

## **The Impact of Information and Communication Technologies on National Competitiveness: A Test of a Mediating Model in the Non-European Union and Central Asian Countries Context**

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### **Abstract**

*This paper investigates the relationship between determinants of information and communication technologies, such as information society, innovation and R&D and network industries, and global national competitiveness. The research is based on data from 16 non-European Union Eastern Europe and Central Asia countries. A mediation model is tested to examine the link between determinants of the economic system, such as liberalization, financial services, enterprise environment, social inclusion and sustainable development, and global national competitiveness. The results of this study support the hypothesis that the relationship between economic system and global national competitiveness is positively and fully mediated through information and communication technologies.*

**Keywords:** Global national competitiveness, economic system, Eastern Europe, Central Asia

### **Introduction**

This paper is the second of a series of papers that investigates the mediation effect of determinants of information and communication technologies, such as information society, innovation and R&D and network industries, in the relationship between determinants of the economic environment, such as liberalization, financial services, enterprise environment, social inclusion and sustainable development, and global national competitiveness. The first paper in this series, referring to the 27 European Union member-states, concluded that the relationship between economic system and global national competitiveness is positively and partially mediated through information and communication technologies (Katos, 2009). Additionally, it was found that the influence of the information and communication technologies on global national productivity is higher, compared to the influence of the economic system.

The purpose of this second paper is to investigate whether the relationship between economic environment and global national competitiveness of the European Union member-states, which is mediated through information and communication technologies, it is holding for non-European Union countries also. Specifically, the country coverage of the study refers to the countries that are already official accession candidates for joining the European Union (Albania, Former Yugoslavian Republic of Macedonia, Turkey), countries that are potential accession countries

(Albania, Bosnia and Herzegovina, Montenegro, Serbia), countries for which European Union has adopted a European Neighboring Policy Action Plan (Armenia, Azerbaijan, Georgia, Moldova, Ukraine), and countries of Central Asia that have no plans to join European Union (Kazakhstan, Kyrgyz Republic, Russian Federation, Tajikistan) (Blanke & Thierry, 2008; Lopez-Claros, 2008).

Specifically, the primary questions examined in this research are:

1. What is the impact (if any) of information and communication technologies on the economic environment and global national competitiveness relationship in the non-European Union context?
2. What are the differences (if any) in the economic environment and global national competitiveness relationship, between the European Union and non-European Union contexts?

Section two presents the operational model and develops the hypotheses to be tested. Data, constructs and the statistical analysis used in estimation, are described in section three. The statistical estimates of the model and discussion of the meaning of these estimates is presented in section four. Finally, section five presents the conclusions of the study.

### Theory and Hypotheses

The operational model used for testing mediation of the information and communication technologies (ICT) between the economic environment (ECON) and global national competitiveness (GNC) is the same model used in Katos (2009). For convenience this model is reproduced in Figure 1. “This model advocates that a positive economic environment leads to higher levels of investment in information and communication technologies, leading to improved global national competitiveness” (Katos, 2009, p. 117).

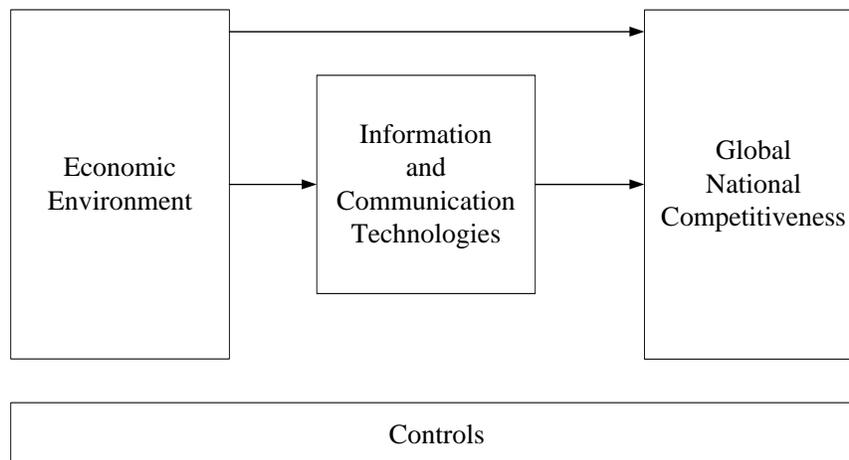


Figure 1. Mediating Model (Source: Katos, 2009, p. 117)

Furthermore, according to the rationale of the 'Economic Environment – Global National Competitiveness linkage model' reproduced in Figure 1, the hypotheses developed in Katos (2009, p. 118) are the following:

- Hypothesis 1:* A positive relationship exists between economic environment and global national competitiveness.
- Hypothesis 2:* A positive relationship exists between economic environment and information and communication technologies.
- Hypothesis 3:* A positive relationship exists between information and communication technologies and global national competitiveness.
- Hypothesis 4:* Increases in information and communication technologies mediate the relationship between economic environment and global national competitiveness.

## Methodology

### Data and constructs

All data in this study were taken from the World Economic Forum database. Following the same steps of analysis proposed in Katos (2009), Table 1 presents the principal components factor analysis with varimax rotation, and eigenvalue greater than one, on the individual items used for each construct. Specifically, the results showed that the three items of the global national competitiveness were factored into one dimension that explains 94.4 percent of the variation, which is above the suggested construct validity level of 0.50 (Hair, Anderson, Tatham, & Black, 2006). The Cronbach alpha score for these items is 0.971, which is above the suggested reliability level of 0.70 (Nunnally, 1978). We used the scores of GNC for three successive years, to minimize random fluctuations of competitiveness over the past three years. Furthermore, the three items of the information and communication technologies were factored into one dimension that explains 86.2 percent of the variation, which is above the suggested construct validity level, and the Cronbach alpha score for these items is 0.887, which is above the suggested reliability level. Additionally, the five items of the economic environment were factored into one dimension that explains 74.5 percent of the variation, which is above the suggested construct validity level, and the Cronbach alpha score for these items is 0.861, which is above the suggested reliability level. Finally, the three constructs were created based on weighed averages with weights being the corresponding factor loadings.

One control variable was included in the analysis, to capture other environmental forces that are related to all the variables involved in the study, named '*DASIA*', which was taking the value of '0' for the candidate countries (Croatia, Former Yugoslavian Republic of Macedonia, Turkey) and the potential candidate countries (Albania, Bosnia and Herzegovina, Montenegro, Serbia) to join European Union, and '1' for the countries (Armenia, Azerbaijan, Georgia, Moldova, Ukraine) for which has been adopted a European Neighbouring Policy Action Plan, and other Central Asia countries (Kazakhstan, Kyrgyz Republic, Russian Federation, Tajikistan).

Table 1. Factor analysis results for the constructs used

Global National Competitiveness		Information and Communication Technologies		Economic Environment	
(GNC)		(ICT)		(ECON)	
Variables	Loadings	Variables	Loadings	Variables	Loadings
GNC_07	0.969	Information Society	0.928	Liberalization	0.891
GNC_08	0.975	Innovation and R&D	0.895	Financial Services	0.888
GNC_09	0.972	Network Industries	0.962	Enterprise Environment	0.736
				Social Inclusion	0.578
				Sustainable Development	0.826
Explained variation	94.457%		86.229%		74.511%
Eigenvalue	2.834		2.578		2.669
Cronbach alpha	0.971		0.887		0.861

### Statistical analysis

For testing whether variable Z mediates the relationship between variable X and variable Y, the four steps proposed by Baron and Kenny (1986) and Katou and Budhwar (2006) were followed: These steps have been for convenience reproduced bellow (Katos, 2009, p. 119):

- Step 1:* Conduct a regression analysis with X predicting Y to test if there is an effect that may be mediated,  $Y = a + bX + e$ .
- Step 2:* Conduct a regression analysis with X predicting Z to test if X is related to Z,  $Z = a + bX + e$ .
- Step 3:* Conduct a regression analysis with Z predicting Y to test if Z is related to Y,  $Y = a + bZ + e$ .
- Step 4:* Conduct a regression analysis with X and Z predicting Y to test if Z completely mediates Y,  $Y = a + b_1X + b_2Z + e$ .

As it is presented in Katos (2009, p. 120), “the purpose of Steps 1 to 3 is to establish that ‘zero-order’ relationships among the variables exist. If one or more of these relationships are non-significant, mediation is not likely. Assuming there are significant relationships from Steps 1 through 3, one proceeds to Step 4. In Step 4, some form of mediation is supported if the effect of Z remains significant after controlling for X. If X is no longer significant when Z is controlled, the findings support ‘full mediation’. If X is still significant (i.e., both X and Z significantly predict Y), the finding supports ‘partial mediation’ (Kenny, 2001)”.

## Results

Table 2 presents the results of the regression analysis for testing the effects of economic environment (ECON) on global national competitiveness (GNC), using as mediator the information and communication technologies (ICT). The mediation effect is tested through the steps presented above:

1. From the regression results in Model 1, we see that ECON positively affects GNC, thus supporting Hypothesis 1.
2. From the regression results in Model 2, we see that ECON positively affects ICT, hence supporting Hypothesis 2.
3. From the regression results in Model 3, we see that ICT positively affects GNC, consequently supporting Hypothesis 3.
4. From the regression results in Model 4, we see that although ECON is not significant, ICT positively affects GNC, therefore supporting Hypothesis 4. However, because ICT is significant and ECON is not significant, this finding supports full mediation (Kenny, 2001).

Furthermore, with the introduction of the control variable we tried to capture effects that may identify differences in competitiveness between the countries that are attributed to factors other than the factors that constitute the independent variables included in the regression equations. Specifically, from the results presented in Table 2 we found that in all cases the DASIA control is not significantly related to global national competitiveness. This means that there is no any exogenous significant difference in global national competitiveness between the candidate and the potential candidate countries to join European Union and the other Central Asian countries.

From the results presented above we may conclude that, contrary to the findings with respect to the European Union countries where information and communication technologies were ‘partially’ mediating the relationship between economic environment and global national competitiveness (Katos, 2009), information and communication technologies ‘fully’ mediate the relationship between economic environment and global national competitiveness in the non-European Union and Central Asia countries. This finding is important for policy makers, because it suggests that in the non-European Union and Central Asia countries economic policies aiming at changing economic environment do not directly influence global competitiveness of the nation but they pass through the information and communication technologies filter.

Table 2. Regression results for testing mediation of ICT (non-European Union and Central Asia countries)

	Model 1	Model 2	Model 3	Model 4
	GNC	ICT	GNC	GNC
Constant	1.378 (0.070)	-0.275 (0.801)	1.916 (0.000)	1.526 (0.007)
<b>Controls</b>				
DASIA	-0.068 (0.530)	-0.117 (0.477)	0.002 (0.980)	-0.009 (0.905)
<b>Mediators</b>				
ICT			0.596 (0.000)	0.506 (0.001) [0.794]
ECON	0.669 (0.003)	0.960 (0.005)		0.184 (0.304) [0.192]
R <sup>2</sup>	0.507	0.483	0.777	0.797
Adjusted R <sup>2</sup>	0.431	0.403	0.743	0.746
F	6.676 (0.010)	6.062 (0.014)	22.678 (0.000)	15.681 (0.000)
N	16	16	16	16

Notes: Significant levels in parentheses  
Beta coefficients in brackets []

Considering the second research question, which refers to the possible differences in the economic environment and global national competitiveness relationship between the European Union and non-European Union contexts Table 3 presents the estimates of the mediation model using log-linear regression equations for both groups of countries. This is because in log-linear equations the estimated regression coefficients refer to the ‘elasticities’ of the dependent variable with respect to the independent variables. Thus, the values of the regression coefficients between the various equations are directly comparable, by bearing of course in mind the standard errors of the coefficients for comparison.

Table 3. Regression results for testing mediation of ICT (log-linear equations)

	Model 1		Model 2		Model 3		Model 4	
	Log(GNC)		Log(ICT)		Log(GNC)		Log(GNC)	
	EU	Non EU						
Constant	0.527 (0.000)	0.488 (0.067)	-0.094 (0.591)	-0.295 (0.500)	0.674 (0.000)	0.750 (0.000)	0.561 (0.000)	0.618 (0.003)
<b>Controls</b>								
Eurozone	-0.036 (0.041)		-0.001 (0.951)		-0.036 (0.030)		-0.035 (0.023)	
Accession	-0.067 (0.002)		-0.051 (0.084)		-0.045 [0.032]		-0.048 (0.015)	
DASIA		-0.022 (0.450)		-0.039 (0.434)		-0.001 (0.945)		-0.004 (0.820)
<b>Mediators</b>								
Log(ICT)					0.596 (0.000)	0.510 (0.000)	0.362 (0.009)	0.439 (0.001)
					{0.058}	{0.076}	{0.126}	{0.106}
					t-ratio = 0.899		t-ratio = 0.468	
Log(ECON)	0.689 (0.000)	0.661 (0.003)	1.062 (0.000)	1.130 (0.004)			0.305 (0.051)	0.165 (0.357)
	{0.073}	{0.184}	{0.105}	{0.322}			{0.148}	{0.172}
	t-ratio = 0.141		t-ratio = 0.339				t-ratio = 0.617	
R <sup>2</sup>	0.899	0.507	0.898	0.497	0.913	0.781	0.927	0.797
Adjusted R <sup>2</sup>	0.886	0.431	0.885	0.420	0.901	0.747	0.913	0.746
F	68.478 (0.000)	6.673 (0.010)	67.484 (0.000)	6.430 (0.011)	80.036 (0.000)	23.193 (0.000)	69.596 (0.000)	15.671 (0.000)
N	27	16	27	16	27	16	27	16

Notes: Significant levels in parentheses  
Standard errors in brackets {}

Applying t-tests to investigate the differences between the estimated elasticities of the EU countries and the non-EU countries it has been found that there are no significant differences between them, although numerically they look to be different. This insignificance is indicated by the very low values of the t-ratios between the pairs of coefficients, which are shown in Table 3. This result means that the structure of the relationships between economic environment, information and communication technologies, and global national competitiveness is the same in both groups of countries, the EU and the non-EU.

However, the only difference is that information and communication technologies partially mediates the relationship in the EU countries and fully mediates this relationship in the non-EU countries. In other words, for the EU countries the final equation that applies is that of Model 4\_EU in Table 3, i.e.,

Equation (1):

$$\begin{aligned} \text{Log}(GNC)_i = & 0.561 - 0.035\text{Euro}_i - 0.048\text{Acce}_i + 0.362\text{Log}(ICT)_i + 0.305\text{Log}(ECON)_i \\ & (0.000) \quad (0.023) \quad (0.015) \quad (0.009) \quad (0.051) \\ & \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \{0.126\} \quad \{0.148\} \end{aligned}$$

$$R^2 = 0.927 \quad \bar{R}^2 = 0.913$$

and for the non-EU countries the final equation that applies is that of Model 3\_Non EU in Table 3, i.e.,

Equation (2):

$$\begin{aligned} \text{Log}(GNC)_i = & 0.750 - 0.001\text{DASIA}_i + 0.510\text{Log}(ICT)_i \\ & (0.000) \quad (0.945) \quad (0.000) \\ & \qquad \qquad \qquad \qquad \qquad \qquad \qquad \qquad \{0.076\} \end{aligned}$$

$$R^2 = 0.781 \quad \bar{R}^2 = 0.747$$

Considering these two equations, the t-ratios reported in Table 3 may not be directly applicable. In fact, by comparing the estimated coefficients of the Log(ICT) variable in the two equations the t-ratio is equal to 1.006, which although still is not indicating significant difference between the two coefficients is much larger than the t-ratio=0.468 reported in Table 3. Thus, we may say that there is tendency for indicating significant difference between the two estimates, which may be stronger in case that the sample sizes used in estimation were larger.

Summarizing, equation (1), considering the partial mediation effect, indicates that if information and communication technologies increase by 10 percent, other things being equal, global national competitiveness will be improved by 3.62 percent, and if economic environment improves by 10 percent, global national competitiveness will be improved by 3.05 percent, for the European Union member-states. Additionally, equation (2), considering the full mediation effect, indicates that if information and communication technologies increase by 10 percent, other things

being equal, global national competitiveness will be improved by 5.10 percent for the non-European Union and Central Asia countries.

### Conclusions

In investigating the mediating mechanism, usually called the 'black box', which exists in the relationship between economic environment and global national competitiveness in the 27 European Union member-states, Katos (2009) found that information and communication technologies partially mediate this relationship.

Applying the same methodology to 16 non-European Union and Central Asia countries, the results of this study support that determinants of the economic environment positively affect global national competitiveness. Specifically, the relationship between liberalization, financial services, enterprise environment, social inclusion and sustainable development, and global national competitiveness, is mediated through information society, innovation and R&D and network industries. In particular, considering the highest loadings of the constructs in Table 1, it is seen that liberalization positively influences network industries, which in turn positively influence global national competitiveness. This result for the non-European Union and Central Asia countries is exactly the same with the result found for the European Union member-states (Katos, 2009).

Additionally, the study supports that the mediation effect of the information and communication technologies is full in the economic environment – global national competitiveness relationship when it refers to the non-European Union and Central Asia countries, although this effect is partial in the same relationship when it refers to the European Union member-states.

However, all research has its limitations and ours is no different. The conclusions above should be treated with caution. This is mainly because biases in estimating equations employing weighted average indexes may have distorted the results (Katsouli, 2006). Furthermore, the sample size used in the study is rather small, and thus further research is needed trying to avoid these limitations.

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