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Economic Infrastructure, Private Capital Formation, and FDI inflows to Hungary: A Unit Root and Cointegration Analysis with Structural Breaks.

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Economic Infrastructure, Private Capital Formation, and FDI inflows to Hungary: A Unit Root and Cointegration Analysis with Structural Breaks.

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This paper investigates the important question of what relationship, if any, exists between economic infrastructure, gross fixed capital formation, and FDI inflows to Hungary during the 1995-2012 period. Although this question has great significance from an economic policy standpoint, there has been little to no empirical analysis undertaken so far in the case of transition economies such as Hungary. Utilizing single- break unit root and cointegration analysis, this study finds a stable long-run relationship among the included variables, thus an error correction model is developed to capture both the short-and long-run behavior of the variables. In the short run, lagged changes in economic infrastructure, as well as lagged changes in private capital formation are positively associated with changes in FDI inflows; a dummy variable to capture the 2008 financial crisis and euro crisis has a negative and highly significant effect. In the long run, however, FDI inflows and private capital formation are substitutes for one another, while economic infrastructure crowds in private capital formation. The real effective exchange rate is positively correlated with FDI inflows in the long run, but not in the short run. The VEC model leads to the general conclusion that FDI flows and real GFCF have a significant short-run adjustment mechanism, while economic infrastructure and the real exchange rate can be treated as weakly exogenous. (JEL, C22, F21, O52).

Key words : *Granger causality test, error correction model (ECM), foreign direct investment (FDI), Gregory-Hansen single-break cointegration test, Gross fixed capital formation (GFCF), Johansen cointegration test, KPSS unit root test, vector error correction model (VECM), Zivot-Andrews single-break unit root test.*

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1. Introduction

The relationship between foreign direct investment (FDI) flows, economic infrastructure, and private capital formation in developing countries is an important, controversial, and widely discussed topic in economics. It is important because a rapid and sustained rate of private capital formation is the basis for future economic growth and employment creation in both developed and emerging nations. It is also a source of controversy because the literature analyzing the impact of FDI flows and economic infrastructure spending on private capital formation (and vice versa) does not speak with one voice regarding the strength of the relationship or the direction of causality, given that it tends to vary from country to country and over time. Local economic and political factors strongly influence the macro variables in question, which makes country-specific analysis particularly important. As with most developing and transition economies, sufficiently long time-series have only recently become readily available for some macro variables; the FDI dynamics of transition economies such as Hungary or Czech Republic, important as it is, is not yet a well-researched nor understood topic in the literature. To the best of our knowledge, there is no extensive time-series analysis of the impact of economic infrastructure on private capital formation or FDI inflows in the Hungarian case, which makes studying this question all the more vital.

During the 1995-2012 period Hungary's economy changed from a post-transition economy to a fast growing, market-based, and outward-oriented economy. Some indication of this can be garnered from the following figures: the country's exports of goods and services as a proportion of its GDP rose from 45.2 percent in 1995 to 71.2 percent in 2001, and a high of 81.7 percent in 2008 before it was hit by the global crisis of 2008-09 (World Bank, 2012). More importantly, from the standpoint of this study, gross fixed capital formation--the country's source of future growth and employment creation—also experienced a robust increase, particularly during the 1998-2008, when it grew at an average annual rate of 4 percent, reaching 23.5 percent of GDP in 2008. Finally, value added in industry and services grew, respectively, at an impressive average annual rate of 4.1 percent and 3 percent during the 1998-2008 period and, as a percentage of GDP, industry value added rose from 28 percent in 1994 to almost 31 percent in 2008, while that of services increased from 62.5 percent to 66.1 percent (World Bank, 2012).

In fact, Hungary led the way among the Eastern Central European countries in terms of socioeconomic and political reforms during the transition period and became highly integrated with the EU countries, so much so that over 70 percent of its trade is now undertaken with European countries. The country's rapid integration with the West culminated in its accession to the European Union in 2004, but not the adoption of the euro as it tries to meet the Maastricht Convergence criteria. However, during the period in question Hungary slowly lost its initial regional advantage. The transition created multi-layered and long-lasting social and economic problems. The economy was shaken after the "post-accession crisis" and the market opening of the new EU member states and, as discussed below, was hard hit by the global economic crisis of 2008-2009 due to high levels of private and public borrowing (Hungary 2012, BTI).

The opening and integration of the Hungarian economy has also led to a surge in inward FDI flows, with FDI inflows as a percentage of GDP rising from 2.7 percent in 1994 to 7.5 percent in 2001, and an incredible 48.6 percent in 2008.Table 1 below shows that, from the standpoint of contributing to the financing of gross fixed capital formation, FDI inflows as a percentage of gross fixed capital formation rose impressively from 24.1 percent in 2000 to 33.7 percent in 2005, and an incredible 75.5 percent in 2007! (computed from World Bank Development Indicators, 2012). As can be surmised from Table 1, FDI flows as a percentage of gross fixed capital formation averaged an impressive 30.3 percent for the 1998-2006 period, excluding the very high figures for 2007 and 2008 which appear to be anomalous and may have been influenced by the 2008-09 crisis. Insofar as the stock of FDI is concerned, it more than quadrupled between 2000 and 2009, from $22.8bn to $99.1bn—the latter figure representing 78.3 percent of the country's gross domestic product (UNCTAD, 2012).

Table 1. Hungary: FDI flows as a percentage of Gross Fixed Capital Formation, 1998-2008*

Country:	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Hungary	29.7	28.9	24.1	31.8	19.2	11.6	18.5	33.7	75.5	238.7	223.9

*Source: Computed from World Bank (2012), World Bank Indicators.

In 2009 the country was severely hit by the global crisis of 2008-09 and its GDP plummeted by 6.8 percent only to recover slowly since then, growing by 1.3 percent in 2010 and 1.7 percent in 2011. The unemployment rate also jumped from 7.4 percent in 2007 to 10 percent in 2010 and 10.9 percent in 2011 and, more worrisome, the percentage of long-term unemployed relative to total unemployed rose from 47.5 percent in 2007 to 50.6 percent in 2010. Not surprisingly, FDI inflows to the country were negatively affected as they plummeted from an average of $6.3bn in 2005-2008 to an average of only $2.9bn over the 2009-2011 period (UNCTAD, 2012). Finally, gross fixed capital formation which had grown so impressively up to the eve of the crisis, dropped precipitously in 2009 by 29.3 percent and its ratio to GDP fell to 17.9 percent in 2010 and 16.7 percent in 2011 (World Bank, 2012).

The most detailed time-series analysis of the economic role of FDI in Hungary is by Balatoni and Pitz (2012) who report that the FDI/GDP ratio in Hungary, already the highest among Eastern European countries in 1995, rose from 24.5 percent in 1995 to 71.0 percent in 2010. They also indicate that 68 percent of FDI inflows are invested by other European countries, mostly EU member states, and that 82 percent of these flows are channeled to the services sector. According to the Central Statistical Office of Hungary foreign subsidiaries of TNCs operated more efficiently and paid higher wages than domestic firms and accounted for between 60 and 70 percent of Hungarian exports in 2006-2009. However, there are few, if anytime series studies which investigate the relationship between Hungarian FDI and other key macro variables. For example, Mileva (2008) using a pooled analysis for 22 transition economies (including Hungary) found that FDI has a positive effect on total factor productivity via spillover effects and enhanced domestic investments. In their study, Balatoni and Pitz (2012) undertook a cointegration analysis to examine the relationship between FDI inflows (as a proportion of GDP), GNI, and Total

Factor Productivity (TFP). Their findings suggest that FDI inflows not only accounted for 69-89 percent of the average annual GDP growth over the 1995-2009period, but contributed to enhanced TFP growth—more so than other sources of financing (loans and portfolio investments).

To the best of our knowledge, there are no rigorous time series studies which examine the direction of causality and/or strength of the potential feedback between FDI inflows and economic infrastructure, the real exchange rate, and private capital formation for Hungary in the presence of structural breaks. In view of this, we investigate the economic relationship between Hungarian gross fixed capital formation, the Hungarian Forint/Euro real effective exchange rate, gross value added in economic infrastructure, and Foreign Direct Investment during the period 1995-2012 using quarterly data. The paper is organized as follows. First, it develops a conceptual framework of analysis that seeks to identify some of the major economic and institutional determinants of private capital formation and FDI inflows. Second, the paper briefly discusses the nature and sources of the data used in this study. Third, single-break unit root and multivariate Johansen cointegration analysis is undertaken, respectively, to investigate the time series properties of the variables and whether a unique long-run (equilibrium) relationship exists among them. This study also undertakes a Gregory-Hansen cointegration test with a level shift (break) in the data. It is determined that a unique contegrating relationship exists which makes it possible to generate an error correction model that reconciles the short-and long-run properties of the estimated model. That is, it enables the investigator to determine the structural relationship among the variables in the long run, as well as their short-run adjustment back to the equilibrium relationship. Fourth, a more general VECM framework is estimated to investigate the causal relationships and the adjustment process of the variables in the system as a whole; it is determined that a negative adjustment process exists for two equations in the system and that the real effective exchange rate and economic infrastructure spending are weakly exogenous. The concluding section summarizes the main results and points to some shortcomings in the estimated model that can be addressed by future research and data availability.

2. Conceptual Framework

Economic theory suggests that FDI inflows to developing countries increase their stock of capital or private capital formation which, in turn, raises the host country's labor productivity and incomes, a process that eventually translates into higher levels of output, employment creation, and potential tax revenues. A similar line of reasoning can be undertaken for increases in the stock of public capital provided that the latter is directed to expenditures on roads, highways, bridges, and ports—expenditures that complement rather than substitute for private capital formation (see Aschauer, 1989; and Ramirez, 1994). In addition to the direct effects of FDI, De Mello (1997), Huang (2004) and Kehal (2005) observe that indirect positive spillover effects on overall efficiency may arise from the enhanced competition generated by foreign firms, the transfer of needed technology and managerial knowhow to local firms, and trade-induced learning-by-doing effect as local firms attempt to overcome competition in the global market.

The voluminous empirical literature on the hypothesis of FDI-Led Growth (FLG) by no means speaks with one voice but, in general, finds in cross-country studies that the "nexus between FDI and the host country's growth in private capital formation (or GDP growth) seems generally positive" when host countries adopt a more liberalized trading regime (see De Mello, 1997; Huang, 2004; Kehal, 2005; Ram & Zhang, 2002; Zhang, 2001;). Recent country studies also suggest that export-oriented FDI, such as that undertaken by TNCs in Chile, Mexico and China, may promote exports (and private capital formation) by establishing assembling plants and helping host firms access international markets for exports (see Aitken et al., 1997; De Mello 1997; Zhang, 2001). Other country studies, notably by Chakraborty and Basu (2002) for India and De Mello (1997) for Brazil, have found no support for the FLG hypothesis; in fact, their empirical work suggests that the line of causality runs from private capital formation (or GDP) growth to FDI.–a finding consistent with the market-seeking FDI hypothesis of Dunning (1988) and Mortimore (2003), viz., that FDI is attracted to growing internal markets for services such as telecommunications, gas and electricity, retail commerce, and financial services.

FDI flows may also have a negative effect on the growth prospects of a country if they give rise to substantial reverse flows in the form of remittances of profits and dividends and/or if the TNCs obtain substantial tax or other concessions from the host country. These negative effects would be further compounded if the expected positive spillover effects from the transfer of technology are minimized or eliminated altogether because the technology transferred is inappropriate for the host country's factor proportions (e.g., too capital intensive); or, when this is not the case, as a result of overly restrictive intellectual property rights and/or prohibitive royalty payments and leasing fees charged by the TNCs for the use of these "intangibles" (see Ram & Zhang, 2002; and Kehal, 2005)

After Ram and Zhang (2002) and Ramirez (2000), it is possible to analyze the potential impact of inward FDI (or public capital) on private capital formation and economics growth in Hungary by appealing to the modified neoclassical production function given in equation (1) below.

$$Y = AF [L, K_{p,} K_{f;} ; \alpha_i] \qquad (1)$$

$F_1, F_2 > 0; F_{11}, F_{22} < 0; F_{12} > 0;$

$F_3 > 0; F_{13} \geq 0; F_{23} \geq 0$

$<$ $<$

where: Y is the level of real output; L denotes labor; K_p is the stock real private capital; K_f refers to the stock of real FDI capital (K_g , the stock of public capital, can also be included as an additional argument, but is excluded to simplify the presentation without loss of generality); A captures the efficiency of production; and α_i represents other relevant variables that researchers have incorporated into the modified production function to explain the level of GDP such as real exports of goods and services, real bank credit to the private sector, and real government consumption expenditures (see De Mello, Jr., 1997).

By treating the stock of FDI (or the stock of public capital) as a separate input in the production function, a *ceteris paribus* increase in inward FDI gives rise to three conceptually distinct effects. First, if the stock of FDI capital is productive and complements the private capital stock by augmenting domestic savings and investment, a *ceteris paribus* increase in the stock of FDI capital will increase output directly in the same way that an increase in any other factor of production raises output ($F_3 > 0$). Secondly, if it generates (unmeasured) positive spillover effects via the transfer of advanced technology and managerial skills to local firms, then it will indirectly increase private investment and output by further raising the marginal productivity of domestic capital ($F_{23} > 0$) relative to the real interest rate. Third, it will increase output via its positive impact on the marginal productivity of labor; i.e., by increasing the amounts of both domestic private and foreign capital per worker (F_{12} and $F_{13} > 0$). A similar line of reasoning can be undertaken with respect to increases in the stock of public capital (see Aschauer, 1989; and Ramirez, 1994).

From the standpoint of the host country, FDI is usually considered to be a source of external financing that is relatively more stable and involves a longer term commitment than portfolio flows such as bond and equity investments. For capital scarce economies such as Hungary's, FDI is essential for financing private capital formation and promoting economic growth. FDI inflows also bring modern technology and managerial know-how which promotes economic growth and encourages the development of financial markets (Ramirez, 2006; and Kumar, 2007). This technological and managerial transfer, particularly if it involves the establishment of new enterprises in leadings sectors—so-called "Greenfield investments"--generally has a positive spillover effect on the country's economy as a whole.[1] The majority of the literature has found a strong connection between the economic growth of the host country and the inflow of FDI(see Chakraborty and Basu 2002, Huang, 2004, Kehal, 2005, Ram and Zhang, 2002,Ramirez, 2006).

Another important factor in determining private capital formation (or FDI inflows) in developing is the real exchange rate, given that most capital inputs and intermediate goods are imported (and denominated

[1]However, the short-and long-run effects of FDI can differ from each other and might even be negative for the country's economy if it leads to the elimination of domestic firms and/or substantial reverse flows of profits and dividends to the parent company that divert resources away from financing domestic capital formation (see Ram and Zhang, 2002).

in euros or dollars); it is also the most important link between economic policy and international competitiveness. However, there is no consensus in the literature as to whether a real depreciation or appreciation of the exchange rate stimulates private capital formation or FDI inflows, ceteris paribus. On the one hand, if the domestic currency depreciates in real terms, it raises the domestic currency costs of imported capital inputs and intermediate goods, thus lowering profits and investment levels (particularly in those industries that lack mark-up rules for passing rising costs to consumers in the form of higher prices). On the other hand, it could encourage FDI inflows and private capital formation because it reduces the costs of domestic inputs and enhances the competitiveness of leading export-oriented sectors in the economy by lowering the foreign currency price of domestic goods, for a given set of domestic prices. Therefore, the effect of the depreciation of the host country's currency on both private capital formation and FDI inflows is ambiguous and depends on which of the above mentioned factors is stronger.

Finally, it is likely that there is bidirectional causality between FDI flows and other macro variables (including the real exchange rate and infrastructure expenditures). For example several studies have found that higher inflows of FDI have a positive effect on GDP as it leads to greater private investment spending, exports, and production (see De Mello, 1997; Zhang, 2001). On the other hand, other studies suggest that the line of causation runs the other way, viz., robust private capital formation (or GDP growth) acts as a proxy for a larger market size which, in turn, attracts market-seeking FDI (see Mortimore, 2003). Clearly, modeling the macro determinants (and impact) of FDI or private capital formation in a developing or transition economy such as Hungary's is fraught with conceptual challenges and empirical difficulties that, in the best case scenario, can only lead investigators to formulate tentative conclusions..

3. Data

The data used in this study were obtained from the databases of the National Bank of Hungary (NBH), the Hungarian Central Statistical Office and Haver Analytics. The data is quarterly for the period 1995

Q1 – 2012 Q4 (72 observations for each variable).The Stock FDI variable is measured in millions of Hungarian Forints (HUF) and it is seasonally adjusted at constant prices, using the 1995 Q1 price levels.[2] The real gross domestic fixed capital formation variable is measured in constant average prices of 2005 and it is also seasonally adjusted. The exchange rate variable used in this paper is the real effective exchange rate index--a CPI-deflated (2005=100) index relative to 16 trading partners. Basically, it takes into account the average relative real purchasing power of the domestic currency relative to the currencies of its main trading partners. An increase in the real effective exchange rate denotes a real average effective appreciation of the Hungarian Forint relative to the currencies of its trading partners. Finally, the economic infrastructure variable, also seasonally adjusted, is proxied by gross value added in transportation, communication, and information, and it is measured in millions of Hungarian Forints at constant 2005 prices.

4. Unit Root and Cointegration Analysis

4.1.Stationarity

Before including time series in regression analysis, it is critical to test for unit roots or non-stationarity in order to avoid misspecified or spurious regressions (see Engle and Granger, 1987).Given the relatively low power of units root tests, this study used a variety of tests, including the well-known Augmented Dickey Fuller (ADF) and non-parametric Phillips-Perron test (PP) unit root tests, as well as the less well known (confirmatory) Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationary (no unit root) test to investigate the order of integration of the series. The Doldado-Sosvilla-Rivero (1990) procedure was used

[2]The FDI series used in this paper includes capital in transit flows and the operation of special purpose entities (SPE). Capital in transit (as it is defined in the database of the National Bank of Hungary (NBH)) includes large capital inflows and outflows during a short period within companies or group of companies. The capital transactions flow through special purpose entities not affecting the external financing of the resident economy. Special purpose entities (SPE) are playing a role in the intermediation of substantial financial resources within groups of companies, due to channeling funds (the direction and size of which are controlled by their parents), rather than being a target for direct investment (net flows on various financial instruments are close to zero taking a longer period).Balatoni and Pitz (2012) note that during the privatization and acquisition of formerly state-owned firms the capital in transit had a major part in inducing FDI inflows which might cause some bias in the results.

to determine the best specification of the test equation (in terms of whether to include an intercept and/or a deterministic trend while testing). The appropriate lags were determined via the Eviews 8.0 default procedure, using the more robust SBC as a criterion. Finally, Zivot-Andrews single-break unit root tests were also undertaken because the power of unit root tests is reduced significantly when the stationary alternative is true and a possible structural break is ignored. For all the included variables, the results reported in Table 2 below yield the same general conclusion, viz., the variables in level form are non-stationary while in first difference they are stationary. (See 6. Appendix A for a visual representation of the data.)

Table 2.Stationarity Tests*

	Logarithmic Level Data				First Log-Difference			
	ADF	PP	KPSS	ZA	ADF	PP	KPSS	ZA
REER	1.843	2.104	0.253***	-3.710	-8.125***	-6.772***	0.225	-8.937***
GFCF	-1.553	-1.678	0.209**	-3.734	-8.841***	-8.831***	0.079	-9.828***
SFDI	-2.266	-2.455	0.266***	-2.910	-8.856***	-9.497***	0.124	-7.295***
INFR	-0.337	-2.208	0.277***	-3.604	-13.02***	-15.24***	0.071	-8.209***

*Table 2 summarizes the results of the stationarity tests. The table contains the calculated t-statistics. * denotes a significance of 10%, ** stands for 5% and *** is for 1%. The ADF and PP test critical values are 1%: -4.09, 5%: -3.48, 10%: -3.17. The KPSS critical values are 1%: 0.216, 5%: 0.146, 10%: 0.119The Zivot Andrews critical values are 1%: -5.57, 5%: -5.08, 10 %: -4.82.

More specifically, the ADF and PP results are entirely consistent and indicate that for the level data we cannot reject the null hypothesis, while for first differences it can be rejected at the 1% level. The confirmatory KPSS LM test reverses the null hypothesis of a unit root and tests for stationarity in the variables. The KPSS test also rejects stationarity for the level data and concludes that the variables are stationarity in their first differences. The results for the Zivot-Andrews test also lead to the same general conclusion, viz., a failure to reject the null a unit root in the presence of a single structural break for the variables in level form. Overall, the results suggest that all the series used in this study are integrated of the first order, I(1) series. (A visual representation of the data is found in 6. Appendix A.)

4.2 Cointegration Analysis

Having shown that the variables are integrated of order one, I(1), it is necessary to determine whether there is at least one linear combination of these variables that is I(0). In other words, is there a stable and non-spurious (cointegrated) relationship among the regressors in each of the relevant specifications? This was done by using the Johansen and Juselius(1990) cointegration method because it is capable of determining the number of cointegrating vectors for any given number of non-stationary series (of the same order) and, unlike the ADF tests, the likelihood ratio tests used in this procedure have well-defined limiting distributions. The Johansen test includes the log of the stock of FDI, log of real GFCF, log of real infrastructure expenditures, and the log of the effective exchange rate. The number of lags in the test equation is 4, which is the usual choice when using quarterly data (other lag specifications were tried but the results were not altered).The Pantula Principle was used to select the appropriate specification of the model regarding the deterministic components, trend, and intercept of the equation. The procedure compares the trace and the Max-Eigen statistics of Models 2, 3 and 4 (in this order) to their critical values starting from the most restrictive model (no cointegration) to the least restrictive one (2 cointegrating vectors), and stops when the null hypothesis of no cointegration cannot be rejected for the first time.

Table 3. Johansen Test Results*

	Trace statistics			Max - Eigen Statistics		
R	Model 2	**Model 3**	Model 4	Model 2	**Model 3**	Model 4
0	75.991 (54.079)	67.786 (47.856)	73.336 (63.876)	43.664 (28.588)	38.375 (27.584)	40.984 (32.118)
1	32.326* (35.192)	29.411 (29.797)	32.352 (42.195)	17.775* (22.299)	17.104 (21.132)	17.475 (25.823)
2	14.550 (20.261)	12.307 (15.495)	14.877 (25.872)	9.153 (15.892)	7.032 (14.265)	8.083 (19.387)

*Table 3 reports the Trace and Max-Eigen value statistics of the Johansen cointegration method for the three relevant models .The test is conducted on the logarithmic series. R stands for the number of cointegrating vectors and the 5 % critical values of the tests are in parenthesis. Model 2 includes a constant but no trend in the cointegration equation (CE) and does not allow a trend in the VAR part of the test equation. Model 3 allows an intercept, but no trend in both the CE and the VAR parts of the test equation. Model 4 includes an intercept in both the CE and VAR, a trend in the CE, but no trend in the VAR. It should be noted that the Johansen test does not include additional exogenous variables. Although this would make the model more complete, the conclusions regarding the existence of cointegrating relationships do not change.

Based on the Pantula selection procedure, there is one unique cointegrating vector and Model 4 should be chosen because it is the last significant estimate before the null of no cointegration cannot be rejected (denoted by an asterisk for both the trace and Max-Eigen statistics). However, the estimated trend for Model 4 (available upon request) is not statistically significant (t-ratio: 1.5), which is consistent with the unit root tests for the level and differenced series suggested by the Doldado et al. procedure. Therefore, Model 3 which allows for an intercept (but no trend) in both the CE and VAR specification is selected instead to estimate the Vector Error Correction Model presented in Section 4.3; at any rate, no matter which relevant Model is chosen, there exists a unique linear combination of the I(1) variables that links them in a stable and long-run relationship.

4.3 Gregory-Hansen Single-Break Cointegration Analysis

Before turning to the EC models, it should be noted that the cointegrating test performed in the previous sections does not allow for structural breaks in the sample period, whether level (intercept) shifts or regime (intercept and slope) shifts. However, Gregory and Hansen (1996) have shown that ignoring these breaks reduces the power of conventional cointegration tests similar to conventional unit root tests and, if anything, should lead to a failure to reject the null hypothesis of no cointegrating vector, which is clearly not the case in the present study. This study therefore undertook a G-H cointegration test with level shift and the results are consistent with the Johansen test above. The G-H cointegration test (ten lags) with endogenously determined level (intercept) shift (CC) generated a minimum ADF* stat. = -6.164 [break point=2001:02] which is smaller than the tabulated 5 % critical value [-6.05 (1%); -5.56(5%)] reported by Gregory and Hansen. Thus, the null hypothesis of no cointegration with endogenously determined break is rejected at the 1 percent level of significance. It should be noted that the break date is found by estimating the cointegrating relationship for all possible break dates in the sample period. The Rats program selects the break date where the modified [trimmed] ADF* = inf ADF (τ) test statistic is at its minimum.[3]

The cointegrating equation (normalized on the log of SFDI) is reported below and it shows that the long- run estimate for the log of INFR and the log of the real effective exchange rate are positive, while the long-run estimate for the log of GFCF is negative (signs are reversed because of the normalization process);[4] the t-ratios for all included variables are significant at least at the 5 percent level for a one-tailed test. In other words, a ceteris paribus increase in real economic infrastructure and the real exchange rate (appreciation) induces FDI flows to Hungary, while a ceteris paribus increase in GFCF (a proxy for market size) reduces inflows to the country. Thus, in the long run, it appears that FDI inflows and private capital formation are substitutes for one another which is a somewhat unexpected result and in line with the critics of FDI flows to emerging nations (see Cypher and Dietz, 2004). That is, instead of augmenting the pool of resources available for financing GFCF, FDI inflows may actually divert resources away from the financing of private capital formation. The presence of one cointegrating equation from which residuals (EC terms) can be obtained also makes it possible to investigate whether there is a short-run adjustment back to the long-term relationship after a shock, using the Engle-Granger two-step procedure.

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[3] Similar significant results (at least at the 5 percent level) were obtained for the G-H test with eight and nine lags. For further details, see 6. Appendix D below.
[4] The Johansen test was also normalized on the log of real GFCF and the results are consistent with those reported in the text and are available upon request.

Table 4. Normalized Cointegration Coefficients

	LSFDI	LGFCF	LREER	LINFR	C
cointegration coefficients	1.0000	0.854	-2.218	-3.583	41.96
t-ratios		(5.94)	(-2.93)	(-7.08)	(10.2)

4.2. Short-Run Error Correction Model

Given that there is a stable long-run relationship among the relevant variables even in the presence of a structural break, it is possible to estimate an error correction (EC) model that captures both the short-and long-run behavior of the FDI relationship (Engle and Granger, 1987). The changes in the relevant variables represent short-run elasticities, while the coefficient on the EC term represents the speed of adjustment back to the long-run relationship among the variables. Treating the percentage change in FDI inflows as the "dependent" variable, an estimated EC model is reported below in terms of logarithmic differences of the variables.

$$DLSFDI_t = \beta_0 + \beta_1 DLGFCF_{t-i} + \beta_2 DLREER_{t-i} + \beta_3 DLINFR_{t-i} + \beta_4 ECT_{t-1} + u_t \quad (2)$$

$$DLSFDI_t = 0.041 + 0.215 DLGFCF_{t-1} - 0.273\, DLREER_{t-4} + 1.049 DLINFR_{t-3} - 0.485\, ECT_{t-1} \quad (3)$$

[3.871***] [5.384***] [-2.698***] [4.527**] [-5.125***]

$$- 0.103 D_{crisis} + u_t$$

[-6.198***]

R-Squared: 0.60 Adjusted R-Squared: 0.542 Prob(F): 0.000
SBC: -3.186 AIC: -3.471 DW: 2.039

The short-run estimate for real GFCF suggests that a 10 percent increase in this variable during the current quarter generates a statistically significant 2.15 percent increase in FDI flows in the following quarter; the positive effect supports Dunning's market size hypothesis and is contrary to that for the long-run relationship reported above where the effect is negative. The short-run (lagged) impact of the real effective exchange rate is negative and statistically significant at the 5 percent level, which is not consistent with its long-run effect; it suggests that a 10 percent real appreciation during the current quarter generates a 2.73 percent decrease in FDI inflows within four quarters. These results suggest that, as opposed to the long run, in the short run foreign investors focus more on the real domestic costs of labor and raw materials (which a ceteris paribus real appreciation of the domestic currency would raise in terms of the investors' currency), rather than the real rate of return on their investment *per se*. The short-run impact of economic infrastructure spending is positive and significant at the 5 percent level; it suggests that a ceteris paribus 10 percent increase gross value added in economic infrastructure during the current quarter will increase FDI inflows by 10.5 percent within three to four quarters. The lagged effect makes economic and intuitive sense because it takes time for these types of expenditures to gestate and have their full effect.[5] As the theory predicts, the EC term is negative and highly significant, suggesting that a 10 percent deviation from the long-run FDI relationship during the current quarter is corrected by about 4.85 percent in the next quarter, and by 19.4 percent on an annual basis. Finally, the dummy variable for the crisis years of 2008, 2009 (1st quarter), and 2010-11 is negative and highly significant, indicating that the economic and financial debacle of 2008-09, as well as the ongoing euro crisis, has had a damaging effect on the Hungarian economy. The adjusted R-squared is relatively high at 54.2 percent, and the p-value for the F-stat. suggests that the EC model as a whole is statistically significant at the 1 percent level. The Durbin Watson statistics is close to 2 which suggests that there is no first-order autocorrelation in the model. To ensure that the model does not suffer from higher order serial correlation, an AR(4) specification was fitted and a Breusch-Godfrey test was performed. Again, the results indicate that there is no serial correlation in the model. The non-significant p-values of the Ramsey Reset Test with 1 to 4 powers also suggest that the model is not misspecified.

[5] The length of the lags in the EC model was determined by the AIC and SBC criteria.

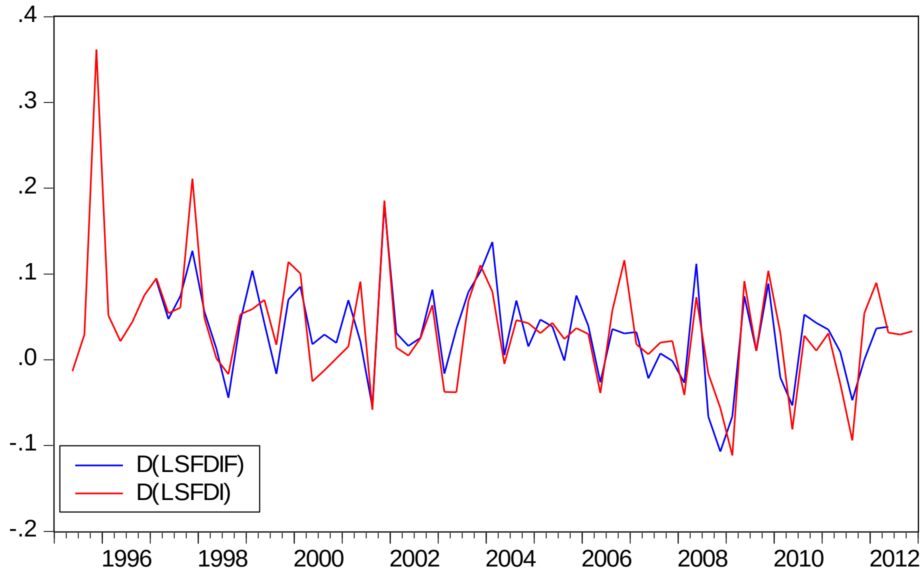
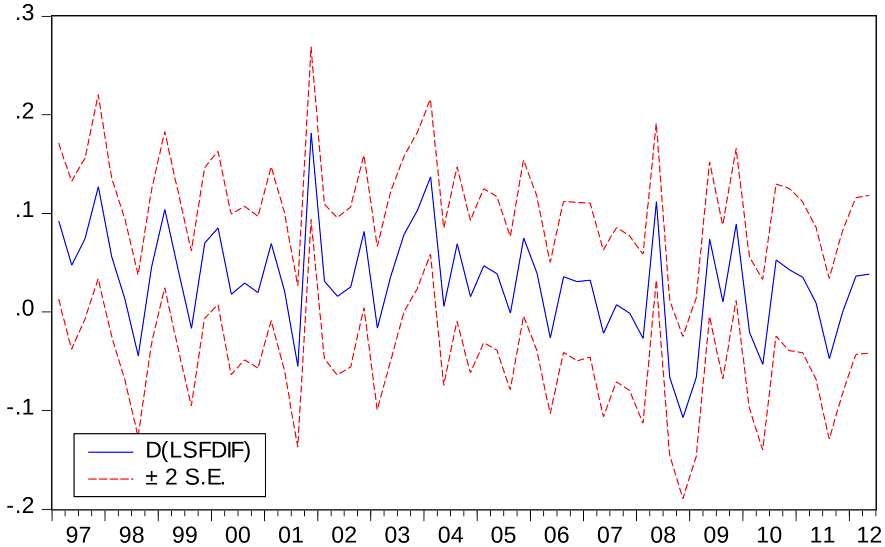


Figure 1. Actual and Simulated Percentage Changes in FDI Inflows to Hungary, 1995-2012.

The reported EC model was also used to track the historical data on the percentage change in FDI flows for the period under review. Figure1 above shows that the model was able to track the turning points in the actual series relatively well. D(LSFDI) refers to the actual series and D(LSFDIF) denotes the in-sample forecast. In addition, Figure 2 below shows that the Theil inequality coefficient for this model is 0.268, which is below the threshold value of 0.3, and suggests that the predictive power of the model is quite good (see Theil, 1966). The Theil coefficients can be decomposed into three major components: the bias, variance, and covariance terms. Ideally, the bias and variance components should equal zero, while the covariance proportion should equal one. The reported estimates suggest that all of these ratios are relatively close to their optimum values (bias= 0.0000, variance= 0.0315, and covariance = 0.9684). Sensitivity analysis on the coefficients also revealed that changes in the initial or ending period did not alter the predictive power of the selected models (results are available upon request).



Forecast: D(LSFDIF)	
Actual: D(LSFDI)	
Forecast sample: 1995Q1 2012Q4	
Adjusted sample: 1997Q1 2012Q2	
Included observations: 62	
Root Mean Squared Error	0.034453
Mean Absolute Error	0.027419
Mean Abs. Percent Error	116.9413
Theil Inequality Coefficient	0.268153
Bias Proportion	0.000000
Variance Proportion	0.031544
Covariance Proportion	0.968456

Figure 2. Theil Inequality Coefficient, 1995-2012.

4.3. Vector Error Correction Model

The VECM framework allows investigators to model the short-run correction mechanism of a system of variables to their long-run equilibrium without deciding, apriori, about the endogeneity or exogeneity of the included variables. The vector autoregressive framework treats all variables as endogenous and determines the direction of causality between them based on econometric tests instead of assuming exogeneity based on economic theory. The VAR/VECM modeling has faced severe criticism because of its atheoretic, empirically-based methodology, though it often generates better forecasts than the complex economic theory based-models. In our case there are advantages from not predetermining the direction of causality. First, as indicated in Section 2, there is no consensus in the literature about the direction of causality between the exchange rate, GFCF, FDI flows, and economic INFR. Second, Hungary is not only a developing country, but a relatively small economy that has experienced significant structural and institutional change and opened itself to the West in a very short period of time—as attested by its accession to the EU in 2004 and the negative aftermath it experienced in the wake of the great recession of 2008-09. This could cause any predictions from economic theory about the behavior of some key macro variables to deviate significantly from their actual trajectory. Thus, the flexibility of this specification represents a distinct advantage in modeling the system-wide error correction mechanisms of the relevant variables. VECM specifications can only be estimated if there is a cointegrating relationship among the variables which, according to the Johansen test, is indeed the case for our study.

First, an unrestricted VECM is estimated using LSFDI, LGFCF, LREER, and LINFR variables to examine whether a system-wide error correction mechanism exists for these variables. The VECM is estimated based on Model 3 with 7 lags (based on AIC and SBC criteria) to allow for the impact of real infrastructure expenditures which, a priori, is likely to have a delayed effect on FDI inflows.[6] The unrestricted VECM finds a negative and highly significant adjustment coefficient for two of the four equations, viz., the D(LFSDI) and D(LGFCF) equations. This means that for these system equations there is a short-run adjustment mechanism to the equilibrium relationship when shocks to the system are sustained. The best specification, based on the adjusted R-squared values and the AIC/SBC criteria, is the equation with D(LSFDI) as the “dependent variable”. In this specification, the long-run cointegration equation has significant coefficients for all the variables and is consistent with the results obtained for the Johansen test in the previous section.[7] *(See 6 Appendix B).*

Turning to the short-run EC specification for D(LSFDI), it can be readily seen that the error correction term is negative and highly significant, implying that a 10 percent shock (deviation) away from the long-run equilibrium in the current quarter is corrected by 8.36 percent in the subsequent quarter. The short-run estimates for this equation also suggest that percentage changes in real GFCF “crowd-in” FDI inflows when lagged one, five, six, and seven periods. Insofar as percentage changes in infrastructure expenditures are concerned, the short-run estimates suggest that it has a positive and highly significant effect on FDI inflows when lagged three and four quarters which is consistent with the ECM presented in

[6] Model 3 is chosen because, as indicated in Section 4.2, the trend variable in Model 4 was not statistically significant. The VECM was also estimated with a dummy variable for the 2008-09 crisis and the ongoing euro crisis and the results were significantly better and more significant. See 6.Appendix E below.

[7]VECM/VAR modeling is especially useful for building strong forecasting models on the basis of R-squared and SBC/AIC criteria. In this study we focus on the relationship among the four variables and a forecast model is not estimated.

the previous section. Finally, percentage changes in the real effective exchange rate have a negative effect on FDI inflows, which is consistent with the results reported for the ECM model presented in the previous section

On the other hand, treating D(LGFCF) as the "dependent variable," it can be readily ascertained from Table 5 that the error correction term is negative and significant at the 5 percent level, again implying that a 10 percent deviation away from equilibrium during the current quarter is corrected in the subsequent quarter by 8.79 percent. Changes in D(LFDI) have a negative and significant effect when lagged five quarters, while percentage changes in real infrastructure expenditures have a positive and highly significant effect when lagged six to seven quarters. Finally, percentage changes in the real effective exchange rate have a negative and significant effect on D(LGFCF) when lagged three periods.

Table 5. Error Correction **Table.**

	D(LSFDI)	D(LGFCF)	D(LREER)	D(LINFR)
Error Correction Coefficient	-0.8687	-0.8370	0.1058	-0.0659
Standard Error	(0.018675)	(0.39529)	(0.13504)	(0.06443)
t-statistics	[-4.6519]	[-2.1176]	[0.7836]	[-1.0232]
R-squared	0.6891	0.4507	0.5731	0.6141
Adj. R-squared	0.4405	0.3028	0.2316	0.3055
Akaike AIC	-3.109	-1.609	-3.757	-5.237
Schwarz SBC	-2.130	-0.631	-2.779	-4.259

A very useful property of the VECM framework is that it enables the investigator to impose zero restrictions on the adjustment coefficients of each equation, thus determining which variables can be treated as weakly exogenous in the system, thereby omitting them from the interdependent system of variables. Based on this weak exogeneity test, Table 6 below indicates that the real effective exchange rate and real value added in economic infrastructure can be omitted from the system (treated as weakly exogenous) because the null hypothesis of a zero restriction is not rejected for these variables at least at the 5 percent level. In other words, in this simple four equation system, we can treat LSFDI and LGFCF as endogenous variables, while LREER and LINFR are weakly exogenous.

Table 6.Exogeneity Test

H0: weakly exogenous variable	Chi-Square statistics (65 obs)	Probability
D(LSDFI), A(1,1)=0	19.311	0.0000
D(LGFCF), A(2,1)=0	7.4657	0.0062
D(LREER), A(3,1)=0	1.0542	0.3045
D(LINFR), A(4,1)=0	1.2082	0.2716

In order to investigate further the "causal" relationship among these variables, we performed a Granger Block Causality test with the restrictions. This test examines all four equations and tries to determine whether the presumed exogenous variables can be omitted from each equation. This test finds "causality" or precedence in the D(LSFDI) equation at the 5% level, for GFCF, INFR, and the real effective exchange rate (p-value $_{DLGFCF}$:0.0128, p-value $_{DLINFR}$: 0.0101; p-value $_{DLREER}$:).0001). Not surprisingly, the test finds the presence of reverse "causality" or precedence in the D(LGFCF) for the percentage change in FDI inflows (p-value $_{DLSFDI}$: 0.0329). Somewhat surprisingly, it finds precedence in the D(LINFRA) equation from percentage changes in the real exchange rate (p-value $_{DLEER}$: 0.0250), but not the other way around; that is, from D(LINFR) to D(LREER) (p-value $_{DLINFR}$: 0.5426). *(*See 6 Appendix C).

Based on this important information, we assessed visually the dynamic interactions among the variables in the system by appealing to impulse response functions for the variables in our simple system. Given that the Cholesky decomposition is arbitrary and sensitive to the ordering of the variables, this study employed a generalized decomposition process first proposed by Pesaran and Shin (1998). Basically it constructs an orthogonal set of innovations that does not depend on the VAR ordering. Figure 3 below shows the generalized impulse responses of the four variables in question to both a unitary shock in their own values and the rest of the variables over a 10 quarter period. It can be readily ascertained that the response of FDI inflows to a one standard deviation (SD) innovation in economic INFR is significant and sustained (particularly after three to four periods); on the other hand, the reverse line of "causation" is not as strong. Figure 3 also shows that the lagged response of private GFCF to a one (SD) innovation in FDI inflows to be positive and sustained (again, after two to three periods), while the reverse is not as strong. Interestingly, and somewhat unexpectedly, the response of the real effective exchange rate is relatively strong to both a one standard innovation in real GFCF and a one standard innovation in economic INFR, but this strong "causal"effect is not captured in the Granger Block causality test reported above. Finally, the response of GFCF to a one standard deviation in FDI inflows is negative and sustained after one to two periods and then increases dramatically in magnitude after three periods, corroborating the results in the VECM (see 6. Appendix B).

Next, this study traced the variance decomposition (VDC) of each variable over a ten quarter period. The VDC gives information about the relative importance of each random (one-standard deviation) shock to the endogenous variables in the VECM. The results (available upon request) suggest that, after 10 quarters, a unitary shock in economic INFR explains 40.3 percent of the accumulated forecast error variance of FDI inflows and 37.5 percent of that of private real GFCF. Again, both proportions are significant while the reverse proportions (viz., the accumulated percentage variance of FDI inflows due to GFCF and the accumulated percentage variation of INFR due to FDI inflows) are only 7.1- percent and -3.5 percent, respectively. A unitary shock in FDI inflows explains 10.2 percent of the accumulated variance in the real exchange rate, while a unitary shock in economic INFR explains 10 percent of the accumulated variance in the real exchange rate. Finally, a unitary innovation in the real effective exchange rate explains approximately 5 percent of the variance in the econ. INFR variable.

Overall, based on the analysis of the unrestricted VECM specifications, we can conclude that short-run deviations of the included variables from their long-run cointegrated relationship are corrected in subsequent quarters between 8.2 and 8.8 percent for two of the equations in the system. The restricted VEC models suggest that there are two weakly exogenous variables in the system, that is, not all variables can be treated as endogenous. In line with this finding, the Block Granger causality test finds two-way "causality" between FDI inflows and GFCF, and one-way causality or precedence from real INFR spending and the real effective exchange rate to FDI inflows (as well as from the real exchange rate to INFR expenditures). In general, the short-run impulse response functions (and variance decompositions) are consistent with the VECM and Granger Block exogeneity tests, with the exception of the real effective exchange rate equation. In view of the findings reported in this paper, policy makers should consider paying close attention to maintaining a competitive and stable real effective exchange rate, as well as making sure that adequate and reliable economic infrastructure is in place to attract FDI flows.

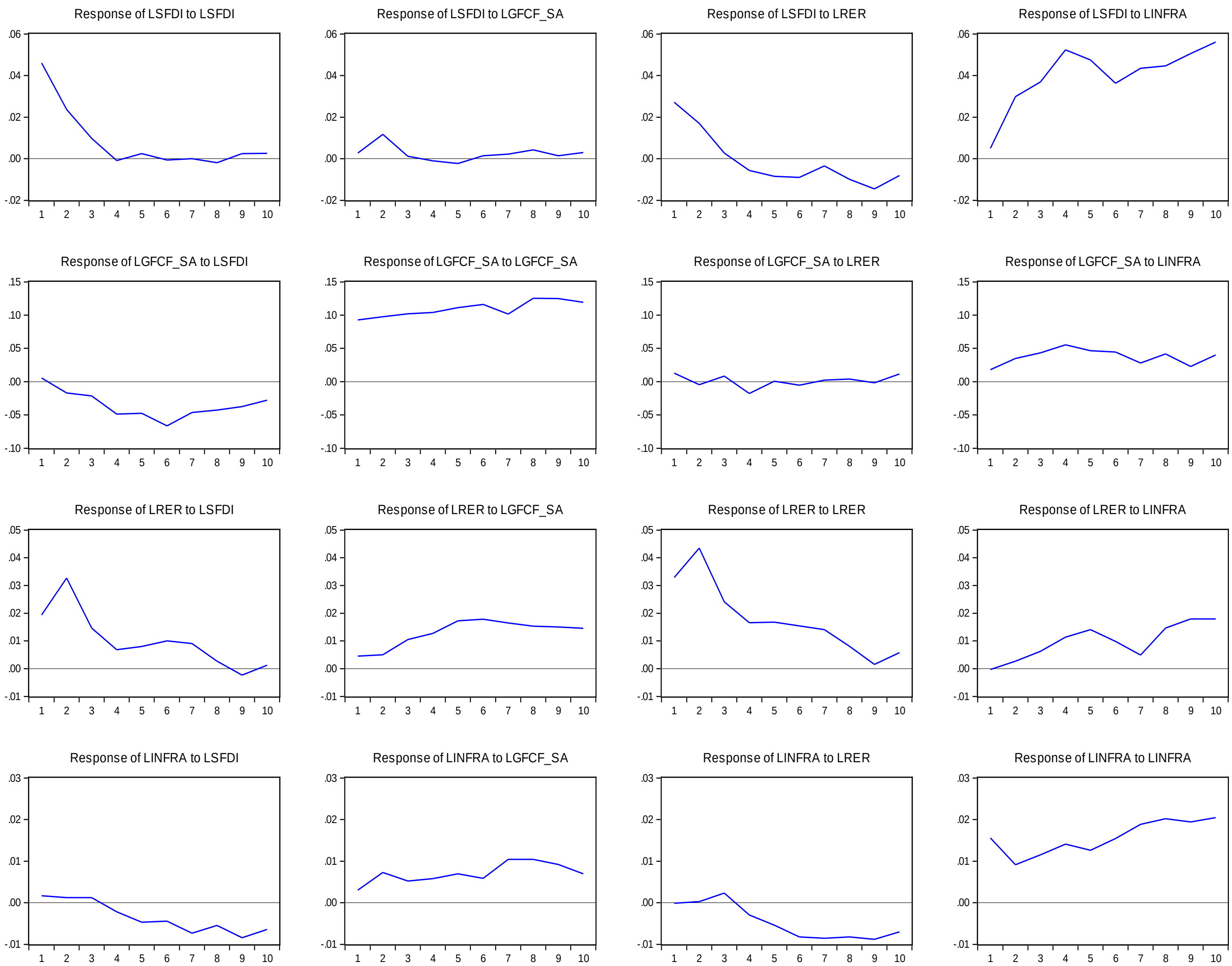


Figure 3. Response to Generalized One S.D. Innovations.

5. Conclusion

To the best of our knowledge, this is the first rigorous time series studies to investigate the potentially causal relationship between inward FDI flows to Hungary, real GFCF, economic infrastructure, and the Hungarian Forint / Euro real effective exchange rate during the 1995-2012 period. The unit root and stationarity tests indicated that the economic variables are, by and large, integrated of order one. The multivariate Johansen cointegration test and Gregory-Hansen cointegration test showed that there is a stable long-run relationship among the included variables even in the presence of an endogenously determined structural break, which means that non-spurious EC models can be estimated on the basis of the series. Using the Engle-Granger approach, an error correction model was generated that reconciles both the short-and long-run properties of the variables. The EC model has relatively good explanatory power and was able to track the turning points of the in-sample data well. In the long run, increases in both real economic infrastructure and a higher real exchange rate (real appreciation of the domestic currency) increase the stock of FDI, while increases in the level of real GFCF are negatively associated with changes in the stock of FDI. In contrast to the long-run results, the real exchange rate has a negative effect on FDI inflows when lagged more than one period in the short run, while lagged increases in real GFCF have a positive and statistically significant effect. Lagged real economic infrastructure also has a positive and highly significant effect on FDI inflows in the short run—consistent with the long-run results. The EC term is negative and significant for both the D(LSFDI) and D(LFCF) equations, suggesting that deviations during the current quarter from the equilibrium relationship are corrected in subsequent quarters.

The estimates from the unrestricted VECM model suggest that two of the variables in the system have a statistically significant adjustment (reversion) mechanism. Restricted versions of the VECM model suggest that the real effective exchange rate and real gross value added in economic infrastructure are weakly exogenous. Finally, Granger Block Causality tests and impulse response functions generate results which suggest that there is two-way causality between FDI inflows and GFCF, but one way-causality or precedence from real infrastructure expenditures and the real effective exchange rate to FDI inflows.

Despite the important findings reported in this study, further research and data is needed to come to more general and robust conclusions regarding the determinants of both FDI flows and private capital formation in Hungary. First, although the sample size of 72 data points exceeds the 50 data point threshold recommended in time series analysis, it is still relatively small so the results have to be taken as tentative. Second, the lack of data did not allow for the inclusion of other macro variables that are important in terms of explaining the variation in FDI flows and gross fixed capital formation in Hungary, such as unit labor costs, the real interest rate, real bank credit to the private sector or proxies for human capital such as secondary or tertiary enrollment ratios. Finally, the VECM results regarding the direction of causality give mixed results in the long and short run for some variables, particularly the real effective exchange rate, which might be a sign of some problem with the specification of the model.

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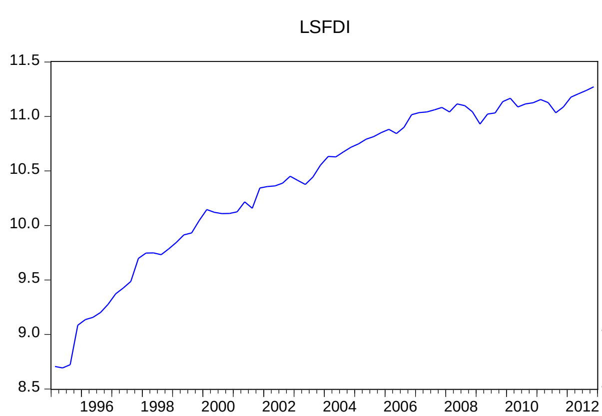
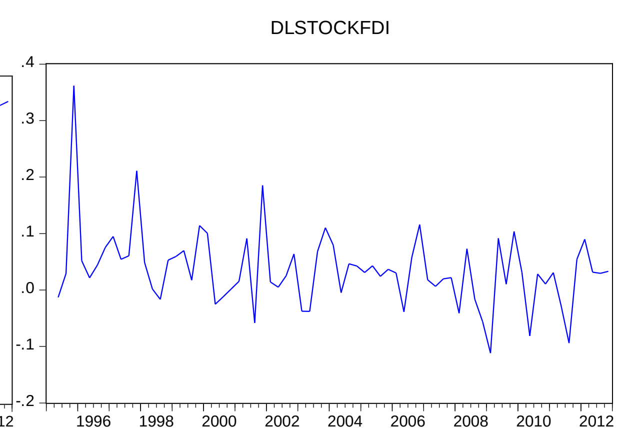
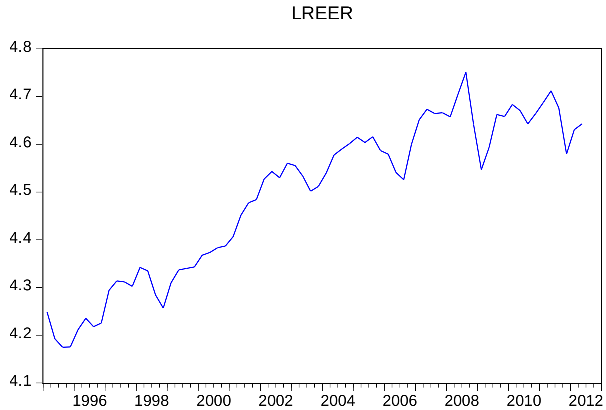
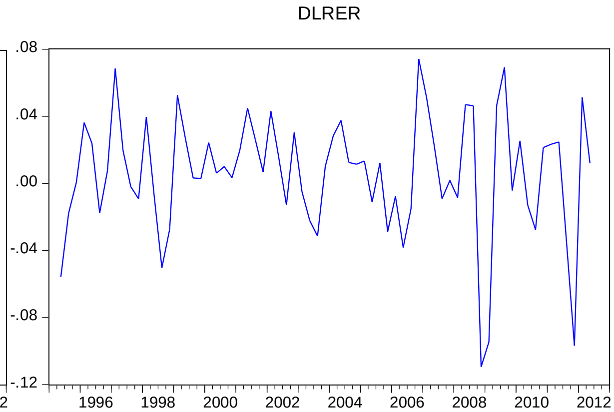
6. Appendix A.

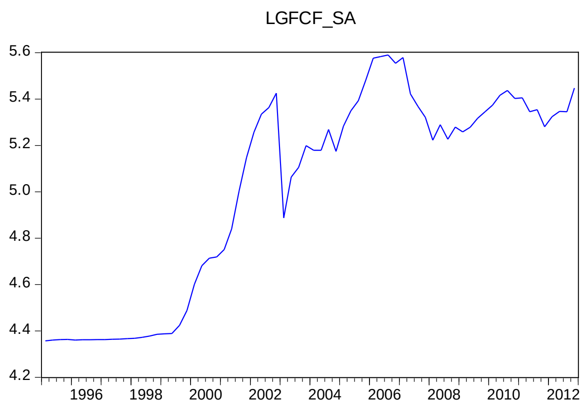
1. Graphs

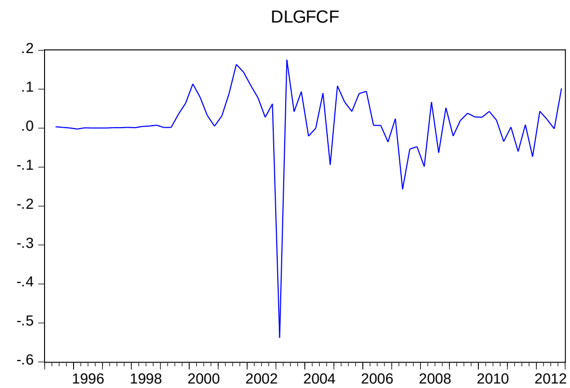





LREER
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
1996 1998 2000 2002 2004 2006 2008 2010 2012


DLRER
.08
.04
.00
-.04
-.08
-.12
1996 1998 2000 2002 2004 2006 2008 2010 2012


LGFCF_SA
5.6
5.4
5.2
5.0
4.8
4.6
4.4
4.2
1996 1998 2000 2002 2004 2006 2008 2010 2012


DLGFCF
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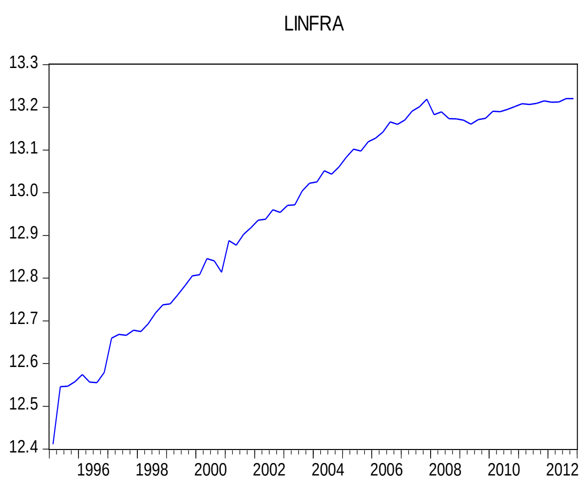
.0
-.1
-.2
-.3
-.4
-.5
-.6
1996 1998 2000 2002 2004 2006 2008 2010 2012


LINFRA
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13.1
13.0
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12.7
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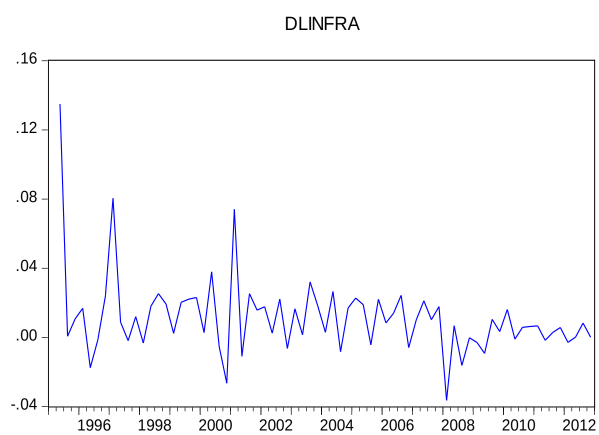
12.5
12.4
1996 1998 2000 2002 2004 2006 2008 2010 2012


DLINFRA
.16
.12
.08
.04
.00
-.04
1996 1998 2000 2002 2004 2006 2008 2010 2012

6. Appendix B.

Vector Error Correction Estimates
Date: 10/03/13 Time: 16:16
Sample (adjusted): 1997Q1 2012Q4
Included observations: 64 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LSFDI(-1)	1.000000
LGFCF_SA(-1)	0.394194 (0.06531) [6.03565]
LRER(-1)	-0.884291 (0.32018) [-2.76187]
LINFRA(-1)	-2.942330 (0.17737) [-16.5883]
C	29.71091 (1.48388) [20.0225]

Error Correction:	D(LSFDI)	D(LGFCF_SA)	D(LRER)	D(LINFRA)
CointEq1	-0.868734 (0.18675) [-4.65196]	-0.837063 (0.39529) [-2.11760]	0.105820 (0.13504) [0.78364]	-0.065925 (0.06443) [-1.02324]
D(LSFDI(-1))	0.231525 (0.17461) [1.32597]	0.398369 (0.36960) [1.07785]	0.125517 (0.12626) [0.99412]	0.075375 (0.06024) [1.25124]
D(LSFDI(-2))	0.206220 (0.16651) [1.23845]	0.156964 (0.35246) [0.44533]	-0.208381 (0.12041) [-1.73064]	0.052841 (0.05745) [0.91981]
D(LSFDI(-3))	0.099662 (0.17144) [0.58132]	-0.225118 (0.36289) [-0.62035]	-0.071082 (0.12397) [-0.57339]	0.008299 (0.05915) [0.14031]
D(LSFDI(-4))	0.223874 (0.16148) [1.38640]	0.006633 (0.34180) [0.01941]	-0.104814 (0.11676) [-0.89765]	0.070850 (0.05571) [1.27175]
D(LSFDI(-5))	0.085138 (0.11573) [0.73569]	-0.842024 (0.24496) [-3.43742]	0.025629 (0.08368) [0.30627]	0.091822 (0.03993) [2.29983]

D(LSFDI(-6))	-0.137013	0.127399	0.059832	0.075041
	(0.13378)	(0.28317)	(0.09674)	(0.04615)
	[-1.02417]	[0.44990]	[0.61850]	[1.62587]
D(LSFDI(-7))	-0.362828	-0.284804	0.068343	0.002828
	(0.13913)	(0.29450)	(0.10060)	(0.04800)
	[-2.60783]	[-0.96708]	[0.67932]	[0.05891]
D(LGFCF_SA(-1))	0.391410	0.332349	-0.052615	0.085993
	(0.09991)	(0.21148)	(0.07225)	(0.03447)
	[3.91759]	[1.57151]	[-0.72828]	[2.49475]
D(LGFCF_SA(-2))	0.147247	0.318477	0.017393	0.020287
	(0.09244)	(0.19566)	(0.06684)	(0.03189)
	[1.59298]	[1.62772]	[0.26022]	[0.63616]
D(LGFCF_SA(-3))	0.128728	0.289091	-6.25E-05	0.030536
	(0.08790)	(0.18606)	(0.06356)	(0.03033)
	[1.46446]	[1.55373]	[-0.00098]	[1.00692]
D(LGFCF_SA(-4))	0.104502	0.114623	0.013381	0.023154
	(0.08169)	(0.17292)	(0.05907)	(0.02818)
	[1.27921]	[0.66287]	[0.22652]	[0.82152]
D(LGFCF_SA(-5))	0.180535	0.171896	-0.021748	0.020240
	(0.08038)	(0.17014)	(0.05812)	(0.02773)
	[2.24601]	[1.01031]	[-0.37417]	[0.72988]
D(LGFCF_SA(-6))	0.206643	-0.122000	-0.018560	0.039554
	(0.08322)	(0.17615)	(0.06017)	(0.02871)
	[2.48320]	[-0.69261]	[-0.30844]	[1.37772]
D(LGFCF_SA(-7))	0.176605	0.213764	-0.023174	0.059521
	(0.08349)	(0.17673)	(0.06037)	(0.02881)
	[2.11518]	[1.20953]	[-0.38383]	[2.06629]
D(LRER(-1))	-0.599150	-0.770043	0.212628	-0.078352
	(0.25546)	(0.54073)	(0.18472)	(0.08813)
	[-2.34538]	[-1.42407]	[1.15106]	[-0.88902]
D(LRER(-2))	-0.841432	-0.160470	-0.377360	0.042134
	(0.26932)	(0.57006)	(0.19474)	(0.09291)
	[-3.12434]	[-0.28150]	[-1.93774]	[0.45347]
D(LRER(-3))	-0.954428	-1.106781	0.107753	-0.207371
	(0.30371)	(0.64287)	(0.21961)	(0.10478)
	[-3.14254]	[-1.72162]	[0.49064]	[-1.97909]
D(LRER(-4))	-0.859585	0.136819	-0.153683	-0.083077
	(0.27224)	(0.57625)	(0.19685)	(0.09392)
	[-3.15750]	[0.23743]	[-0.78070]	[-0.88453]
D(LRER(-5))	-0.909448	-0.899063	-0.016183	-0.357522
	(0.31034)	(0.65689)	(0.22440)	(0.10707)
	[-2.93053]	[-1.36866]	[-0.07212]	[-3.33926]
D(LRER(-6))	0.106319	-0.013756	-0.097009	-0.049510

	(0.26656)	(0.56423)	(0.19275)	(0.09196)
	[0.39885]	[-0.02438]	[-0.50329]	[-0.53836]
D(LRER(-7))	-0.293857	-0.722627	-0.162602	-0.186216
	(0.22253)	(0.47103)	(0.16091)	(0.07677)
	[-1.32052]	[-1.53413]	[-1.01050]	[-2.42553]
D(LINFRA(-1))	-0.835221	-1.323206	0.422244	-0.647052
	(0.61005)	(1.29131)	(0.44113)	(0.21047)
	[-1.36910]	[-1.02470]	[0.95719]	[-3.07434]
D(LINFRA(-2))	-0.026872	-0.626678	0.155803	-0.263785
	(0.51997)	(1.10064)	(0.37599)	(0.17939)
	[-0.05168]	[-0.56938]	[0.41438]	[-1.47045]
D(LINFRA(-3))	1.213375	0.354201	0.559576	0.024663
	(0.42332)	(0.89605)	(0.30610)	(0.14605)
	[2.86632]	[0.39529]	[1.82806]	[0.16887]
D(LINFRA(-4))	0.989575	0.699932	0.289775	-0.030994
	(0.41842)	(0.88568)	(0.30256)	(0.14436)
	[2.36502]	[0.79028]	[0.95774]	[-0.21471]
D(LINFRA(-5))	0.228003	1.275452	0.119283	0.100400
	(0.44021)	(0.93180)	(0.31832)	(0.15187)
	[0.51794]	[1.36881]	[0.37473]	[0.66108]
D(LINFRA(-6))	0.431148	1.451763	-0.254103	0.284718
	(0.42113)	(0.89141)	(0.30452)	(0.14529)
	[1.02379]	[1.62862]	[-0.83444]	[1.95966]
D(LINFRA(-7))	0.269057	1.666023	0.145625	0.275066
	(0.30795)	(0.65183)	(0.22268)	(0.10624)
	[0.87372]	[2.55591]	[0.65398]	[2.58906]
R-squared	0.689184	0.450775	0.573118	0.614195
Adj. R-squared	0.440532	0.011394	0.231613	0.305551
Sum sq. resids	0.067586	0.302817	0.035339	0.008044
S.E. equation	0.043943	0.093016	0.031776	0.015161
F-statistic	2.771675	1.025932	1.678211	1.989978
Log likelihood	128.4916	80.50023	149.2409	196.6009
Akaike AIC	-3.109113	-1.609382	-3.757527	-5.237528
Schwarz SC	-2.130869	-0.631138	-2.779283	-4.259284
Mean dependent	0.031159	0.016952	0.006491	0.010018
S.D. dependent	0.058750	0.093550	0.036250	0.018193

Determinant resid covariance (dof adj.)	2.34E-12
Determinant resid covariance	2.09E-13
Log likelihood	570.9956
Akaike information criterion	-14.06236
Schwarz criterion	-9.980724

6. Appendix C

VEC Granger Causality/Block Exogeneity Wald Tests
Date: 10/06/13 Time: 11:14
Sample: 1995Q1 2012Q4
Included observations: 64

Dependent variable: D(LSFDI)

Excluded	Chi-sq	df	Prob.
D(LGFCF_SA)	17.81823	7	0.0128
D(LRER)	31.11202	7	0.0001
D(LINFRA)	18.43880	7	0.0101
All	69.26502	21	0.0000

Dependent variable: D(LGFCF_SA)

Excluded	Chi-sq	df	Prob.
D(LSFDI)	15.24835	7	0.0329
D(LRER)	5.270317	7	0.6270
D(LINFRA)	8.874782	7	0.2618
All	20.32918	21	0.5005

Dependent variable: D(LRER)

Excluded	Chi-sq	df	Prob.
D(LSFDI)	9.007915	7	0.2521
D(LGFCF_SA)	1.243604	7	0.9899
D(LINFRA)	5.975292	7	0.5426
All	29.34633	21	0.1059

Dependent variable: D(LINFRA)

Excluded	Chi-sq	df	Prob.
D(LSFDI)	11.13235	7	0.1329
D(LGFCF_SA)	7.683317	7	0.3613
D(LRER)	16.01391	7	0.0250
All	28.88839	21	0.1167

6. Appendix D

CALENDAR(Q) 1995

Allocate 2012:4

Open data hung1.xls

Data(format=xls, org=columns)

@gregoryhansen (lags=10)

lsfdi lgfcf_sa lrer linfr

Gregory-Hansen Cointegration Tests

Variables

LSFDI

LGFCF_SA

LRER

LINFR

Break in Intercept. No Trend

Including 2 Lags of Difference Selected by User

Minimum T-Statistic   -6.16371 at 2001:02

Critical Values are 1% -6.05 and 5% -5.56

6. Appendix E

Vector Error Correction Estimates
Date: 10/06/13 Time: 18:06
Sample (adjusted): 1997Q1 2012Q4
Included observations: 64 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1
LSFDI(-1)	1.000000
LGFCF_SA(-1)	0.439248 (0.05920) [7.42003]
LRER(-1)	-0.737331 (0.29298) [-2.51665]
LINFRA(-1)	-3.219635 (0.17042) [-18.8922]
C	32.43073 (1.44206) [22.4891]

Error Correction:	D(LSFDI)	D(LGFCF_SA)	D(LRER)	D(LINFRA)
CointEq1	-0.765742 (0.18280) [-4.18899]	-0.741979 (0.40580) [-1.82843]	0.086382 (0.14280) [0.60493]	-0.028118 (0.06868) [-0.40940]
D(LSFDI(-1))	0.227476 (0.17167) [1.32505]	0.398224 (0.38111) [1.04492]	0.129783 (0.13411) [0.96776]	0.057981 (0.06450) [0.89891]
D(LSFDI(-2))	0.284648 (0.16373) [1.73847]	0.242036 (0.36348) [0.66589]	-0.216078 (0.12791) [-1.68936]	0.046941 (0.06152) [0.76306]
D(LSFDI(-3))	0.112052 (0.16798) [0.66705]	-0.215951 (0.37291) [-0.57910]	-0.069313 (0.13122) [-0.52821]	-0.002891 (0.06311) [-0.04581]
D(LSFDI(-4))	0.219825 (0.15658) [1.40392]	-0.005243 (0.34760) [-0.01508]	-0.101324 (0.12232) [-0.82838]	0.061903 (0.05883) [1.05224]
D(LSFDI(-5))	0.122673 (0.10935) [1.12183]	-0.815138 (0.24275) [-3.35789]	0.022481 (0.08542) [0.26318]	0.093039 (0.04109) [2.26455]
D(LSFDI(-6))	-0.080212 (0.12397)	0.181682 (0.27520)	0.052498 (0.09684)	0.081245 (0.04658)

	[-0.64704]	[0.66017]	[0.54211]	[1.74432]
D(LSFDI(-7))	-0.344375	-0.274789	0.065658	0.009507
	(0.12910)	(0.28659)	(0.10085)	(0.04850)
	[-2.66757]	[-0.95883]	[0.65106]	[0.19601]
D(LGFCF_SA(-1))	0.370859	0.309709	-0.046993	0.072983
	(0.10119)	(0.22464)	(0.07905)	(0.03802)
	[3.66488]	[1.37868]	[-0.59447]	[1.91961]
D(LGFCF_SA(-2))	0.076569	0.237357	0.029726	0.005591
	(0.09405)	(0.20878)	(0.07347)	(0.03533)
	[0.81416]	[1.13689]	[0.40462]	[0.15822]
D(LGFCF_SA(-3))	0.079527	0.235016	0.009038	0.017128
	(0.08787)	(0.19506)	(0.06864)	(0.03301)
	[0.90507]	[1.20483]	[0.13167]	[0.51881]
D(LGFCF_SA(-4))	0.117768	0.131195	0.013195	0.016619
	(0.08041)	(0.17851)	(0.06281)	(0.03021)
	[1.46459]	[0.73496]	[0.21006]	[0.55010]
D(LGFCF_SA(-5))	0.189636	0.182629	-0.021527	0.014623
	(0.07836)	(0.17395)	(0.06121)	(0.02944)
	[2.42009]	[1.04988]	[-0.35168]	[0.49668]
D(LGFCF_SA(-6))	0.211198	-0.114975	-0.017568	0.032402
	(0.08139)	(0.18068)	(0.06358)	(0.03058)
	[2.59485]	[-0.63633]	[-0.27631]	[1.05958]
D(LGFCF_SA(-7))	0.158521	0.194675	-0.019228	0.051784
	(0.08055)	(0.17883)	(0.06293)	(0.03027)
	[1.96788]	[1.08864]	[-0.30555]	[1.71099]
D(LRER(-1))	-0.354585	-0.506290	0.176942	-0.048393
	(0.23996)	(0.53270)	(0.18745)	(0.09016)
	[-1.47766]	[-0.95041]	[0.94392]	[-0.53676]
D(LRER(-2))	-0.661459	0.018442	-0.403484	0.070460
	(0.24668)	(0.54761)	(0.19270)	(0.09268)
	[-2.68145]	[0.03368]	[-2.09384]	[0.76024]
D(LRER(-3))	-0.679059	-0.814305	0.066284	-0.166360
	(0.28460)	(0.63179)	(0.22232)	(0.10693)
	[-2.38604]	[-1.28889]	[0.29815]	[-1.55581]
D(LRER(-4))	-0.699395	0.297207	-0.176745	-0.059160
	(0.25098)	(0.55716)	(0.19606)	(0.09430)
	[-2.78668]	[0.53344]	[-0.90149]	[-0.62738]
D(LRER(-5))	-0.730215	-0.706949	-0.043299	-0.331105
	(0.29133)	(0.64673)	(0.22758)	(0.10946)
	[-2.50652]	[-1.09312]	[-0.19026]	[-3.02500]
D(LRER(-6))	-0.049238	-0.209519	-0.073456	-0.059445
	(0.25655)	(0.56952)	(0.20041)	(0.09639)
	[-0.19192]	[-0.36788]	[-0.36653]	[-0.61671]

D(LRER(-7))	-0.068597	-0.472367	-0.194578	-0.165563
	(0.21235)	(0.47140)	(0.16588)	(0.07978)
	[-0.32304]	[-1.00205]	[-1.17299]	[-2.07515]
D(LINFRA(-1))	-0.712972	-1.208195	0.389133	-0.562184
	(0.61190)	(1.35839)	(0.47800)	(0.22990)
	[-1.16517]	[-0.88943]	[0.81408]	[-2.44531]
D(LINFRA(-2))	0.104091	-0.475403	0.126084	-0.208977
	(0.51288)	(1.13857)	(0.40065)	(0.19270)
	[0.20295]	[-0.41754]	[0.31470]	[-1.08447]
D(LINFRA(-3))	1.344748	0.515459	0.531391	0.068724
	(0.42095)	(0.93449)	(0.32884)	(0.15816)
	[3.19455]	[0.55160]	[1.61597]	[0.43453]
D(LINFRA(-4))	0.842437	0.553290	0.304794	-0.028123
	(0.39843)	(0.88448)	(0.31124)	(0.14970)
	[2.11441]	[0.62555]	[0.97929]	[-0.18787]
D(LINFRA(-5))	-0.060450	0.987373	0.156611	0.074135
	(0.40730)	(0.90418)	(0.31817)	(0.15303)
	[-0.14842]	[1.09201]	[0.49222]	[0.48445]
D(LINFRA(-6))	0.390736	1.448357	-0.252056	0.277384
	(0.39291)	(0.87225)	(0.30693)	(0.14762)
	[0.99446]	[1.66049]	[-0.82120]	[1.87898]
D(LINFRA(-7))	0.350439	1.770250	0.132496	0.282739
	(0.29073)	(0.64541)	(0.22711)	(0.10923)
	[1.20536]	[2.74283]	[0.58339]	[2.58839]
DCRISIS1	-0.066098	-0.078747	0.009753	-0.005176
	(0.02074)	(0.04604)	(0.01620)	(0.00779)
	[-3.18712]	[-1.71043]	[0.60198]	[-0.66431]
R-squared	0.735292	0.485515	0.575701	0.610315
Adj. R-squared	0.509511	0.046690	0.213800	0.277936
Sum sq. resids	0.057560	0.283663	0.035125	0.008125
S.E. equation	0.041145	0.091340	0.032142	0.015459
F-statistic	3.256667	1.106398	1.590767	1.836204
Log likelihood	133.6299	82.59120	149.4351	196.2807
Akaike AIC	-3.238435	-1.643475	-3.732347	-5.196271
Schwarz SC	-2.226459	-0.631499	-2.720370	-4.184295
Mean dependent	0.031159	0.016952	0.006491	0.010018
S.D. dependent	0.058750	0.093550	0.036250	0.018193

Determinant resid covariance (dof adj.)	1.63E-12
Determinant resid covariance	1.30E-13
Log likelihood	586.2285
Akaike information criterion	-14.41339
Schwarz criterion	-10.19682