INVALIDATION OF A CLASSIC MULTI-FACTORIAL ECONOMETRIC FDI MODEL IN SOME EX-SOCIALIST COUNTRIES

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Abstract

In the introductory section are presented the main categories of validated classical foreign direct investment (FDI) models, ending with some of the recently published ones, belonging to the literature of the last decade. A section of methodology presents the main validation tests of the classical econometric model in general. However, the main thrust is the invalidation of a classical model in which FDI is specified in a macroeconomic context starting from GDP value, gross fixed capital formation (FBCF), imports (M) and exports (X), in the case of the Czech Republic, Hungary and Poland. Choosing these ex-socialist European economies and presenting the invalidation of country-specific FDI models, while also exemplifying Fisher or Durbin-Watson tests, reflect certain changes in the investors' image of these economies, and incite discussion of the similarity of invalidations, which outlines the decision not to invest, rather than invest in these economies. A brief final assessment clarifies the value of an article that both invalidates and does not validate, in the perspective of amplified knowledge, a modelling approach describing situations of real statistical and econometric interest.

Key words: *Foreign direct investment (FDI), econometric model, invalidation, GDP value, Gross fixed capital formation (GFCF), imports (M), exports (X), tests (F, D-W, t, etc.)*

1. Introduction

Testing and testing remain concepts of purely statistical and mathematical content, and detailing them gives an an instrumental contour in econometric or econometric pre-modelling. The objective of formulating a hypothesis reveals the importance and practical utility of knowing the economic processes and phenomena, in this case those belonging to the foreign direct investment (FDI) type. At the end of any testing, the identifying of the modelling explanatory factors, reaching the validation or invalidation of a model, at the specific stage of the formulation of the statistical decision can take place in a natural phenomenon and in an iterative process.

The knowledge of classical tests (Jarque-Bera – J-B, Student – t, Fisher – F, Durbin-Watson, etc.), and also the increasing number of modern tests, are necessary conditions in the complex process of econometric and econometric modelling. An equally important target in this article is to analyze a seemingly secondary situation, or else which is falsely considered less important: that of invalidating a hypothesis, a model, a theory. The phased or iterative knowledge of statistical testing of the hypotheses of the classic multifactorial model, and its practical application by means of specialized Eviews programs, are derived objectives of this paper.

2. Typology of FDI models in the literature

The econometric financial investment modelling in Eastern and Central European countries has deeply diversified following the direct investment phenomenon in these economies, and the resulting models have expanded into complex factor FDI areas, which are important through their economic impact (Săvoiu and Popa, 2012).

The main classes of foreign direct investment models describe and bring together: i) models derived from the economic conceptualization of FDI; ii) classic statistical models focusing on the correlation between economic growth (GDP) and FDI; iii) classical theoretical structural models of FDI; iv) modern eclectic and restructured FDI models (in keeping with R-squared) (Săvoiu, Broştescu, 2017, pp.178-179).

An attempt to synthesize the major factors of the FDI models classes is shown in the following Box no. 1.

Explanatory factors in the classic multi-factorial econometric models of FDI

Box no. 1

a) factor-derived indicators of GDP (GDP growth rates, GDP or GDP / capita, as a general productivity indicator of an economy) and FDI;
b) external trade indicators (exports, imports, export orientation of the host country, correlation of exports with rising demand, heterogeneity of export companies and their exports in correlation with FDI;
c) the impact of corruption on the FDI dimension, describing an intense relationship between corruption and FDI;
d) various risks of instability (general or politically restricted macroeconomic risk, the risk of securing fundamental human rights) and FDI;
e) national taxation policies, number and categories of taxes and FDI of multinationals;
f) inflation or exchange rate and FDI;
g) employment and unemployment with FDI;
h) indicators of the various markets, from the proximity of the commercial market, growth rates and market shares, to population size, labour mobility and availability, wage differences and level of education, from government subsidies and aids, to state expenditures and FDI;
i) networks, strategies, history of diplomatic relations, or resources and FDI;
j) inequality of income distribution and ISD;
k) business cycle, productivity and FDI;
l) trade, institutional symmetries, and FDI;
m) patterns of FDI and spatial characteristics of FDI;

Sources: Săvoiu and Popa, 2012; Săvoiu, Broştescu, 2017.

In addition to these, there are recent models, some of which focus on validations and updates of the classic ones, according to papers published in the last decade, from which twelve more important examples were selected in Box no. 2:

Twelve examples of FDI models in papers from the past five years

Box no. 2

1.An amplified gravitational model (Dauti, 2015), where the determining factors of the FDI stock are modelled to predict the potential level of the FDI stock (e.g. FDI in Macedonia); the model distinguishes general factors of gravity (market size and distance), institutional factors (related to corruption control, corruption perception index, regulatory quality, transition progress and membership of the WTO), as well as other traditional determinants of FDI (schooling, bilateral exports, regional FDI), etc.
2.Another model (validated in 2017 by Jeswald Salacuse on twenty-six countries) concerning the bilateral investment treaties signal identifies a strong / weak country by associating it with the Bilateral Investment Treaties (BIT), based on the theory of information and signaling in the economy, arguing that investment treaties (bilateral investment contracts) influence capital flows through the signals they transmit on international capital markets, and affect the cost a country pays for FDI.
3.Ojede and Kishan's FDI model identifies a major exogenous variable in the volume of IMF credit, which is correlated with FDI flows to developing countries below / above a threshold value of economic freedom;
4.The conceptual European model of Paniagua, Korzynski and Mas-Tur (2017) focuses on the capability-based theory of multinationals, which is also empirically grounded, explaining the effect of social networks on FDI, and suggests that online social networking stimulates foreign capital spending and new network affiliates;
5.The model specified and parameterized by Omri and Kahouli includes capital stock, labour and inflation, with FDI and energy, confirming the interdependence between energy consumption, FDI and economic growth;
6.The Ramos and Ashby model (2017) is a realistic one, based on the existence of a geographic halo-effect caused by violent crimes, and is supported by the results of research showing that the highest number of killings is associated with diminishing FDI inflows: criminal violence in certain locations in Latin America affects FDI;
7.The Kozhevnikov, Pridvizhkin and Bazhenov model for 19 emerging economies allows the estimation of the influence of the various factors on the net inflows of FDI, starting from two distinct structures of exogenous variables: a group of macro-economic factors and a group of factors related to the general development of society (11 factors);
8.The Arel-Bundock model is focused on the influence of political risk, institutional risks and FDI, with the conclusion that none of the policy variables investigated determines the majority of the change in aggregate FDI inflows;
9.Using the existing FDI theory creatively in order to justify a simpler model, Edwards Romero and Madjd-Sadjadi (2016) used a determinant set of characteristics, starting from the interaction between economic growth (while considering economic stability) and current FDI.
10.The Lee Hoon model demonstrates that investors do not reduce FDI against political risk if an armed conflict is expected to increase profits by raising commodity prices (exemplified by oil and its price: the effect of an armed conflict over FDI in oil industry varies depending on the price of oil).
11.Cezar and Escobar (2015) study the link between FDI and institutional distance, starting from a heterogeneous framework of companies, and explain how the institutional distance or gap changes FDI.
12.Cardamone and Scoppola tried to develop an appropriate model able to assess the impact of tariffs on the EU's external FDI stocks, ultimately estimating a model based on the theory of the multinationals' knowledge capital.

Sources: Dauti, 2015; Salacuse, 2017; Ojede și Kishan, 2017; Paniagua, Korzynski și Mas-Tur, 2017; Omri și Kahouli, 2017; Ramos, Ashby, 2017; Kozhevnikov, Pridvizhkin și Bazhenov, 2017; Arel-Bundock, 2016; Lee Hoon, 2016; Cezar și Escobar, 2015; Cardamone și Scoppola, 2014.

3. Metodology

Beyond a promptly computed descriptive statistic, or a rapidly quantified correlation matrix, the paper capitalizes on the EViews program package, giving an image, based on the practical modelling conducted, of the most important tests of the classic multi-factorial econometric model in order to facilitate a final validation/invalidation decision.

Hypotheses of the classical multifactorial regression model

Table 1

H1: Linearity of multifactor model (possibly, linearization)
H2: Data without measurement errors: $x \in \left(\bar{x} \pm 3\sigma_x \right)$ **and** $y \in \left(\bar{y} \pm 3\sigma_y \right)$
H3: The residual variable has a nil mean value: $E(\acute{I}_i \mid x_i)=E(\acute{I}_i)=0$
H4: Homoscedasticity of the model: $var(\acute{I}_i \mid x_i)=\acute{o}^2$ **(constant)**
H5: Non-correlation of residues: $cov(\acute{I}_i, \acute{I}_j \mid x_i, x_j)=E[(\acute{I}_i \mid x_i)(\acute{I}_j \mid x_j]=0$
H6: Independent residual and exogenous variable: $cov(x_i,\acute{I}_i) = 0$
H7: Normally distributed residual variable: $\acute{I}_i \sim N(0, \acute{o}^2)$
H8: Number of observations (*n*) > number of estimated parameters
H9: Variability in the values of the exogenous variable x_i
H10: Regression model correctly specified
H11: Multicollineriarity of exogenous variables is absent

Source: Săvoiu, 2013, p. 170.

In particular, the EViews program package simplifies the validation/invalidation process by calculating certain statistical values of known tests (F-statistic, Durbin-Watson stat, t-Statistic, etc.), including the resulting characteristic probabilities [Prob (F-statistic) etc.].

The series of values of the endogenous variables (the value of net inflows ISD – SER01) and exogenous variables (GDP – SER02; gross fixed capital formation – GFCF – SER04; imports (M) – SER05; exports (X) – SER06) were processed for two distinct periods: a) an extended period (1996-2016); b) a limited period (2000-2016). The classical multi-factorial econometric model for which we have opted, and which has been specified and parameterized is given by the formula:

$$\text{ISD net inputs}_i = \alpha + \beta \times GDP_i + \gamma \times GFCF_i + \lambda_i \times M_i + \omega i \times X_i + \varepsilon_i \qquad (1)$$

The 21-term databases (1996-2016), and the 17-term ones (2000-2016), were created for the economies of Poland, the Czech Republic and Hungary, based on World Bank indicators available online at http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators

4. Results and discussion

The classical multi-factorial model proposed in the methodology is invalidated by the quantitative or value-related developments of the indicators described for the economies in Poland, the Czech Republic and Hungary.

Practically, invalidation of the model is not caused by the intensity of the correlations (according to the R-simple value), or the determination (according to the value of R-squared), but rather by the fact that the models do not pass essential tests such as Fisher (F statistic value) or Durbin-Watson (Durbin-Watson stat), etc. More than clarifying the option for a certain significance threshold (α) – in economics, an error rate of 5% or α = 0.05 can be considered sufficient as the maximum limit in econometric modelling – and the type of unilateral or bilateral test (one- or two-tailed), particularization, through limit or critical values, of the rejection region is determined after consulting the theoretical (tabulated) values of the respective test (F, D-W, t, etc.), detailed with respect to the number of degrees of freedom and the threshold of significance (α).

The Eviews program package simplifies and simulates the whole validation/invalidation process by determining and very quickly providing results, within the model frame (redefined as a statistical, stat one, and thus substituting the classical calculated F value, or calculated D-W, t calculated, etc.). Regulation of the statistical decision to validate/invalidate the model is done by the detailed determination of the validation rules, and implies unambiguously formulating three sets of distinct interpretations in relation to the type of the bilateral, unilateral right and left test, all of which are done for a certain level of probability.

The reasoning presented and explained leads to the immediate question: *From what level can a probability (p critical) be considered insufficient or small?* To exclude any trace of subjectivism in the decision-making process, the manner of choosing the famous α, or the significance threshold of any test, becomes quite important. *The decision rule* also, and ultimately, refers to both the alpha (α), and the critical probability of the test ($p_{critical}$):

i) if $p_{critical} > \alpha$, then the hypothesis originally formulated, H_0 (e.g., a valid model) is not rejected in favour of the alternative hypothesis H_1 (invalid model);

ii) if $p_{critical} \leq \alpha$, then the initial hypothesis H_0 is rejected in favour of the alternative H_1.

In Tables 2, 3 and 4 are presented the classical multi-factorial models invalidated according to the value of F-statistic (but also the value of Durbin-Watson-stat test, and even that of some of the parameters of the model specified with Eviews):

Invalidated classical multi-factor FDI models for Poland, the Czech Republic and Hungary for the extended period (1996-2016), and the limited period (2000-2016)

Table no. 2

Polonia (1996-2016)-model invalidat

Dependent Variable: SER01 = ISD Method: Least Squares				
Sample: 1996 2016 Included observations: 21				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	6.23E+09	7.29E+09	0.854114	0.4056
SER03	-0.078426	0.114450	-0.685239	0.5030
SER04	0.226994	0.360146	0.630285	0.5374
SER05	0.202829	0.363677	0.557717	0.5848
SER06	-0.089099	0.240587	-0.370341	0.7160
R-squared	0.391806	Mean dependent var		1.16E+10
Adjusted R-squared	0.239757	S.D. dependent var		6.74E+09
S.E. of regression	5.88E+09	Akaike info criterion		48.03193
Sum squared resid	5.53E+20	Schwarz criterion		48.28062
Log likelihood	-499.3353	F-statistic		2.576844
Durbin-Watson stat	1.463140	Prob(F-statistic)		0.077403

Polonia (2000-2016) model invalidat

Dependent Variable: SER01 = ISD Method: Least Squares				
Sample: 2000 2016 Included observations: 17				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.12E+10	9.45E+09	1.183167	0.2597
SER03	-0.138830	0.142877	-0.971674	0.3504
SER04	0.441052	0.455440	0.968410	0.3520
SER05	0.131148	0.416748	0.314695	0.7584
SER06	-0.001841	0.282766	-0.006509	0.9949
R-squared	0.307856	Mean dependent var		1.30E+10
Adjusted R-squared	0.077142	S.D. dependent var		6.78E+09
S.E. of regression	6.51E+09	Akaike info criterion		48.27062
Sum squared resid	5.08E+20	Schwarz criterion		48.51568
Log likelihood	-405.3003	F-statistic		1.334360
Durbin-Watson stat	1.538513	Prob(F-statistic)		0.313030

Software used: E-Views

Table no. 3

Cehia (1996-2016) model invalidat

Dependent Variable: SER01= ISD Method: Least Squares				
Sample: 1996 2016 Included observations: 21				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.22E+09	2.88E+09	0.769651	0.4527
SER03	-0.115677	0.222768	-0.519270	0.6107
SER04	0.458033	0.710705	0.644477	0.5284
SER05	0.009674	0.760802	0.012715	0.9900
SER06	0.019443	0.680671	0.028564	0.9776
R-squared	0.221772	Mean dependent var		6.50E+09
Adjusted R-squared	0.027214	S.D. dependent var		3.56E+09
S.E. of regression	3.52E+09	Akaike info criterion		47.00292
Sum squared resid	1.98E+20	Schwarz criterion		47.25161
Log likelihood	-488.5306	F-statistic		1.139879
Durbin-Watson stat	2.114762	Prob(F-statistic)		0.373242

Cehia (2000-2016) model invalidat

Dependent Variable: SER01= ISD Method: Least Squares				
Sample: 2000- 2016 Included observations: 17				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.48E+09	3.60E+09	1.244615	0.2370
SER03	-0.216130	0.232000	-0.931596	0.3699
SER04	0.710963	0.741709	0.958547	0.3567
SER05	0.015453	0.819641	0.018854	0.9853
SER06	0.043734	0.729987	0.059910	0.9532
R-squared	0.186188	Mean dependent var		7.28E+09
Adjusted R-squared	-0.085083	S.D. dependent var		3.38E+09
S.E. of regression	3.52E+09	Akaike info criterion		47.04341
Sum squared resid	1.49E+20	Schwarz criterion		47.28847
Log likelihood	-394.8690	F-statistic		0.686353
Durbin-Watson stat	2.652771	Prob(F-statistic)		0.615025

Software used: E-Views

Table no. 4

Ungaria (1996-2016) model invalidat

Dependent Variable: SER01 = ISD Method: Least Squares				
Sample: 1996 2016 Included observations: 21				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.02E+09	2.53E+10	0.040508	0.9682
SER02	-1.027790	1.524221	-0.674305	0.5097
SER03	0.915171	5.126322	0.178524	0.8606
SER04	3.479163	3.086229	1.127319	0.2762
SER05	-2.091673	2.370375	-0.882423	0.3906
R-squared	0.269496	Mean dependent var		1.31E+10
Adjusted R-squared	0.086870	S.D. dependent var		2.56E+10
S.E. of regression	2.45E+10	Akaike info criterion		50.88546
Sum squared resid	9.60E+21	Schwarz criterion		51.13416
Log likelihood	-529.2973	F-statistic		1.475670
Durbin-Watson stat	1.333926	Prob(F-statistic)		0.255926

Ungaria (2000-2016) model invalidat

Dependent Variable: SER01 = ISD Method: Least Squares				
Sample: 2000 2016 Included observations: 17				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.05E+10	3.21E+10	-0.327157	0.7492
SER02	-1.464043	1.750800	-0.836214	0.4194
SER03	1.223912	5.639952	0.217007	0.8318
SER04	4.858811	3.615036	1.344056	0.2038
SER05	-2.832366	2.683872	-1.055328	0.3121
R-squared	0.316767	Mean dependent var		1.54E+10
Adjusted R-squared	0.089022	S.D. dependent var		2.82E+10
S.E. of regression	2.69E+10	Akaike info criterion		51.10658
Sum squared resid	8.67E+21	Schwarz criterion		51.35164
Log likelihood	-429.4059	F-statistic		1.390885
Durbin-Watson stat	1.407396	Prob(F-statistic)		0.295055

Software used: E-Views

Thus, one can see how the classical model is dominantly invalidated, which translates as a different behaviour of some economies in the group of EU ex-socialist countries in terms of FDI, according to calculated values and tabulated values compared in model testing leading to invalidation (e.g. F-statistical and p critical)

A classic multi-factorial model with a validating/invalidating selective finality in relation to an optimal econometric and financial investment model for the economies of the Eastern and Central European ex-socialist countries can lead to a true competition of the various models and patterns, emerging from the tendencies related to the accentuation of the significance of the R-squared coefficient of determination, and the validation/invalidation tests used in selecting the model factors and the primacy of the diversity of these countries' economies according to the databases (factorial eclecticism). The financial econometric modelling of FDI is a living and complex process, which analyzes countless variables expressed variously, from value indicators, which are relative, to structural indicators, including specific indicators of the original models, synthesizing important conclusions, where the completion by invalidation of some models can have the same importance as the validation of some others.

5. Conclusions

Punctually subjected to the tests specific to the econometric model, many of the classic ISD models may be false regressions (i.e. *spurious regression*) or illusory correlations, and the determination coefficient (R^2, or R-squared) is a mere prerequisite for initial selection, and eventually few of the models chosen are going to be validated using specific tests (Fisher,

Durbin-Watson, Student, and other tests and graph procedures). The classical econometric model of multifactorial regression represents in practice an iteration, or a successive and selective iteration/reusing of unifactorial models, which can however bring about another form of detriment-induction, through the multicollinearity phenomenon. Factorial excess is compensated in this type of modeling by the Latin adage *"non multa, sed multum"*, or *"multum in parvo"*, extracted from the Pythagorean thought: *"Do not say a little in many words, but much in a few words"* (Săvoiu, 2013, p. 167). At the same time, an undeniable truth is that selecting variables with major determination in the variation of the endogenous variable may become more important than simply multiplying them and overcrowding the model (from all points of view, both as data source multiplications and as tests, validations, etc.), but several factors, like several heads, can give rise to several meanings in the knowledge of an economic phenomenon such as FDI. A paradox resulting from the invalidation of the models presented for Poland, the Czech Republic and Hungary can be expressed by saying that some trends in a country's economy are not found, in the medium term, either globally or in the EU, or in all Eastern and Central European ex-socialist economies, or else they may be less intense or offset even in relation to global trends.

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