) = \max_{b_{t+1}, d_{t+1}, l_{Bt}} E_0 \sum_{t=0}^{\infty} \eta^t \{-b_{t+1} + b_t (1 + R_t) + d_{t+1} - d_t (1 + R^d_t) - w_t l_{Bt} + \lambda_t (A_B e^{v_t} (l_{Bt})^{\gamma} (d_t)^{1-\gamma} - b_t)\}$$

(C.16)

The first order conditions with respect to $b_{t+1}, d_{t+1}, l_{Bt}$ are given by equations C.17-C.19:

$$b_{t+1}:$$

$$-\eta^t + E_t \{\eta^{t+1} (1 + R_{t+1})\} - E_t \{\eta^{t+1} \lambda_{t+1}\} = 0$$

(C.17)

$$d_{t+1}:$$

$$\eta^t - E_t \{\eta^{t+1} (1 + R^d_{t+1})\} + E_t \{\eta^{t+1} \lambda_{t+1} (1 - \gamma) \frac{b_{t+1}}{d_{t+1}}\} = 0$$

(C.18)
\[ l_{Bt} : \]
\[ -\eta^t w_t + \eta^t \lambda_t' \gamma \frac{b_t}{l_{Bt}} = 0 \]  
(C.19)

Equations C.17-C.19 produce the following two equilibrium conditions for the underwriting spread and marginal product of labour:

\[ E_t(R_{t+1}^d) - E_t(R_{t+1}^d) = E_t\{\lambda_{t+1}'(1 - (1 - \gamma)\frac{b_{t+1}}{d_{t+1}})\} \]  
(C.20)

\[ w_t = \lambda_t' \gamma \frac{b_t}{l_{Bt}} \]  
(C.21)

The derivative with respect to \( l_{Bt} \) gives the value for the shadow cost of output of the bank \( b_t \):

\[ \lambda_t' = \frac{w_t}{\gamma \frac{b_t}{l_{Bt}}} \]  
(C.22)

Therefore, interpreting the underwriting spread given by equation 1.15, \( E_t(R_{t+1}^d) - E_t(R_{t+1}^d) \) is proportional to the expected shadow cost of output of the bank \( E_t\lambda_{t+1}' \) multiplied by the term \( 1 - (1 - \gamma)\frac{b_{t+1}}{d_{t+1}} \leq 1 \) that is the fraction less then one. This makes the marginal cost \( \lambda_{t+1}' \) always equal to some multiple of the underwriting (gross) spread \( E_t(R_{t+1}^d) - E_t(R_{t+1}^d) \).

Substituting \( \frac{b_{t+1}}{d_{t+1}} \) in 1.15 with \( A_B\left(\frac{l_{Bt+1}}{d_{t+1}}\right)^\gamma \) we get:

\[ E_t(R_{t+1}) - E_t(R_{t+1}^d) = E_t\{\lambda_{t+1}'(1 - (1 - \gamma)A_B\left(\frac{l_{Bt+1}}{d_{t+1}}\right)^\gamma)\} \]  
(C.23)

The spread is not a simple function in \( \frac{l_{Bt}}{d_t} \) so needs further assumptions to simplify the equilibrium condition for the underwriting spread. The simplest assumption with no uncertainty is that all of the deposits are turned into loans \( d_t = b_t \) (or in this case government loans) (Gillman (2010)). This is assumed because the model has no uncertainty, and the consumer invests all funds into the firm’s capital.

An alternative assumption is to let \( d_t - b_t \) be positive amount of capital requirements that a bank must hold and invest into risk-free government bonds instead of risky firm’s capital. As soon as in this model the only choice for the bank is to invest into riskless government bonds, I define that the ratio of the factor prices multiplied by the factor itself
is equal to the ratio of shares of these factors:

$$\frac{R^d_t d_t}{R_t b_t} = 1 - \gamma$$  \hspace{1cm} (C.24)

That after substituting into 1.15 defines the spread as proportional to the ratio of the value for the shadow cost of output of the bank $\lambda'_{t+1}$ to the marginal return of the output of the bank $R_{t+1}:

$$E_t(R_{t+1}) - E_t(R^d_{t+1}) = E_t\{\frac{\lambda'_{t+1}}{R_{t+1}} (R_{t+1} - R^d_{t+1})\}$$  \hspace{1cm} (C.25)
Appendix D
Estimation and empirical testing

Construction of shocks

The procedure of construction of the shocks on the basis of the theoretical model is adopted from Gillman, Kejak and Benk (2005, 2008) and Ingram, Kocherlakota and Savin (1994). By identifying the magnitude of the credit shocks on the business cycle for different periods they study the effects of the changes in banking laws. AR(1) values for the shock processes are computed on the basis of the existing data and assigned as initial values for the parameters of the theoretical model. Following the Uhlig’s underdetermined coefficients procedure under the ‘certainty equivalence’ assumption the state space solution from which later I recover the Markov decision rules that can be obtained numerically from the model on the basis of the state space form solution. The state space solution is used further for construction of the shocks and model simulation. The state space solution is:

\[ \hat{s}_{t+1} = \Omega_1 \hat{s}_t + \Omega_2 \hat{\varepsilon}_{t+1} \]  \hspace{1cm} (D.1)

\[ \hat{q}_t = \Omega_3 \hat{s}_t \]  \hspace{1cm} (D.2)

Where \( \hat{q}_t \) is the vector of the endogenous control variables including 'jump' variables, and \( \hat{s}_t \) is the vector of the predetermined and exogenous variables. Predetermined state variables appear first in the vector \( \hat{s}_t \) and the exogenous driving processes follow up endogenous predetermined state variables in D.2. More explicitly D.2 can be represented in the following form:

\[ \hat{q}_t = \Omega_{31} \hat{s}_{1t} + \Omega_{32} \hat{s}_{2t} = \Omega_{31} [\hat{k}_t, \hat{d}_t, \hat{c}_t, \hat{w}_t, \hat{R}_t^d, \hat{R}_t^e]' + \Omega_{32} [\hat{\varepsilon}_t, \hat{\nu}_t, \hat{\mu}_t]' \]  \hspace{1cm} (D.3)

To solve the model we need to take a guess as to the value of the autocorrelation coefficient of each of the driving processes and on any cross correlation to their innovations. I solve the model and extract the coefficients of the matrices \( \Omega_{31} \) and \( \Omega_{32} \). By assigning
values from the existing data to the vector of endogenous control variables, $\hat{q}_t$ and vector of variables $\hat{s}_{1t}$, I estimate the processes for the three shocks $[\hat{z}_t, \hat{v}_t, \hat{u}_t]$ on the basis of the theoretical prediction of the model and existing data series. Explicitly vector of shocks is straightforward to obtain an estimated via the following transformation:

$$[\hat{z}_t, \hat{v}_t, \hat{u}_t]' = (\Omega'_{32} \Omega_{32})^{-1} \Omega'_{32} [\hat{q}_t - \Omega_{31} \hat{s}_{1t}]$$  \hspace{1cm} (D.4)

There are three underlying shocks in the model that require at least three variables in the vector of endogenous control variables, $\hat{q}_t$. Using more than three endogenous control variables makes the system overspecified, nevertheless overidentification still allows for a unique identification of three shocks.

After backing up the shocks from the model on the basis of derived transformation formula D.4, the next step is to estimate the autocorrelation coefficients for the obtained series for the three shocks processes. Seemingly unrelated regressions estimator is applied to the following three equations:

$$\begin{bmatrix}
\begin{bmatrix}
\hat{z}_t \\
\hat{v}_t \\
\hat{u}_t
\end{bmatrix}
= \begin{bmatrix}
\rho_z & 0 & 0 \\
0 & \rho_v & 0 \\
0 & 0 & \rho_u
\end{bmatrix}
\begin{bmatrix}
\hat{z}_{t-1} \\
\hat{v}_{t-1} \\
\hat{u}_{t-1}
\end{bmatrix} + \begin{bmatrix}
\varepsilon_{zt} \\
\varepsilon_{vt} \\
\varepsilon_{ut}
\end{bmatrix}
\end{bmatrix}$$  \hspace{1cm} (D.5)

Assuming error term to be correlated across the equations seemingly unrelated regressions estimation method will produce more efficient results.\footnote{Two cases when SUR is in fact equivalent to OLS are: either when the error terms are in fact uncorrelated between the equations (so that they are truly unrelated and variance-covariance matrix is diagonal), or when each equation contains exactly the same set of regressors on the right-hand-side.} Obtained values of autocorrelation coefficients $\rho_z, \rho_v$ and $\rho_u$ are substituted back into the model solution algorithm and the new coefficients for the matrix $\Omega_{32}$ is obtained. The iteration procedure continues until coefficients $\rho_z, \rho_v$ and $\rho_u$ converge. The model is simulated on the basis of the ultimate version of the coefficients and variance-covariance matrix.

As soon as I am interested in estimating three shocks, I need data on $\hat{s}_{1t}$ and at least three variables contained in $\hat{q}_t$. The combination of five variables in vector $\hat{q}_t$ provide the best fit to the model on the basis of practice adopted from Nolan and Thoenissen (2009). Vector $\hat{q}_t$ may contains output $\hat{y}_t$, government expenditure $\hat{g}_t$, labour hours in goods and banking sector $\hat{l}_{Gt}$ and $\hat{l}_{Bt}$, and real government bonds $\hat{b}_t$: $\hat{q}_t = [\hat{y}_t, \hat{g}_t, \hat{l}_{Gt}, \hat{l}_{Bt}, \hat{b}_t]'$. $\hat{y}_t$ and $\hat{l}_{Gt}$
can be chosen to better capture the goods sector productivity, $\hat{b}_t$ and $\hat{t}_{B_t}$ are used for capturing the shock process in the banking sector and $\hat{g}_t$ explains the behaviour of government expenditure over time.
Appendix E
Participants and Project Timetable

E.1 Participants

Project leader and main researcher: Dr Kateryna Onishchenko, PhD in Economics, Cardiff University, United Kingdom

E.2 Alternative/additional sources of funding

NO

E.3 Project timetable

<table>
<thead>
<tr>
<th>Month</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 2012</td>
<td>Collection, processing and analysis of historical data</td>
</tr>
<tr>
<td>September 2012</td>
<td>Theoretical model development, work on literature review</td>
</tr>
<tr>
<td>October 2012</td>
<td>Calibration of the theoretical model and simulation</td>
</tr>
<tr>
<td>November 2012</td>
<td>Econometric testing of the theoretical model, analysis of first empirical results.</td>
</tr>
<tr>
<td>December 2012</td>
<td>Preparation of the Interim Report</td>
</tr>
<tr>
<td>January 2013</td>
<td>Presentation of Interim Report at EERC research workshop</td>
</tr>
<tr>
<td>February 2013</td>
<td>Work on the corrections</td>
</tr>
<tr>
<td>March 2013</td>
<td>Empirical testing of the model, analysis of the results</td>
</tr>
<tr>
<td>April 2013</td>
<td>Development of the policy recommendations</td>
</tr>
<tr>
<td>May 2013</td>
<td>Preparation of the Final Report</td>
</tr>
<tr>
<td>June 2013</td>
<td>Work on the publication</td>
</tr>
<tr>
<td>July 2013</td>
<td>Presentation of the Final Report at EERC research workshop</td>
</tr>
<tr>
<td>August 2013</td>
<td>Finalizing the project; communication and dissemination of the results</td>
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</tbody>
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