HOW SHOULD WE MEASURE THE IMPACT OF CHANGES IN GLOBAL FINANCIAL SENTIMENT ON THE HUNGARIAN MACROECONOMY?

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Abstract

This thesis paper attempts to disentangle the interconnections between the global financial sentiment, the Hungarian interest rate and the Hungarian business cycles. We build two Structual VAR models: the first one is based on Uribe and Yue (2005), and uses the US Treasury bill rate as a measure of global financial sentiment. The second one is our own model, and uses the Volatility Index of the S&P 500 as a measure of global financial sentiment. While the overall fit of the first model does not meet our expectations, the second model provides an appropriate identification scheme for quantifying the impact of changes in investors' risk appetite on the Hungarian interest rate and domestic economy. The variance decomposition of our own model points out that about 25% of the variation in the Hungarian interest rate is explained by innovations in the Volatility index of the S&P500, which implies that the interest rate responds systematically to changes in the global financial sentiment. At the same time, a much larger part (45%) of the fluctuations in the Hungarian interest rate is explained by domestic macroeconomic fundamentals. As for the decomposition of the Hungarian GDP and investment shocks, we find that shocks in the Volatility index of the S&P500 account for about 10-15% of aggregate fluctuations in Hungary. Volatility index shocks and Hungarian interest rate shocks are together responsible for about 45% of movements in investments.

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1 INTRODUCTION

The strong interconnection of global financial markets and the macroeconomic stability of sovereign countries is a well-known phenomenon that has been newly demonstrated by the current crisis in Greece. European stocks immediately started to slide as the first indistinct news about the Greek government's insolvency came to light, and in the following days, the depreciation of the European currency was exacerbated by financial market speculations on the currency's further depreciation. Moreover, because of an unfolding negative market sentiment, underpinned by news about the fragile fiscal positions of several European countries, the crisis now seems to experience a spill-over effect in many parts of Europe.

The intricate relation linking the financial markets and the real economy of a country or a region has become a forefront topic of academic policy analyses throughout the past two years, as the world experienced a sequence of economic turbulences. Even though there is abundant qualitative analysis available, most of the research results on the impact of global financial sentiment on emerging countries' fundamentals have not been adequately underpinned by quantitative research results, in particular, with reference to the Central-Eastern-European region. Therefore, this thesis paper attempts to quantify the impact of changes in global financial sentiment on the Hungarian real economy. We introduce two empirical models. First, we check whether the model, elaborated by Uribe and Yue (2005), would appropriately describe movements in the Hungarian business cycles. After finding that the overall fit of the model is not adequate, we estimate our own model which uses, as a measure of global financial sentiment, the volatility index of the S&P 500 instead of the US Treasury bill rate used by Uribe and Yue (2005).

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The fundamental qualitative facts, which are widely recognized in policy analysis, are as follows. International capital markets and the risk taking propensity of global investors have a significant effect on the direction of global capital movements as well as on the yields of developing countries' domestic financial assets. Consequently, a country's risk assessment by global investors plays an important role in its domestic financial stability. Furthermore, global recessions typically exacerbate capital market players' perception about instability, and bring about a wave of risk assessment reevaluations. This phenomenon materializes in decreasing stock indexes and increasing spread indices. Riskier financial assets are less attractive at times of slowing economic growth because at these times investors prefer more secure investments, such as Treasury bills of developed countries. This phenomenon is commonly referred to as "flight to quality". During recessions risky investments such as US stocks and developing market Treasury bills only sell if they provide a higher yield which is generally reflected in higher spread indices. Thus, changes in the global risk appetite do not only influence riskier investments of developed economies, such as US stock indices and riskier US market bonds, but also government bonds of developing countries. These two groups of financial securities generally have a similar global risk assessment.

As for the quantitative analysis, it might involve various measures of risk. The most relevant risk index of developing countries is JP Morgan's *EMBI index (Emerging Markets Bond Index)*, which summarizes the yield difference between the dollar-denominated Treasury bills of developing countries and the US Treasury bill. The implied riskiness of developed markets themselves is measured by various indexes: the *Volatility Index (VIX)* is an implied stock volatility index which reflects investors' expectations about the volatility of the S&P 500. The *junk bond spread* provides information about the yield difference between highly risky US market bonds and presumably riskless US Treasury bills. It has been shown that both indices (VIX and the junk bond spread) incorporate some important information

about the financial conditions of developed markets, and, at the same time, have strong forecasting power over developing countries' domestic business cycle movements (see, for example, Kamin and von Kleist, 1999). Increasing volatility indices and increasing junk bond spreads can be associated with weaker economic perspectives of less creditworthy US companies and, accordingly, with lower level of risk appetite from the investors' side. Throughout the past decade events in the developed world have had an extremely strong effect on investors' approach to developing markets. Empirical evidence shows that the EMBI risk index of developing countries has been moving together with the implied volatility of risky US stock indexes (*see Figure 1*).

Figure 1



Source: MNB; Yahoo Finance

On Figure 1, EMBI is JPMorgan's Global Emerging Market Bond Index, which summarizes the average yield difference between the dollar-denominated government bonds of developing countries and the US Treasury bill. On the other hand, VIX_HAT stands for the Volatility Index of the S&P 500 index options, which is a commonly used name for the Chicago Board Options Exchange Volatility Index. A high VIX value corresponds to a more volatile market. It is often referred to as the fear index as it represents a measure of the market's expectation of volatility over the next 30 day period. Our dataset covers the period between 2000Q1 and 2009Q4.

As a direct consequence of the positive EMBI – VIX correlation coupled with the "flight to quality" phenomenon, a significant negative correlation can be detected between the EMBI and the US Treasury bill rate. The intuition is straightforward: in times of recession, when the EMBI spread and the implied volatility of risky investments increases, capital flows from risky investments into presumably risk-free US Treasuries. And, as the demand for US T-bills gradually increases, gross T-bill rates drop. When, on the contrary, the global economy experiences a boom, indices move in the opposite direction: as a result of decreasing volatility and spreads, capital flows into risky markets and the T-bill rate increases. The research topic

is of high relevance from a technical point of view too, as country spreads do not respond one-for-one to changes in the US rate (or any other measures of implied market volatility), but instead serve as a transmission mechanism, capable of amplifying or dampening the effect of shocks to global financial sentiment on the domestic real economy. The fundamental inducement behind the transmission mechanism is the widely observed empirical fact that the GDP-growth and all relevant variables of domestic economic activities in emerging countries are correlated with the cost of borrowing the country faces. Periods of low interest rates are associated with economic expansions, whereas high interest rates systematically bring about a dampening in the real economic activity.

Most empirical researchers, among them Uribe and Yue(2005), focus on emphasizing the effect of innovations in the US T-bill rate on emerging countries' fundamentals. Alternative measures of implied market uncertainty, such as the Volatility index of the S&P 500 are rarely seen in the literature. Nevertheless, the estimation results of this thesis paper prove that the latter measure has higher forecasting power over developing countries' business cycles than that of the US Treasury bill rate. This observation is most probably due to the fact the US interest rate incorporates other policy-related information too, whereas the implied volatility index of the S&P 500 is a direct measure of market volatility.

A substantial part of the literature reports empirical results on the response of Latin-American spreads to innovations in the US Treasury bill rate. Uribe and Yue (2005) estimate a panel model on seven Latin-American developing countries (Argentina, Brazil, Ecuador, Mexico, Peru, Philippine, and South Africa) in order to disentangle the relation linking the US interest rate, country spreads and emerging market fundamentals. After estimating a baseline structural vector-autoregression (SVAR) model, they perform a robustness check by augmenting the sample with six new developing countries (Chile, Colombia, Korea, Malaysia, Thailand, and Turkey), and conclude that country spreads significantly affect aggregate activity. Eichengreen and Mody (2001) analyze the impact of the "flight to quality" on the volumes, maturities and spreads of developing countries. They conclude that a period of heightened financial turbulence in the developed world typically decreases the volume of lending, and shortens the maturity of new loans, in particular for less creditworthy borrowers as they are regarded as too risky. At the same time, they also found that while changes in market sentiment do have a significant affect on the price and quality of new issues, there was less evidence of an impact on maturities. The econometric evidence of Arora and Cerisola (2001) supports the view the besides country-specific fundamentals, the stance and predictability of the US monetary policy also plays an important role in determining country risks.

The structure of this thesis is organized as follows: Chapter 2 present the methodology applied for the estimations; Chapter 3 describes our first estimated model, *Model1*, which is based on Uribe and Yue (2001). In Chapter 4 we develop our own model, *Model2*, and Chapter 5 concludes the paper.

2 METHODOLOGY¹

Our estimation uses a methodology first developed by Christopher Sims (1980): the vector autoregression (VAR) approach. It is an approach that proved to be successful in capturing the rich dynamics in multiple time series and in providing a coherent but parsimonious approach to forecasting.

Early in the development of VAR methods, researchers started to search for ways in which the driving forces of VAR processes can be matched to the ones described by macroeconomic theory. This pursuit led to the development of structural VAR models (or SVARs). The fundamental issue in this field is the identification of the "structural form" from the estimated "reduced form". This so-called identification problem stems form the fact that a given dynamic response of an economic aggregate might stem from various fundamental economic shocks. Therefore one needs to place identification restrictions on the reduced form model residuals in order to gain a properly interpretable structural model.

A VAR for a *k*-dimensional vector of variables *Z*, is given by:

$$Z_{t} = C_{1}Z_{t-1} + \dots + C_{a}Z_{t-a} + u_{t}, \quad Eu_{t}u_{t} = I$$
(2.1)

where t is the usual time subscript, q is a nonnegative integer and u_t is a random disturbance with zero expected value, and is uncorrelated with all variables dated t-1 and earlier. I is the identity matrix. We get consistent estimates of the C_i matrices by running an ordinary least squares (OLS) estimation equation by equation on (2.1).

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¹ This Chapter is based on CHRISTIANO, LAWRENCE J., MARTIN EICHENBAUM AND CHARLES L. EVANS (1998):

[&]quot;Monetary Policy Shocks: What Have We Learned and to What End?", NBER Working Paper No. 6400.

Now, even though we have estimates for the C_i coefficient matrices and the u_t fitted residual, it is still impossible to disentangle the effect of different fundamental economic shocks in u_t . In general, each element of u_t reflects the effect of all the fundamental economic shocks. Therefore, when we analyze this reduced form model, we have no reason to presume that any element of u_t corresponds to a particular economic shock, for example, a shock in the global financial sentiment.

To proceed, we need to find theoretically underpinned assumptions for the relationship of the VAR disturbances and the fundamental economic shocks, ε_t which is given by $A_0u_t = B_0\varepsilon_t$. Here, A_0 is an invertible, square matrix; B_0 is usually normalized to be a diagonal matrix. Premultiplying (2.1) by A_0 , we get a structural form model: $A_0Z_t = A_1Z_{t-1} + ... + A_qZ_{t-q} + B_0\varepsilon_t$. (2.2)

where A_i is a $k \times k$ matrix of constants, i = 1, ..., q, and

$$C_i = A_0^{-1} A_i, \ i = 1, ..., q.$$

Let's call δ_i the response of Z_i to a unit shock in ε_i . Then, the (j, l) element of δ_i represents the response of the *j*-th component of Z_i to a unit shock in the *l*-th component of ε_i . The δ_i 's characterize the impulse response function of the elements of Z_i to the elements of ε_i .

In order to compute the impulse response functions, we need to know A_0 as well as the C_i 's. As mentioned earlier, the C_i 's can be estimated by ordinary least squares regressions, however A_0 must be defined by economic intuition. The most commonly used identification scheme is the Cholesky factorization, which imposes an ordering of the variables in the VAR and attributes all of the effect of any common component to the variable that comes first in the VAR system. The typical Cholesky A_0 and B_0 pattern matrices (for a k = 5 variable VAR) look as follows:

$$A_{0} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ NA & 1 & 0 & 0 & 0 \\ NA & NA & 1 & 0 & 0 \\ NA & NA & NA & 1 & 0 \\ NA & NA & NA & NA & 1 \end{bmatrix}, \qquad B_{0} = \begin{bmatrix} NA & 0 & 0 & 0 & 0 \\ 0 & NA & 0 & 0 & 0 \\ 0 & 0 & NA & 0 & 0 \\ 0 & 0 & 0 & NA & 0 \\ 0 & 0 & 0 & 0 & NA \end{bmatrix},$$
(2.3)

where *NA* stands for not specified, that is, no restriction is placed on the given element of the residual.

Another popular identification scheme is the structural decomposition. It is an alternative to the recursive Cholesky orthogonalization that allows the researcher to impose additional restrictions on the A_0 matrix in order to identify the structural components of the error term.

This paper estimates two models (*Model 1* and *Model 2*), both of which are identified by the following structural factorization matrices:

$$A_{0} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ NA & 1 & 0 & 0 & 0 \\ NA & NA & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ NA & NA & NA & NA & 1 \end{bmatrix}, \qquad B_{0} = \begin{bmatrix} NA & 0 & 0 & 0 & 0 \\ 0 & NA & 0 & 0 & 0 \\ 0 & 0 & NA & 0 & 0 \\ 0 & 0 & 0 & NA & 0 \\ 0 & 0 & 0 & 0 & NA \end{bmatrix}.$$
(2.4)

The economic theoretical reasons for placing these additional zero restrictions $(A_{0,41} = A_{0,42} = A_{0,43} = A_{0,45} = 0)$ on the A_0 matrix is unfolded in the following chapters.

3 MODEL1

3.1 Identification Scheme

Based on the methodology of Martín Uribe and Vivian Z. Yue (2005) we first estimate a Structural VAR system that includes the US T-bill rate, the Hungarian interest rate and three fundamental measures of domestic macroeconomic variables. The main objective of our empirical research is to identify US interest rate shocks and country spread shocks and to assess their impact on the domestic variables. On one hand, a US interest rate shock might have a direct effect on domestic variables; however, on the other hand it might also have an indirect effect through the transmission mechanism of the Hungarian country spread. The model should also provide a quantitative measure on the feedback of business cycle movements on the country spread itself.

The reduced form *Model 1* looks as follows:

$$\begin{bmatrix} \hat{y}_{t} \\ \hat{i}_{t} \\ tby_{t} \\ \hat{R}_{t}^{US} \\ \hat{R}_{t} \end{bmatrix} = C_{1} \begin{bmatrix} \hat{y}_{t-1} \\ \hat{i}_{t-1} \\ tby_{t-1} \\ \hat{R}_{t-1}^{US} \\ \hat{R}_{t-1} \end{bmatrix} + C_{2} \begin{bmatrix} \hat{y}_{t-2} \\ \hat{i}_{t-2} \\ tby_{t-2} \\ \hat{R}_{t-2}^{US} \\ \hat{R}_{t-2} \end{bmatrix} + \begin{bmatrix} u_{t}^{y} \\ u_{t}^{i} \\ u_{t}^{tby} \\ u_{t}^{rus} \\ u_{t}^{r} \end{bmatrix}$$
(3.1)

where \hat{y}_t stands for real gross Hungarian output, \hat{i}_t denotes real gross Hungarian investment, tby_t is the trade balance to output ratio, \hat{R}_t^{us} denotes the gross real US interest rate, and \hat{R}_t denotes the gross real Hungarian interest rate. A "hat" on \hat{y}_t and \hat{i}_t denotes log deviations from a HP trend. A hat on \hat{R}_t^{us} and \hat{R}_t signs that they are in log form. We measure \hat{R}_t^{us} as the 3month gross Treasury bill rate divided by the average gross US inflation over the previous four quarters. We measure \hat{R}_t as the sum of JP Morgan's EMBI Hungary stripped spread and the US real interest rate. Our domestic variables were chosen according to the following criteria: they should be identified in the literature as the most relevant motives of country spreads; they should be able to describe domestic business cycle movements; and finally their number should be kept as small as possible in order not to produce redundant loss of degrees of freedom. These three guiding principles have helped us identify the output, the investment and the trade balance to output ratio as the most representative variables of Hungarian domestic activity.

In order to sort out the contemporaneous links among the variables, we decided to apply the method of Structural VAR. The standard restriction criterion for identification of a Structural VAR is called "order condition" (Rothenberg, 1971). The order condition is implemented by directly counting the number of restrictions, which should be at least $k \times (k - 1)/2$, where *k* is the number of endogenous variables. By imposing three more identification restrictions, we create an over-identified SVAR system.

Our fundamental assumption is that real domestic shocks (output shock, ε_t^y ; investment shock ε_t^i , tby shock, ε_t^{iby}) affect financial variables contemporaneously, whereas innovations to the financial variables (US and domestic interest rate) only affect domestic real variables with a one-period lag. This distinction between real and financial variables can be motivated by economic theory. The assumed instantaneous reaction of financial variables is motivated by the semi-strong version of the Efficient Market Hypothesis, which asserts that prices reflect all publicly available information on the real economy as well as all financial indices, and that prices instantly change to reflect new public information. The assumed sluggish reaction of the real variables to the financial ones is motivated by Neo-Keynesian macroeconomics. According to this theoretical approach nominal rigidities (sticky prices and wages) introduce inertia to the adjustment process of the economy to an economic shock. Therefore real business cycle changes are not instantaneous.

Our additional restriction to a Cholesky VAR construction is that R_i^{us} follows a simple univariate AR(1) process. Therefore we impose the following additional restriction: $A_{0,4i} = 0$ for i=1,2,3,5. This restriction is based on the reasonable assumption that Hungarian real and financial variables do not have any effect on the American Treasury bill rate. To check the validity of our additional restriction, the Granger-causality statistics of the model are examined (see in Appendix). From these we can conclude that the lagged values of the other variables do not help to predict R_i^{us} , therefore our three structural restrictions are valid both theoretically and statistically. (The coefficients on the lags of the other four variables are insignificant or zero in the reduced form R_i^{us} regression.)

However, the real cornerstone of our identification scheme, which is based on the methodology of Uribe and Yue (2005), is the recognition that in a Structural VAR with variables ordered as \hat{y}_t , \hat{i}_t , tby_t , R_t^{us} , and \hat{R}_t , the Hungarian interest rate shock can equivalently be interpreted as the Hungarian spread shock. If we replace the Hungarian interest rate \hat{R}_t equation with the Hungarian spread equation, which we define as $\hat{S}_t = \hat{R}_t - \hat{R}_t^{us}$, it can easily be seen that the estimated residual of our new \hat{S}_t regression is identical to that of the original \hat{R}_t equation. Therefore, the impulse response functions of output, investment and trade balance to output ratio are identical in both cases, i.e. the impulse response functions of a Hungarian interest rate shock can be interpreted as the impulse response functions of a Hungarian spread shock.

3.2 Data

Our dataset consists of quarterly data over the period 2000Q1 to 2009Q4. The relatively small sample size is in line with the relevant empirical literature.² The following Table gives a detailed summary of the characteristics of our dataset.

	Abbreviation	Unit	Source	Conversion
Output, \hat{y}_t	GDP_HAT	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	Log-deviation from its HP trend
Investment , \hat{i}_t	INVESTMENT_HAT	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	Log-deviation from its HP trend
Trade balance to GDP ratio, tby _t	TBY	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	(Exports-Imports)/GDP
US interest rate, \hat{R}_t^{us}	R_US_HAT	Percentage points	IFS; Eurostat	Log of (Gross Treasury bill rate/ Average Gross US inflation of previous four quarters)
Hungarian interest rate, \hat{R}_t	R_HU_HAT	Percentage points	IFS; Eurostat; MNB	Log of ((Gross US Treasury bill rate/ Average Gross US inflation of previous four quarters)+EMBI HU)

3.3 Reduced Form Estimation Output

Table 2 shows the system parameters estimated equation by equation. All equations were estimated by OLS using our quarterly series from the period 2000 Q1 – 2009 Q4. The lag length of two was chosen according to the Akaike Information Criterion test results. The US interest rate follows an AR(1) process, i.e. it is regressed on its first lag. Standard errors are shown in parenthesis.

² See for instance, VONNÁK, BALÁZS (2006): "Estimating the effect of Hungarian monetary policy within a structural VAR framework", in: Monetary Transmission in Hungary, Magyar Nemzeti Bank

Table 2	
Reduced form Parameter estimates of the VAR	system

Independent variable	Dependent variable					
•	GDP_HAT	INVESTMENT_HAT	TBY	R_US_HAT	R_HU_HAT	
GDP_HAT	-	-2.008 (1.863)	0.249 (0.748)	-	-5.233 (12.32)	
GDP_HAT(-1)	1.344 (0.194)	10.60 (3.134)	0.517 (1.476)	-	-11.88 (23.16)	
GDP_HAT(-2)	-0.277 (0.250)	-7.412 (2.484)	-0.156 (1.13)	-	27.19 (17.38)	
INVESTMENT_HAT	-	-	-0.22 (0.077)	-	1.959 (1.425)	
INVESTMENT_HAT(-1)	-0.026 (0.018)	0.598 (0.186)	0.104 (0.086)	-	-1.229 (1.447)	
INVESTMENT_HAT(-2)	-0.012 (0.015)	0.023 (0.155)	0.135 (0.061)	-	0.263 (1.471)	
TBY	-	-	-	-	0.033 (3.29)	
TBY(-1)	-0.016 (0.043)	0.145 (0.426)	0.668 (0.167)	-	-1.159 (3.298)	
TBY(-2)	-0.004 (0.044)	0.126 (0.430)	0.275 (0.169)	-	-0.411 (2.844)	
R_US_HAT	-	-	-	-	0.065 (0.179)	
R_US_HAT(-1)	0.0017 (0.002)	0.047 (0.025)	0.011 (0.01)	0.986 (0.074)	0.029 (0.28)	
R_US_HAT(-2)	0.0012 (0.002)	-0.066 (0.027)	-0.023 (0.012)	-	-0.156 (0.22)	
R_HU_HAT(-1)	-0.0025 (0.003)	-0.139 (0.032)	-0.019 (0.016)	-	1.095 (0.27)	
R_HU_HAT(-2)	0.0008 (0.003)	0.146 (0.032)	0.022 (0.017)	-	-0.235 (0.28)	
R-squared	0.9432	0.8230	0.9267	0.8333	0.8467	
S.E. equation	0.0045	0.0439	0.0172	0.3632	0.2595	
No. of obs.	37	37	37	37	36	

3.4 Structural Form Estimation Output

The structural VAR estimations using A_0 and B_0 , from (1.4) yielded the following

estimates for the structural factorization matrices:

Table 3

Structural VAR Estimates							
Structural VAR is	Structural VAR is over-identified (3 degrees of freedom)						
Model: Ae = Bu where E[uu']=I							
Estimated A matrix	::						
1.000000	0.000000	0.000000	0.000000	0.000000			
2.353777	1.000000	0.000000	0.000000	0.000000			
-0.826858	0.222182	1.000000	0.000000	0.000000			
0.000000	0.000000	0.000000	1.000000	0.000000			
13.69041	-2.194222	-2.266863	-0.096722	1.000000			
Estimated B matrix	:						
0.004460	0.000000	0.000000	0.000000	0.000000			
0.000000	0.043685	0.000000	0.000000	0.000000			
0.000000	0.000000	0.014451	0.000000	0.000000			
0.000000	0.000000	0.000000	0.319859	0.000000			
0.000000	0.000000	0.000000	0.000000	0.229645			

With the help of the impulse response functions we trace out the response of current and future values of each of the variables to a one-unit increase in the current value of one of the Structural VAR errors, assuming that the shocked error returns back to zero in the following period, and there are no other shocks at that moment. As the primary objective of our identification scheme is to reveal the effects of US interest rate shocks and Hungarian spread shocks on the Hungarian business cycles, we focus on the impulse responses to these two shocks.

Figure 2 depicts the effect of an unexpected one unit increase in the Hungarian spread on all 5 variables, whereas Figure 3 depicts the effect of an unexpected one unit increase in the US interest. A two standard error band is depicted around the impulse responses. The responses of output and investment are expressed in percent deviation from their respective HP trend, the responses of the trade balance to GDP ratio, the Hungarian spread and the US interest rate are expressed in percentage points.

Figure 2: Impulse Responses to a Hungarian Spread Shock



Investment





Trade-Balance-to-GDP-Ratio

US Interest Rate





Hungarian Interest Rate

5 6

.3

.2

.1

.0

-.1

-.2

-.3

2 3 4

Hungarian Spread



The impulse responses to a Hungarian spread shock are remarkably similar to those observed by Uribe and Yue (2005) on Latin-American countries. The response of the Hungarian interest rate and, accordingly, of the spread to a shock in the spread is subsequent upon our impulse response definition: both radically increase at the moment of the shock, and then gradually return back to their steady state level in five quarters. In the following five quarters, however, they seem to experience a slight undershooting before they eventually find back their way to the steady state level. Due to our identification assumption about the sluggishness of output, investment and the trade balance to output ratio, these variables remain unchanged at the moment of the shock. The observed response of these variables in the following periods is fully in line with economic theory. After an unanticipated interest rate shock, output and investment decline for two-three quarters, and then gradually recover within four or five quarters. The slight overshooting of output and investments in the following five quarters is corresponding to the slight undershooting of the interest rate in these periods. The trade balance increases for three quarters, and then quickly returns back to its pre-shock level by the end of the fourth quarter following the shock. A slight undershooting in the following five periods is in line with the respective interest rate and spread movements. The US interest rate is unaffected by the Hungarian spread shock.

Figure 3 displays the effect of an unexpected one unit increase in the US Treasury bill rate on all five variables of the model. The width of the two standard error bands shows that the impulse responses are measured with a significant uncertainty. The responses of output and investment are expressed in percent deviation from their respective HP trend, the responses of the trade balance to output ratio, the Hungarian spread and the US interest rate are expressed in percentage points.

At this point, our results significantly differ from that of Uribe and Yue (2005) who present impulse responses to a US interest rate ("world interest rate") shock, which are "qualitatively similar to those associated with an innovation in the country spread". Moreover, the impulse responses of their domestic variables to an innovation in the US interest rate are much more pronounced than that of a country spread shock. For example, the amplitude of their output response is twice the size of a country spread shock. These empirical results spectacularly demonstrate the widely discussed and analyzed phenomenon that developing countries' spreads display a delayed overshooting as a response to a change in the US interest rate. That is, they serve as a transmission channel which amplifies the effects of a US interest rate shock.

Our impulse responses to a one unit innovation in the Hungarian spread display a qualitatively different pattern. The error bands of the impulse response functions of output, investment and trade balance to output ratio are so wide that it is hard to observe any statistically and economically meaningful result. Anyhow, according to the literature on developing countries' business cycles, our impulse responses can be considered to be counterintuitive. The output and investment responses are particularly concerning. All fundamental measures of business cycles in a small developing open economy should move in the opposite direction, that is, they should indicate a temporary dampening in the real economy when investors flight to quality. The intuition is as follows: if global lenders become more reluctant to lend, developing countries' spreads will rise, and domestic borrowers with the least attractive projects will withdraw from the market. Therefore, the impulse response functions to a spread shock should depict a qualitatively different picture.

Hence, it is reasonable to conclude that we need to find a better measure of global risk sentiment in order to find an empirical model which properly quantifies the impact of changes in global financial appetite on the Hungarian real economy.

Figure 3: Impulse Responses to a US-interest-rate shock

Output

Investment



Trade-Balance-to-GDP-Ratio









US Interest Rate



Hungarian Spread



4 MODEL2

4.1 Identification Scheme

We estimate a Structural VAR system that includes the Volatility index of the S&P 500 as the measure of the global financial sentiment; the Hungarian interest rate; and three fundamental measures of domestic macroeconomic variables: output, investment, and trade balance to output ratio. The main objective of our empirical research is to assess the impact of the VIX on the Hungarian interest rate as well as on the domestic variables. However, the model also provides a quantitative measure on the feedback of business cycle movements on the Hungarian interest rate itself.

As for the measure of transmission channel, an additional remark is in place. Even though we continue using the Hungarian interest rate, that is, the real 3-month gross Treasury bill rate as the measure of the transmission channel, a shock to this variable can not be interpreted as a spread shock, as it was given in the identification scheme of *Model 1*. But, as the real gross Treasury bill rate has a strong correlation with the country spread (in our sample: $\rho_{r,spread} = 0.80$), and it is also a highly established measure of implied country risk, therefore, throughout the entire Thesis, we refer to \hat{R}_{t} as the measure of the transmission channel.

Our model takes the following reduced form:

$$\begin{bmatrix} \hat{y}_{t} \\ \hat{i}_{t} \\ tby_{t} \\ vi\hat{x}_{t} \\ \hat{R}_{t} \end{bmatrix} = C_{1} \begin{bmatrix} \hat{y}_{t-1} \\ \hat{i}_{t-1} \\ tby_{t-1} \\ vi\hat{x}_{t-1} \\ \hat{R}_{t-1} \end{bmatrix} + C_{2} \begin{bmatrix} \hat{y}_{t-2} \\ \hat{i}_{t-2} \\ tb\hat{y}_{t-2} \\ vi\hat{x}_{t-2} \\ vi\hat{x}_{t-2} \\ \hat{R}_{t-2} \end{bmatrix} + \begin{bmatrix} u_{t}^{y} \\ u_{t}^{i} \\ u_{t}^{vix} \\ u_{t}^{vix} \\ u_{t}^{r} \end{bmatrix}$$
(4.1)

where \hat{y}_t stands for real gross Hungarian output, \hat{i}_t denotes real gross Hungarian investment, tby_t is the trade balance to output ratio, $vi\hat{x}_t$ denotes the Volatility Index of the S&P 500, and \hat{R}_t denotes the gross real Hungarian interest rate. A hat on \hat{y}_t and \hat{i}_t denotes log deviations from a HP trend. A hat on $vi\hat{x}_t$ and \hat{R}_t signs that they are in log form. We measure \hat{R}_t as the sum of JP Morgan's EMBI Hungary stripped spread and the US real interest rate.

By identifying the structure of the model, we applied very similar theoretical assumptions to that of *Model 1*. Real domestic shocks $(\varepsilon_t^y, \varepsilon_t^i, \varepsilon_t^{tby})$ affect financial markets contemporaneously, whereas innovations in the VIX and in the country interest rate $(\varepsilon_t^{vix}, \varepsilon_t^r)$ only percolate into domestic real variables with a one-period lag. That is, financial variables instantaneously incorporate all available information, whereas the adjustment process for real variables is rather sluggish.

As for the VIX index, we assume that it follows a simple univariate AR(1) process, therefore the same restrictions could be imposed as for the US Treasury bill rate in *Model 1*: $A_{0,4i} = 0$ for i=1,2,3,5. This restriction is based on the reasonable assumption that neither the real, nor the financial indices of Hungary have an effect on the American volatility index of options. To check the validity of our additional restrictions, we have examined the Grangercausality statistics of our model, and concluded that the lagged values of the other variables did not help to predict $vi\hat{x}_i$. (The coefficients on the lags of the other four variables are insignificant or zero in the reduced form $vi\hat{x}_i$ equation.)

4.2 Data

Our dataset consists of quarterly data over the period 2000Q1 to 2009Q4. The following Table gives a detailed summary of the characteristics of our dataset.

	Abbreviation	Unit	Source	Conversion
Output, \hat{y}_t	GDP_HAT	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	Log-deviation from its HP trend
Investment, \hat{i}_t	INVESTMENT_HAT	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	Log-deviation from its HP trend
Trade balance to GDP ratio, tby _t	ТВҮ	Millions of national currency, chain-linked volumes, reference year 2000	Eurostat	(Exports-Imports)/GDP
Volatility index of S&P 500	VIX_HAT	Percentage points	Yahoo Finance	Log of Volatility Index of S&P
Hungarian interest rate, \hat{R}_t	R_HU_HAT	Percentage points	IFS; Eurostat; MNB	Log of ((Gross US Treasury bill rate/ Average Gross US inflation of previous four quarters)+EMBI Hungary stripped spread)

4.3 Reduced Form Estimation Output

Table 4 shows the system parameters estimated equation by equation. All equations were estimated by OLS using our quarterly series from the period 2000 Q1 – 2009 Q4. The lag length of two was chosen according to the Akaike Information Criterion test result. The $vi\hat{x}_t$ follows an AR(1) process, i.e. it is regressed on its first lag. Standard errors are shown in parenthesis.

Table 4 Reduced form Parameter estimates of the VAR system of Model 2

Independent variable	Dependent variable						
independent variable	GDP_HAT	INVESTMENT_HAT	TBY	VIX_HAT	R_HU_HAT		
GDP_HAT	-	-2.796 (1.740)	-0.068 (0.730)	-	-4.348 (9.848)		
GDP_HAT(-1)	1.587 (0.168)	11.67 (3.168)	-0.078 (1.558)	-	-10.73 (20.99)		
GDP_HAT(-2)	0.550 (0.242)	-8.761 (2.430)	0.181 (1.186)	-	15.35 (15.99)		
INVESTMENT_HAT	-	-	-0.155 (0.077)	-	1.360 (1.120)		
INVESTMENT_HAT(-1)	-0.022 (0.016)	0.457 (0.156)	0.056 (0.071)	-	-1.152 (0.992)		
INVESTMENT_HAT(-2)	-0.009 (0.018)	0.080 (0.168)	0.153 (0.067)	-	1.1028 (1.003)		
TBY	-	-	-	-	-0.144 (2.641)		
TBY(-1)	-0.033 (0.045)	0.181 (0.424)	0.754 (0.171)	-	-1.370 (3.047)		
TBY(-2)	0.021 (0.051)	0.473 (0.474)	0.336 (0.193)	-	2.866 (2.760)		
VIX_HAT	-	-	-	-	0.377 (0.211)		
VIX_HAT(-1)	0.001 (0.004)	0.031 (0.039)	-0.026 (0.016)	0.990 (0.021)	-0.261 (0.273)		
VIX_HAT(-2)	-0.001 (0.004)	-0.049 (0.041)	0.021 (0.016)	-	-0.245 (0.241)		
R_HU_HAT(-1)	0.003 (0.003)	-0.143 (0.032)	-0.008 (0.017)	-	0.899 (0.234)		
R_HU_HAT(-2)	0.002 (0.003)	0.113 (0.030)	0.002 (0.014)	-	-0.267 (0.202)		

R-squared	0.9472	0.8101	0.9278	0.6693	0.8562
S.E. equation	0.0048	0.0447	0.0179	0.2151	0.2416
No. of obs.	38	38	38	39	38

4.4 Structural Form Estimation Output

The structural VAR estimations using A_0 and B_0 , from (1.4) yielded the following

estimated structural factorization matrices:

Structural VAR Estimates

Model: Ae = Bu where E[uu']=I					
Estimated A matrix	::				
1.000000	0.000000	0.000000	0.000000	0.000000	
3.575133	1.000000	0.000000	0.000000	0.000000	
0.704688	0.173575	1.000000	0.000000	0.000000	
0.000000	0.000000	0.000000	1.000000	0.000000	
7.323299	-1.222103	0.545476	-0.346268	1.000000	
Estimated B matrix	:				
0.004335	0.000000	0.000000	0.000000	0.000000	
0.000000	0.044173	0.000000	0.000000	0.000000	
0.000000	0.000000	0.016826	0.000000	0.000000	
0.000000	0.000000	0.000000	0.213709	0.000000	
0.000000	0.000000	0.000000	0.000000	0.226781	

With an estimate of the Structural VAR system of *Model 2* at hand, we finally posses due estimation results in order to address three central questions: First, how do global financial sentiment shocks and Hungarian interest rate shocks affect real domestic variables such as output, investment and the trade balance? Second, how does the interest rate on dollar-denominated Hungarian Treasury bills respond to changes in the global financial sentiment? Third, how and by how much does the real yield on dollar denominated Hungarian Treasury bills move in response to innovation in Hungarian business cycle fundamentals? The revelation of the answers requires thorough analyses of the impulse response functions.

Figure 4 displays the effect of an unexpected one unit increase in the Hungarian interest rate, whereas Figure 5 displays the effect of an unexpected one unit increase in the

Volatility Index of S&P 500. A two standard error band is depicted around the impulse responses. The responses of output and investment are expressed in percent deviation from their respective HP trend, the responses of the trade balance to output ratio, the Hungarian interest rate and the Volatility Index of S&P 500 are expressed in percentage points.

Figure 4: Impulse responses to a Hungarian interest rate shock



Investment



Trade-Balance-to-GDP-Ratio





Volatility Index of S&P500



Hungarian Interest Rate



The impulse responses to a Hungarian interest rate shock are both qualitatively and quantitatively similar to the impulse responses of the Hungarian interest rate shock in *Model 1*, and accordingly, to that of Uribe and Yue (2005). The Hungarian interest rate increases at the moment of the shock, and then gradually returns back to its steady state level in four-and-a-half quarters. In the following three quarters, however, it seems to experience an

undershooting before it eventually finds back its way to its steady state level. Due to our identification assumption about the sluggishness of output, investment and the trade balance, these variables remain unchanged at the moment of the shock. Afterwards, they decline for two quarters before they gradually recover within the following four or five quarters. The overshooting of output and investment in the following five quarters is corresponding to the undershooting of the interest rate in these periods. The trade balance to output ratio increases for three quarters, and then quickly returns back to its pre-shock level by the end of the fourth quarter following the shock. A slight undershooting in the following five periods is in line with the respective interest rate movements. The Volatility Index of S&P500 is unaffected by the Hungarian interest rate shock.

Figure 5: Impulse responses to a shock in the Volatility Index of S&P500

Output

Investment



Trade-Balance-to-GDP-Ratio





Volatility Index of S&P500



Hungarian Interest Rate



The impulse responses to a shock in the Volatility Index of S&P 500 provide a transparent empirical proof for the spill-over effect of global financial sentiment. The effect of changes in global investors' risk appetite is transmitted to Hungarian domestic variables through the interest rate channel. Due to a heightened level of the interest rate for threequarters following the VIX shock, output and investment decline for a much larger time period than in case they are exposed to a Hungarian interest rate shock of equal magnitude. The two real variables, output and investment, remain significantly dampened for a tenquarter period following the shock, which implies that the Hungarian business cycle is broadly affected by global investors' risk appetite. There is, however, one impulse response which displays a reverse reaction to corresponding empirical results on Latin-American country spreads (Uribe and Yue, 2005; Eichengreen and Mody, 2001; Arore and Cerisola, 2001). The impulse response of Hungarian trade balance gradually declines after a VIX shock, whereas Latin-American trade-balances typically increase at times of heightened market uncertainty in the United States. The interpretation of this result can be traced back to the different structures of the Hungarian and Latin-American exports. Silver, gold and natural sources, all of them typical targets of the flight to quality incident, take up a substantial part of Latin-American exports, whereas Hungary mainly exports manufactured and technological goods to its European neighboring countries, where demand decreases at times of global recessions.

In the next step, we examine the variance decomposition of our SVAR system, which separates the variation in one of the endogenous variables into the component shocks to the SVAR. Thus, the variance decomposition displays important information about the relative importance of each random shock in affecting the variables in the system. Our forecasting horizon of 18 quarters is chosen according to the commonly used definition of business cycles in the literature. Stock and Watson (2001) assert that a business cycle is defined as a period between 6 and 32 quarters, depending on the country analyzed.

About 25% of the variation in the Hungarian interest rate is explained by innovations in the Volatility index of S&P500, which implies that the interest rate responds systematically to changes in the global financial sentiment. At the same time, a much larger part (45%) of the fluctuations in the Hungarian interest rate is explained by domestic macroeconomic fundamentals. As for the decomposition of the Hungarian GDP and investment shocks, Figure 5 shows that the Volatility index of S&P500 shock accounts for about 10-15% of aggregate fluctuations in Hungary. Volatility index shocks and Hungarian interest rate shocks are together responsible for about 45% of movements in investments.

Figure 5



Here, Shock1 stands for the output shock, ε_t^{y} ; Shock2 stands for the investment shock, ε_t^{i} ; Shock3 stands for the trade balance shock, ε_t^{tby} ; Shock4 stands for the shock of the Volatility index of S&P500, ε_t^{vix} ; and Shock5 stands for the Hungarian interest rate shock, ε_t^{r} .

4.5 Robustness check

In order to check the robustness of *Model2*, we considered various alternatives to our own identification scheme.

First, we experimented with financial indicators, which seemed to be potential candidates for being statistically and economically superior measures of global financial sentiment to the Volatility index of the S&P 500. Using the EMBI Hungary stripped spread, we managed to built a model that satisfied the VAR stability conditions. Nevertheless we rejected the validity of this model for two reasons. First of all, an endogeneity problem

evolves when we put the global EMBI index and the Hungarian interest rate in a Structural VAR system, which relies on the identification considerations depicted earlier. Our second reason for rejecting this model was the weak significance of the impulse responses which is a direct consequence of the identification problem.

Then, various alternative domestic variables were considered. As for the choice of the domestic variables, our guiding principles were as follows. We tried to find variables that are identified in the literature as relevant motives of country spreads; that describe business cycle movements; and at the same time, we limited ourselves to a small number of these variables in order not to loose too many degrees of freedom. The most important variables we tried to fit in our model were detrended measures of the Hungarian budget deficit and the government debt, both of which did not seem to develop the overall fit of the model. This result might be surprising as the government debt or the external-debt-to-GDP ratio is considered to be one of the most important motives of country risk assessment. However, the literature on the relationship of government debt and country spreads states that the government debt affects the latter only in case the level of the debt is higher than a certain threshold. Under this threshold, it does not play a role in the risk assessment of the country (see, for instance, Reinhart, Carmen, and Rogoff (2010). And, considering the fact that our sample embraces a highly diverse period in terms of government debt, it should not be surprising that none of the measures of Hungarian debt turned out to be significant in our model. Another explanation for our empirical observation that the government debt does not Granger-cause the Hungarian country risk assessment, is the significantly positive correlation between the trade balance to output ratio and the detrended government debt. (The correlation coefficient of the detrended government debt and the trade-balance-to-output-ratio is 0.83 in out sample.) Economic theory suggests that the exchange rate channel plays an important role in explaining the strength of this interrelation. When the exchange rate increases, that is, the Hungarian currency devaluates, the foreign currency-denominated government debt increases and, at the same time, exporters enjoy a relatively favorable business environment, therefore the tradebalance ameliorates.

On the whole, we did not find any set of real variables that would have outperformed the robustness of output, investment and trade balance. Therefore we concluded that the most representative variables of Hungarian domestic activity as well as the global financial sentiment were the ones applied in *Model2*.

5 CONCLUSION

This thesis paper attempted to disentangle the interconnections between the global financial sentiment, the Hungarian interest rate and the Hungarian business cycles. We built two Structual VAR models: the first one is based on Uribe and Yue (2005), and uses the US Treasury bill rate as a measure of global financial sentiment. The second one is our own model, and uses the Volatility Index of the S&P 500 as a measure of global financial sentiment. While the overall fit of the first model did not meet our expectations, the second model provided an appropriate identification scheme for quantifying the impact of changes in investors' risk appetite on the Hungarian interest rate and domestic economy. The variance decomposition of our own model pointed out that about 25% of the variation in the Hungarian interest rate is explained by innovations in the Volatility index of the S&P500, which implies that the interest rate responds systematically to changes in the global financial sentiment. At the same time, a much larger part (45%) of the fluctuations in the Hungarian interest rate is explained by domestic macroeconomic fundamentals. As for the decomposition of the Hungarian GDP and investment shocks, we found that shocks in the Volatility index of the S&P500 account for about 10-15% of aggregate fluctuations in Hungary. Volatility index shocks and Hungarian interest rate shocks are together responsible for about 45% of movements in investments.

The search for an empirical model that best proxies for global market volatility, and the Hungarian fundamentals is a complicated task, and we do not claim that we have found the true underlying structural model that reveals all observable coherences. Several other methodologies and approaches are available to model the determinants of country risk. In particular, future research could explore the role of the Hungarian monetary authority in determining the degree to which the transmission channel amplifies or dampens the impact of innovations in global financial sentiment.

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Appendix

MODEL1

VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: R_US_HAT					
Excluded	Chi-sq	df	Prob.		
GDP_HAT INVESTMENT_H	0.068785	2	0.9662		
AT	1.777286	2	0.4112		
TBY	0.032745	2	0.9838		
R_HU_HAT	2.692204	2	0.2603		
All	7.186951	8	0.5166		

VAR Lag Order Selection Criteria

Endogenous variables: GDP_HAT INVESTMENT_HAT TBY R_US_HAT R_HU_HAT Exogenous variables: C

Lag	LogL	LR	FPE	AIC	SC	HQ
0	170.1396	NA	5.49e-11	-9.436549	-9.214357	-9.359848
1	293.4981	204.4227	2.02e-13	-15.05704	-13.72388*	-14.59683
2	327.8804	47.15289*	1.30e-13*	-15.59317*	-13.14905	-14.74946*
3	348.8997	22.82085	2.10e-13	-15.36569	-11.81061	-14.13848

* indicates lag order selected by the criterion

VAR Residual Correlograms



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MODEL2

VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable: VIX_HAT

Excluded	Chi-sq	df	Prob.
GDP_HAT INVESTMENT H	0.185550	2	0.9114
AT	2.474406	2	0.2902
TBY	0.152505	2	0.9266
R_HU_HAT	0.720994	2	0.6973
All	8.528313	8	0.3836

VAR Lag Order Selection Criteria

Endogenous variables: GDP_HAT INVESTMENT_HAT TBY VIX_HAT R_HU_HAT Exogenous variables: C

Lag	LogL	LR	FPE	AIC	SC	HQ
0	180.5146	NA	5.22e-11	-9.487275	-9.269584	-9.410529
1	315.0377	225.4171	1.42e-13	-15.40744	-14.10129*	-14.94696
2	352.4394	52.56461*	7.86e-14*	-16.07781*	-13.68320	-15.23360*
3	375.9240	26.65813	1.05e-13	-15.99589	-12.51282	-14.76795

* indicates lag order selected by the criterion

VAR Residual Correlograms











