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Relationships between factors of regional competitiveness in Central and Eastern Europe

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Abstract. The divide between the eastern and western parts of the European Union has been widely discussed. However, significant territorial differences are undoubtedly present even within the narrower eastern region of the EU. This study focuses on the competitiveness of regions in Central and Eastern Europe (CEE). The analysis relies on the pyramid model, the theoretical background of which provides the basis for investigating the factors affecting the competitiveness of the 51 NUTS 2 regions across six CEE countries. Partial least squares structural equation modelling (PLS-SEM) is applied to examine the relationships and effect mechanisms between the model's factors (more specifically, between the latent variables representing the factors). We have adapted our general model to the so-called overperforming and underperforming regions described by Iammarino et al. (2019), exploring the connections of their competitiveness factors in this context. Research results reveal that the effect mechanisms observed between the above-mentioned regions are completely different. Various factors can be considered as either important or less decisive in terms of competitiveness development, which could have implications for regional policy moving forward.

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1. INTRODUCTION

In the past two decades, 'competitiveness' has become a favourite term not only in regional science research, but also in regional policy documents, occasionally generating intense debates (Aiginger and Firgo, 2017; Annoni and Dijkstra, 2019; Camagni, 2017; Capello, 2016; Thissen et al., 2013). As Grassia et al. (2022) state, the economic aspect of the theorem, especially, has garnered significant attention from policymakers and scholars. Starting in the early 2000s, policymakers and subsequently scholars began to shift their focus towards competitiveness at a sub-national level, emphasizing its regional dimension.

In the European Union, cohesion (or regional) policy is still an important pillar among the EU's policies (Fratesi and Wishlade, 2017; Parente, 2019). As suggested by Rodríguez-Pose and Ketterer (2019), the analysis of the axes of development policies shows that the bulk of cohesion resources flows into the least developed regional units of the EU, including the Central and Eastern Europe. Although this policy's effectiveness has raised questions (Kluza, 2015; Pylak, 2015), most resources are intended to improve competitiveness, mainly by developing human resources and expanding individual and corporate innovative capacities in less developed areas. Moreover, as Sánchez de la Vega et al. (2019) have noted, the increasing popularity of the theorem of competitiveness has led to numerous projects using indicators in an effort to assess the competitiveness of countries and regions.

The paper has parallel aims. On the one hand, our goal is to uncover the relationships among factors of regional competitiveness. On the other hand, the achievement of the first aim allows us to distinguish the nature of the relevant competitiveness factors based on the development of a given region.

In our analysis we examined the competitiveness of 51 NUTS 2 regions of Central and Eastern European post-socialist countries that joined the EU in 2004 or 2007 (Bulgaria, Czechia, Poland, Hungary, Romania and Slovakia). We applied a renewed version of the pyramid model to study regional competitiveness (Lengyel, 2017). The model's basic premise is that there is a link between the output indicators used to measure competitiveness and the development factors given as inputs. We tested the relationships between the level of the drivers of competitiveness (five elements comprise level 1) and the elements of revealed competitiveness (outputs). As for methodology, we employed partial least squares structural equation modelling (PLS-SEM). The procedure enabled us to explore the connections between the factors affecting competitiveness (more precisely, between the latent variables representing the factors) and to scrutinise their effect mechanisms.

Iammarino, Rodriguez-Pose, and Storper (2019) delved into the development of the EU's NUTS 2 regions, in addition to which territorial units can be called 'overperformers' and 'underperformers'. Based on the delimitation of the above-mentioned authors, out of 51 Central and Eastern European regions, 25 qualified as overperformers, and 26 as underperformers, which we analysed separately for our paper.

To ensure comperbility of regions of different countries throughout our investigation, we primarily utilised the Eurostat database (24 indicators). However, in a few instances (4 indicators), we incorporated certain indicators from the EU's competitiveness ranking (Annoni and Dijkstra, 2019) (Appendix 1).

2. LITERATURE REVIEW

The viewpoints addressing competitiveness can be categorised into two types: narrower and broader. Narrower approaches link competitiveness to economic growth (e.g. Prabawani et al. 2020), primarily to the level and change in productivity. As Krugman noted in connection with international competition (1994, p. 35), 'if they wish, [they can] use the term "competitiveness" as a poetic way of saying productivity'. Porter took a similar view (2008, pp. xiii–xiv) on a microeconomic basis whereby 'competitiveness arises from the productivity with which firms in a location can use inputs to produce valuable goods and services'.

In regional science, broader interpretations—which focus on the sustainable development of regions and cities among the conditions of global competition—have been given prominence (Aiginger and Firgo, 2017; Camagni and Capello, 2010; Chrobocinska, 2021; Meyer-Stamer, 2008, Smékalova et al., 2015; Wojtasiak-Terech et al., 2022). The European Competitiveness Report expresses that (EC, 2008, p. 15): 'Competitiveness is understood to mean a sustained rise in the standards of living of a nation or region and as low a level of involuntary unemployment as possible'. The European Regional Competitiveness Index (ERCI) developers, Annoni and Dijkstra (2019, p. 3), also made a broader interpretation: 'Regional competitiveness is the ability of a region to offer an attractive and sustainable environment for firms and residents to live and work'.

Regional competitiveness is characterised by a duality: the success achieved in the present, and a region's ability to remain successful in the future. Hence, a special focus is given to the factors that consistently promote development and consequently strengthen a region's competitiveness. Huggins et al. (2019) applied a three-factor model to distinguish the factors of input, output, and outcomes.

The pyramid model, which relies on the approach of inputs-outputs-outcomes, is widely used to analyse competitiveness among regions (Gardiner, et al., 2004; Lengyel, 2004; 2009); 'this model is useful to inform the development of the determinants of economic viability and self-containment for geographical economies' (Pike et al., 2006, p. 26). Among the models employed in research on regional competitiveness, according to Thissen et al. (2013, p. 50), the pyramid model receives the most attention in academic and policy circles, and offers the most opportunities for a diverse research agenda. The renewed pyramid model consists of four levels (Lengyel, 2017, p. 402): (1) long-term sources of competitiveness (inputs-2), (2) drivers of competitiveness (inputs-1), (3) revealed competitiveness (outputs), and (4) target (outcomes) (Figure 1).

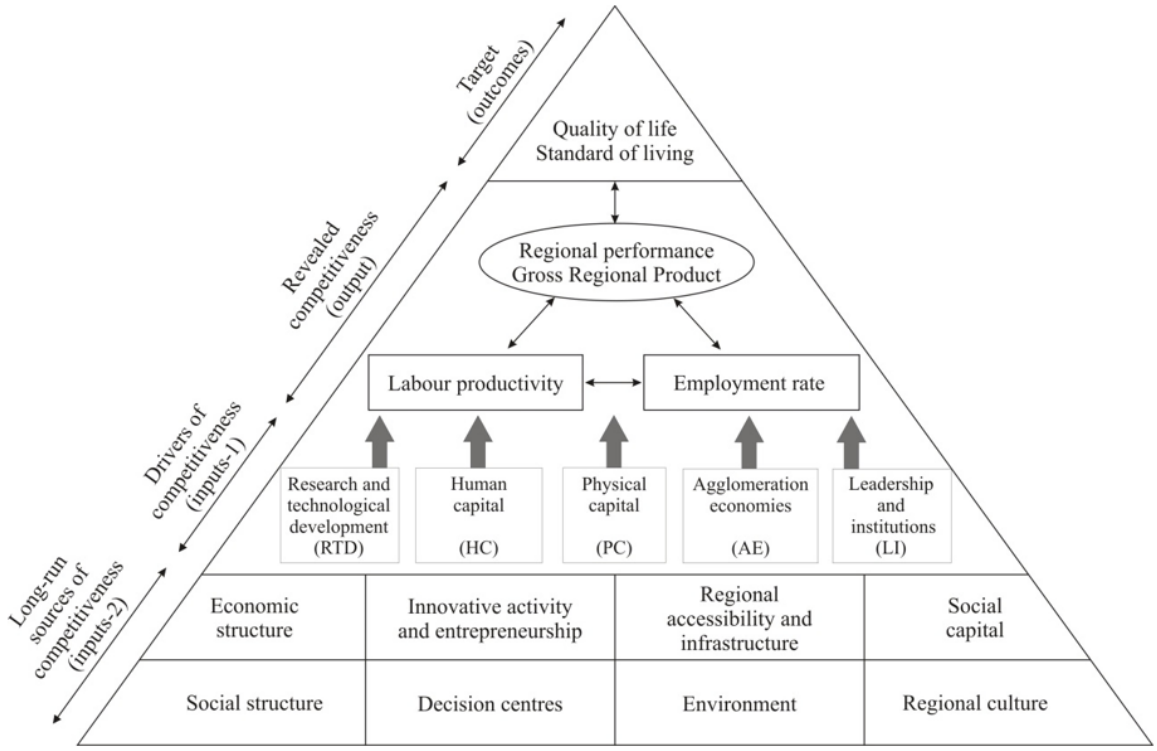

Figure 1. The renewed pyramid model of regional competitiveness

Source: Lengyel (2017, p. 402)

The renewed pyramid model, similar to the earlier mentioned three-factor model, depends on the input–output–outcomes relationships:

- Outcomes (target) include quality of life, standard of living, prosperity, and well-being.
- Outputs (revealed competitiveness) are ex-post indicators: gross domestic product (GDP) per capita, labour productivity, and employment rate.
- Inputs-1 (drivers of competitiveness) have a direct and short-term influence on revealed competitiveness; there are five factors.
- Inputs-2 are long-run sources of competitiveness with an indirect impact on outputs and inputs-1, with eight categories on two levels.

We introduced five factors to examine the relations between the output indicators of revealed competitiveness (RC) and drivers of competitiveness (inputs-1) (Lengyel, 2017, p. 401):

- RTD refers to research and (technological) development, also known as R&D (the technical process);
- HC is human capital (labour);
- PC stands for 'physical capital';
- AE is 'agglomeration economies' (and regional specialisation); and
- LI represents leadership and institutions.

The pyramid model is based on the assumption that there is a relationship between inputs-1 and output (revealed competitiveness) (Lengyel, 2017), which is an extension of the endogenous regional growth and development concepts (Stimson et al., 2009). The model involves traditional factors of endogenous growth theories: capital (PC as K), labour (HC as L), and technical progress (RTD as TFP). In addition, agglomeration economies (AE and regional specialisation) are included in the inputs of the renewed pyramid model, as well as leadership and institutional effects (LI), highlighted by new endogenous development theories (Huggins et al., 2013).

For our study, we analysed the relationships between the factors constituting the level of inputs-1 (R&D, human capital, physical capital, agglomeration economies, leadership, and institutions), which can affect revealed competitiveness; that is, labour productivity and employment rate in the medium term. We measured each factor using several indicators, and scrutinised the relationships between them by applying PLS path analysis.

3. PLS PATH ANALYSIS AND ORIGINAL MODEL

SEM has become a popular tool among social scientists (Benitez et al., 2020). Regarding the emergence of SEM, Henseler et al. (2009) mentioned the world of marketing and management as a scientific field, but suggested that its spread in regional sciences may also produce substantial results.

The procedure has two types (Benitez et al., 2020; Hair et al., 2018; Henseler et al., 2016). At the same time, in terms of exploring the complex relationships between observed and latent variables, covariance-based SEM (CB-SEM) has been dominant for quite some time. Since 2010, the number of scientific works applying variance-based PLS-SEM has significantly increased (Hair et al., 2018).

If we intend to construct a cause-effect model between the factors, it necessitates the simultaneous run of factor analysis and regression models. One potential solution for this could be PLS path analysis.

Although, previously mentioned, the advance of this method dates back to the past decade. That said, it has been an approved and applied technique among researchers to examine the relationships among latent variables for decades (Henseler et al., 2009).

The PLS procedure dates back to the second half of the 20th century, to the 1970s and 1980s specifically, and is connected to the name of the Swedish econometrician Herman O.A. Wold (e.g. Wold 1983). At this time, Wold '…vigorously pursued the creation and construction of models and methods for the social sciences, where "soft models and soft data" were the rule rather than the exception, and where approaches strongly oriented at prediction would be of great value' (Dijkstra, 2010, p. 24).

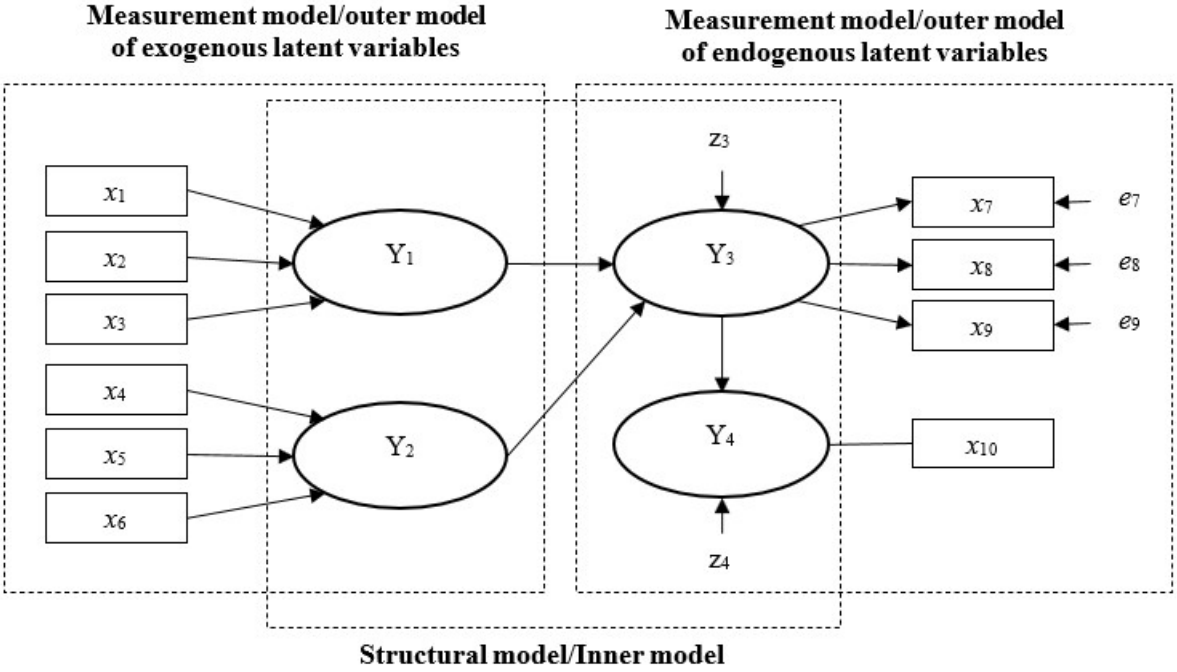

Figure 2. A simple path model
Source: Hair et al. (2017, p. 37)

As written by Hair et al. (2017), the constructs (or latent variables) are indicated by Y (Y1-Y4). The involved indicators (x1–x10) (or manifest variables) can be considered proxy variables, which only indirectly explain the factors. The arrows between each factor represent the cause-effect connections between them. An important characteristic of PLS-SEM is that a circle cannot be formed in terms of the relationships. In addition, these arrows refer to predictive links based on the academic literature; that is, they symbolise the causal link. Hence, the model consists of an inner (or structural model) and an outer (or measurement model) part. In this case, there are two types of outer models. One is for the exogenous latent variables; that is, the constructs that explain other constructs in the model. The other type is the model of endogenous latent variables, which are explained within the model by the model. The error terms (e7–e9) (error terms) connected to the factors represent the unexplained variance. Indications z3 and z4 are connected to the endogenous latent variables (Y3 and Y4), which also have error terms. In contrast, the exogenous latent variables only explain other latent variables and do not have error terms (Figure 2).

Many scholars have highlighted the mathematical background behind the procedure's algorithm (e.g. Esposito Vinzi et al., 2010; Hair et al., 2017; Sarstedt et al., 2017; Tenenhaus et al., 2005; Wold, 1983).

Further, another advantage of the model is that it can be used in the case of variables with non-normal distribution and a small sample size (Hair et al., (2017 and 2018); Sarstedt et al., 2017). We found this to be an especially important attribute of this method. Several studies provide a detailed description of the technique and its advantages (Kovács and Bodnár, 2017; Tubadji and Nijkamp, 2015).

As stated earlier, we analysed the relationships between the factors constituting the inputs-1 level of the renewed pyramid model and revealed competitiveness. Using indicators involved in capturing R&D, human capital, physical capital, agglomeration economies, leadership, and institutions, with the help of the software SmartPLS 3.2.7 we conducted PLS path analysis to scrutinise the relations between the latent factors with corresponding content. Using the 'resulting' latent variables, we aimed to apply a regression model that is able to explain to what extent each factor affects and shapes the competitiveness of the 51 NUTS 2 regions of the six Central and Eastern European countries (Bulgaria, Czechia, Hungary, Poland, Romania and Slovakia) under investigation (Appendix 2).

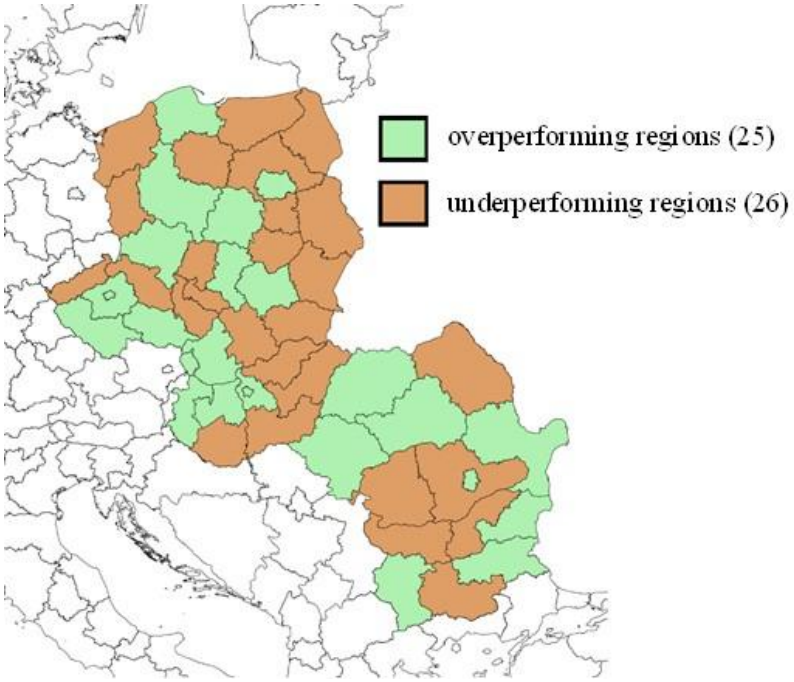

Figure 3. Overperforming and underperforming Central and Eastern European regions
Source: own compilation

We intended to apply our model with a confirmative purpose; that is, we investigated how much the relation of each latent variable supports the current hypothetical relationship set up based on the literature on regional competitiveness.

In light of these considerations, using PLS path analysis (Figure 3), we constructed a model that is able to explain the effects of the featured factors on competitiveness among the NUTS 2 territorial units of the above-mentioned countries. This earlier described competitiveness is embodied by a factor of the same name, in addition to the five more latent variables featured in the model. In the following section, we will demonstrate their goodness (reliability, discriminant validity, and convergent validity). In the first stage, we investigated all the possible paths among the latent variables. The attributes of each factor can be seen in

Appendix 2, while their interpretation is quite extensive (e.g. Dalvi-Esfahani et al., 2018; Kovács and Bodnár, 2017; Maloku et al., 2021) (Appendix 3).

Based on described PLS model, we considered our model worthy of adapting to the examined overperforming and underperforming regions of Central and Eastern Europe. As we mentioned in the introduction, by adapting the approach of Iammarino et al. (2019), 25 regions qualified as overperformers and 26 regions qualified as underperformers out of the 51 Central and Eastern European NUTS2 regions.

4. OVERPERFORMING REGIONS

In the first step of our research, after analysing the latent variables, the question arose as to whether the direct paths in the model of overperforming regions were significant. Since we could not directly explore the significance of the path coefficients in the PLS analysis, we conducted the procedure by bootstrapping 5,000 subsamples (Table 1).

Table 1

Results of testing the direct relationships in the model: The P-values of the model (overperforming regions)

Path	Path coefficients	T value	P value
Agglomeration economies -> Human capital	0.644	9.058	<0.001
Agglomeration economies -> Physical capital	0.931	19.585	<0.001
Leadership and institutions -> Human capital	-0.333	4.257	<0.001
Leadership and institutions -> R&D	-0.597	7.049	<0.001
Leadership and institutions -> Regional competitiveness	-0.246	2.696	0.007
Physical capital -> Regional competitiveness	-0.621	8.684	<0.001
R&D -> Regional competitiveness	0.751	8.842	<0.001

** Significant correlation, p<0.01*

Source: own compilation

Leaving out the non-significant direct paths, all five factors explained the factor of competitiveness directly or indirectly in our final model. Among them, two paths (R&D → regional competitiveness, and leadership and institutions → regional competitiveness) form the target variable directly, while three latent variables (physical capital, human capital and agglomeration economies) shape the target variable indirectly.

Due to the specificities of the indicators involved in measuring the latent variable of leadership and institutions, referring to some sort of social segregation and exclusion, a higher value is attached to a greater level of underdevelopment; thus, the related path coefficients are negative.

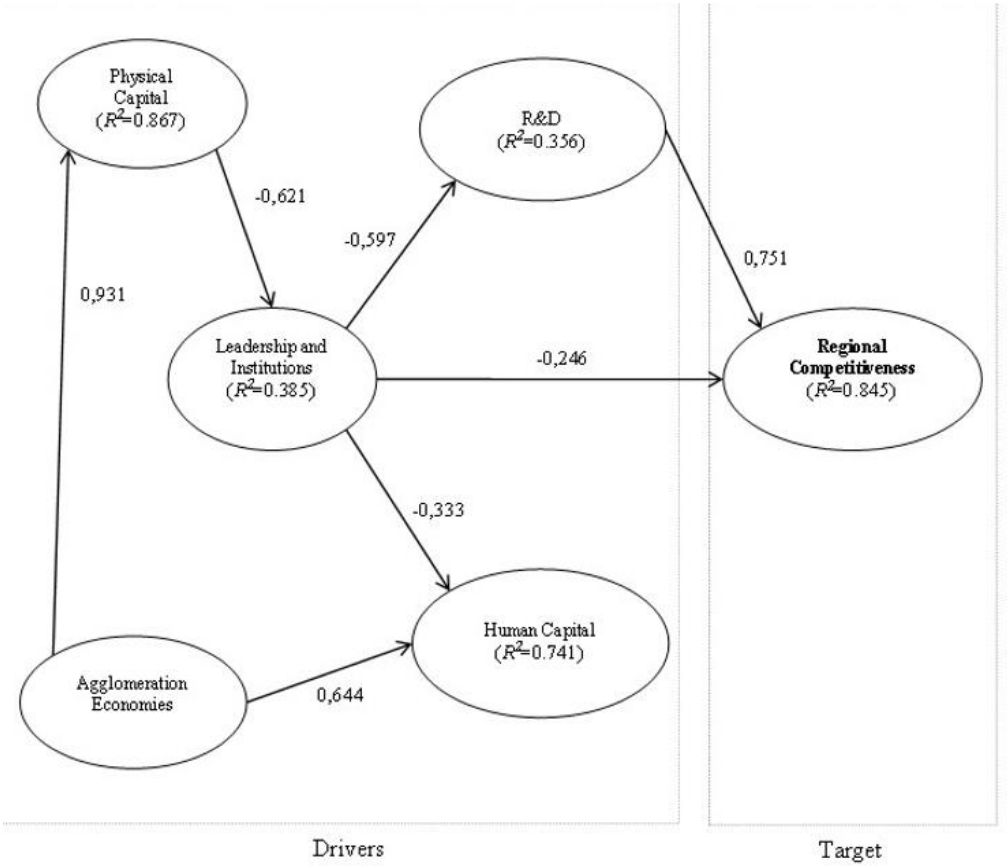

Figure 4. Interactions of factors explaining regional competitiveness among overperforming regions

Source: own compilation

Based on the logic of the endogenous renewed pyramid model (Lengyel, 2017), each factor can be distinguished as a driver or a target (Figure 2). The target is represented by regional competitiveness, and the variance of this factor can be explained in over 84% of cases based on the model (R2=0.845); that is, it is formed in less than 16% by any other factors that we have not included in the model.

Regional competitiveness, as the target variable, is directly affected by R&D and leadership and institutions. The effect of the former can be evaluated as strong, whereas the latter is a weak one. However, both paths are significant.

Within the model, the strongest relationship is seen between the latent variables of physical capital, and agglomeration economies. Moreover, the impact of the latter factor on human capital can be assessed as being medium strong.

We attempted to explore the degree of the direct and indirect effects of each latent variable on regional competitiveness. The direct effects correspond to the coefficients of the path analysis (see Figure 4); the total effect is outlined in Table 2.

Table 2

Values of total effect among overperforming variables

	Human capital	Leadership and institutions	Physical capital	R&D	Regional competitiveness
Agglomeration economies	0.836	-0.578	0.931	0.345	0.401
Human capital					
Leadership and institutions	-0.333			-0.597	-0.694
Physical capital	0.207	-0.621		0.37	0.431
R&D					0.751

Source: own compilation

Interestingly, regional competitiveness is shaped by the latent variables representing leadership-institutions and R&D to closely the same extent. The effect of the former factor is evidently negative due to the variables mentioned earlier.

The total effect of leadership and institutions on competitiveness (-0.694) results from its direct (-0.246) and indirect relationships. The latter indirect effects are exerted through R&D (-0.597 * 0.751 = -0.448). Table 2 displays the total sum of the two paths; that is, the value of the total effect (-0.246 + (-0.448) = –0.694).

As such, we can see that the effect of the two latent variables already affecting the target variable directly is the most significant within the model. The factor representing physical capital has a relatively significant, medium-strong effect (0.431). This is closely followed by the role of agglomeration economies (0.401) in terms of developing regional competitiveness. In contrast, the role of the latent variable of human capital is not significant, hence it does not form target variable. At the same time, regarding the outcomes in interpreting the effect mechanisms, they can only be interpreted in the Central and Eastern European context under examination.

The evaluation of the model also involved Cohen's f^2 (effect size) (Table 3). This measure refers to how the variance of an endogenous variable changes with the omission of an exogenous variable (Hair et al., 2017). Based on the authors mentioned, we found an actual effect over the value of 0.02; the value of f^2 was medium at over 0.15 and significant at over 0.35, based on the aspect of the endogenous variable.

Table 3

Significance of the effects between variables: Values of f^2 – overperforming regions

Path	f^2
Agglomeration economies -- > Human capital	1.197
Agglomeration economies -- > Physical capital	6.513
Leadership and institutions -- > Human capital	0.32
Leadership and institutions -- > R&D	0.553
Leadership and institutions -- > Regional competitiveness	0.252
Physical capital -- > Leadership and institutions	0.626
R&D -- > Regional competitiveness	2.349

Source: own compilation

Consequently, if we study the specific f2 values in terms of our model (Table 3), it is clear that each path exceeds the threshold of 0.02, and they also exceed 0.15. It is interesting that the lowest figure (0.252) belongs to the relationship between the latent variables symbolising leadership-institutions and regional

competitiveness. The relationships between agglomeration economies and physical capital, as well as between R&D and regional competitiveness, are especially 'exciting'; that is, the two values (6.513 and 2.349) suggest that the influence of the former factors on the latter ones is quite significant. The effect of agglomeration economies on human capital is much less significant than the above-mentioned relationships, although it is still strong (1.197).

5. UNDERPERFORMING REGIONS

Based on the previous results, we considered it worthwhile to adapt our model to the examined underperforming regions of Central and Eastern Europe. As mentioned in the introduction, 26 of the 51 Central and Eastern European NUTS2 regions are underperforming (Table 4).

Table 4

Results of testing the direct relationships in the model: The P-values of the model (underperforming regions)

Path	Path coefficients	T value	P value
Agglomeration economies -> Physical capital	0.802	11.043	<0.001
Agglomeration economies -> Regional competitiveness	0.612	5.855	<0.001
Human capital -> Regional competitiveness	0.339	2.919	0.004
Leadership and institutions -> Human capital	-0.704	9.532	<0.001
Physical capital -> Leadership and institutions	-0.794	15.454	<0.001

** Significant correlation, p<0.01*

Source: own compilation

The explanatory power of the model decreased (R^2=0.743), but it could still be assessed to be sufficient (Figure 5). In addition, several interesting changes occurred. The latent variable of R&D cannot be explained properly with the set of indicators developed among the underperforming regions, thus, we could not include it in the new model (its omission is indicated by the dashed ellipse). Consequently, earlier associated paths were also discontinued (dashed arrows). It is also interesting that another paths were discontinued in the model: e.g. the latent variable of leadership and institutions no longer exerted a significant effect on regional competitiveness. At the same time, a new path emerges within the model; agglomeration economies and human capital directly and significantly shape regional competitiveness, in addition the first one's effect is quite strong. Although Human capital's strength is moderate.

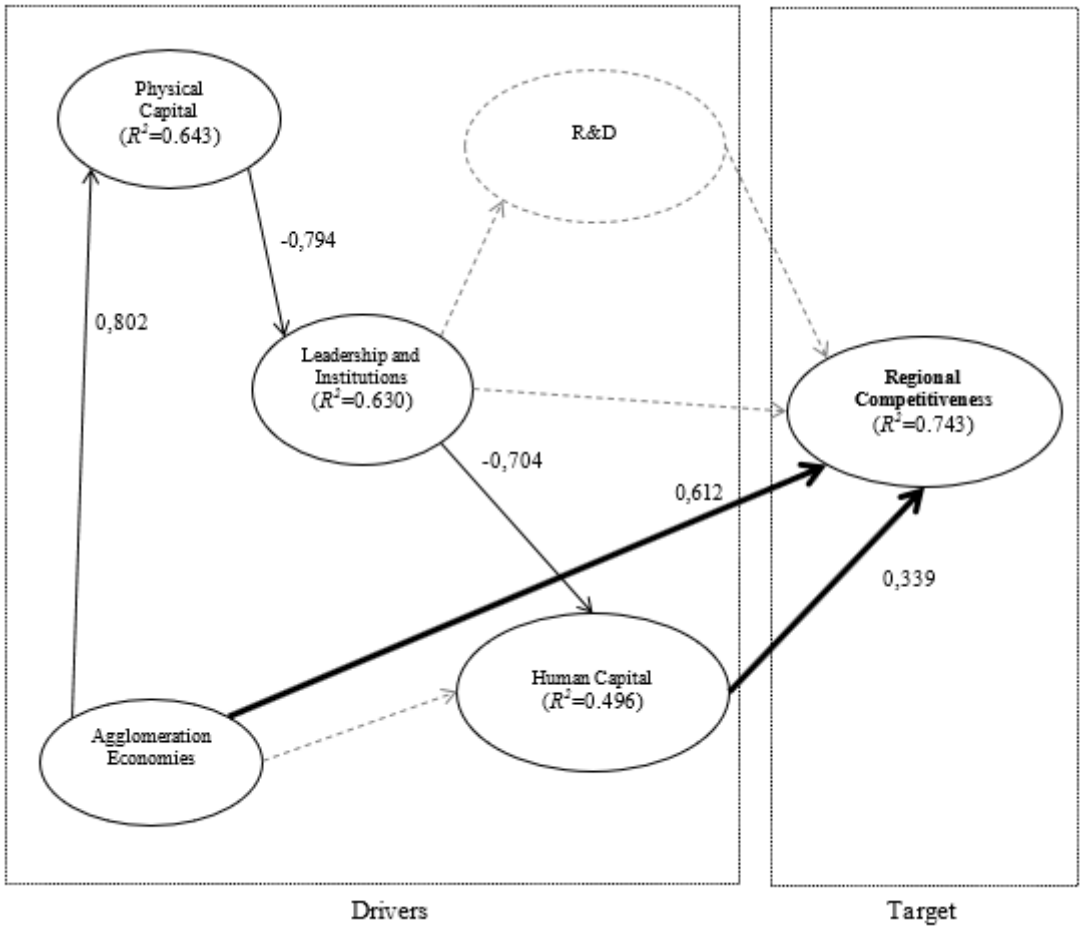

Figure 5. Interactions of factors explaining regional competitiveness among underperforming regions

Source: own compilation.

*Notes: * Bold line: indicates the paths came to be **Dashed line: indicates the eliminated factor of R&D*

On the one hand, it is intriguing to observe that in the new model, the two abovementioned latent variables are those that form the target variable directly. But, on the other hand, we can state that the lack of factor of R&D and the moderate strength of human capital indicate low competitiveness of underperforming territorial units[1].

The necessary tests have also been conducted in the case of underperforming regions, among which the attributes of the factors should be highlighted (Appendix 4). Its interpretation obviously corresponds with the previous conditions (i.e. Table 1); nevertheless, there are certain differences in the results obtained regarding R&D; the values of the latent variable are missing due to its unsatisfying goodness. At the same time, in looking at the correlations between the latent variables, we found a moderately strong relationship between the factors (Appendix 5). There was only one figure over 0.9 (-0,917), otherwise there were no exceptionally high or low values, which can be regarded as favourable.

[1] Attributes of underperforming regions can be seen in Appendix 5.

Table 5

Values of total effect among underperforming regions

	Human capital	Leadership and institutions	Physical capital	Regional competitiveness
Agglomeration economies	0.448	-0.636	0.802	0.764
Human capital				0.339
Leadership and institutions	-0.704			-0.239
Physical capital	0.559	-0.794		0.189

Source: own compilation

Analysing and interpreting the total effects is especially important in the case of underperforming regions (Table 5). Although the 'devaluation' of R&D has already been mentioned, the role of human capital is not too substantial either. At the same time, the total effect of the agglomeration economies (0.764) — that is, the total of the direct and indirect paths — increased compared to what was measured earlier in the case of overperforming regions.

Table 6

Significance of the effects between variables: Values of f^2 – underperforming regions

Path	f^2
Agglomeration economies -> Physical capital	1.799
Agglomeration economies -> Regional competitiveness	0.912
Human capital -> Regional competitiveness	0.28
Leadership and institutions -> Human capital	0.985
Physical capital -> Leadership and institutions	1.701

Source: own compilation

In this case, the lowest figure (0.28) belongs to the relationship between the latent variables symbolising human capital and regional competitiveness. Nevertheless, we cannot see such outstanding values as in the case of overperforming regions. The relationship between agglomeration economies and physical capital has the highest value (1.799), besides the connection between physical capital and leadership and institutions (1.701). So, similar to overperforming regions, f^2 values of underperforming territories (Table 6) exceed the threshold of 0.02, and they also exceed 0.15.

6. CONCLUSIONS

We investigated the competitiveness of the NUTS 2 regions in Central and Eastern Europe using PLS-SEM, quantifying the factors of the renewed pyramid model, more specifically those of its inputs-1 level. We completed the analysis among the overperformed (25) and underperforming (26) regions, which enabled us to explore the role and importance of each factor of regional competitiveness, as well as their regional effect mechanisms. We applied our model with a confirmative purpose, determining the extent to which the relationship between each latent variable supports the hypothetical system of relations established by the literature on regional competitiveness.

Based on our general model, i.e. model related to overperforming regions, we can deduce that regional competitiveness, as the target variable, was directly affected by R&D. We can also state that the strongest relationship was formed between the latent variables of physical capital and the latent variables of the agglomeration economies.

Further, we adapted our model to the set of underperforming regions, regarding which the effect mechanisms changed substantially. In addition to existing similarities, we could not properly explain the latent variable of research and development (R&D) over the course of runs; thus, it was not involved in the new model. In this way, besides the paths discontinued, new paths emerged in the model; agglomeration economies and human capital significantly affected regional competitiveness. Only the direct effect of agglomeration economies is indeed substantial overall, nevertheless human capital appears to be moderately important in shaping competitiveness. Moreover, we have to mention that one more path was discontinued. In the case of underperforming regions, the direct effect of leadership and institutions was not significant. But it still has an indirect effect (-0.239) on regional competitiveness via human capital. Thus, our outcome does not strengthen the findings of Iammarino et al. (2019), who attributed a crucial role to institutions, but we could not empirically reject it.

It is essential to declare, the group of underperforming Central and Eastern European regions provided a very special framework for the analysis. The differences, compared to the examination of all territorial units, could already be seen. In different, broader contexts (the regions of the entire EU, underperforming Western European areas, etc.), different effects prevail presumably, with diverse sizes. Therefore, this question requires further analysis.

Nevertheless, based on the achieved outcomes, our article supports the approach claiming that the solution for regions with different levels of development in the EU may be represented by place-sensitive, distributed growth. Even though we could not completely verify it, Iammarino et al. (2019) made an excellent argument for this theory; and their findings via the shift from the place-based trend towards the policy are presumably even more important among underperforming, less favoured regions than in the case of developed ones.

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APPENDIX 1

Indicators forming each latent variable

Level of pyramid	Latent variable	Indicator	Source
Revealed competitiveness (output)	Regional competitiveness	Employment rate by sex, age, and NUTS 2 regions (%, from 15 to 74 years, 2017)	Eurostat
		GDP (purchasing power standard [PPS]) per inhabitant as a percentage of the EU average (2017)	Eurostat
		Income of households (PPS per inhabitant; a balance of primary income/national income, net 2017)	Eurostat
		Labour productivity (GVA/employee) (million EUR/1,000 people)	Eurostat
Drivers of competitiveness (imputs-1)	R&D	EU trade mark (EUTM) applications per million people by NUTS 3 region (per million inhabitants in 2015)	Eurostat
		Intramural R&D expenditure (GERD) by sectors of performance and NUTS 2 regions; all sectors (percentage of GDP in 2017)	Eurostat
		Patent applications to the European Patent Office (applications per million inhabitants, average of 2016-2017)	Eurostat
		Total R&D personnel and researchers by sectors of performance, sex, and NUTS 2 regions; researchers, all sectors (percentage of total employment - numerator in full-time equivalent [FTE] in 2017)	Eurostat
	Human capital	Employment in technology and knowledge-intensive sectors (High-technology sectors - high-technology manufacturing and knowledge-intensive high-technology services -, Percentage of total employment 2017	Eurostat
		Employment in technology and knowledge-intensive sectors (Total knowledge-intensive services, Percentage of total employment 2017)	Eurostat
		Participation rate in education and training (last 4 weeks) (From 25 to 64 years, percentage, 2017)	Eurostat
		Persons with tertiary education (ISCED) and/or employed in science and technology (Percentage of active population 2017)	Eurostat
	Physical capital	Gross fixed capital formation by NUTS 2 region (per 1,000 people)	Eurostat
		Road, rail and navigable inland waterway networks by NUTS 2 region; motorways (kilometres per 1,000 km², 2017)	Eurostat
		Road, rail and navigable inland waterway networks by NUTS 2 region; total railway lines (kilometres per 1,000 km², 2017)	Eurostat
		Stock of vehicles by category and NUTS 2 regions, Passenger cars, Per thousand inhabitants, 2017	Eurostat
	Agglomeration economies	Economic density (GDP/km², 2017)	Eurostat
		Population density (people/km², 2017)	Eurostat
		Potential market size in GDP (2016)	RCI 2019
		Share of the population of the main municipality within the population of the NUTS 2 region (%, 2017)	Eurostat
	Leadership and institutions	Individuals who have never used a computer (percentage of individuals in 2017)	Eurostat
		Long-term unemployment (12 months or longer) by NUTS 2 region (percentage of the active population in 2017)	Eurostat
		People at risk of poverty or social exclusion by NUTS region (percentage, 2018)	Eurostat
		Unemployment rate by sex, age, and NUTS 2 region (%, from 15 to 74 years, 2017)	Eurostat
		Young people neither in employment nor in education and training (NEET rates) 18-24, 2017	Eurostat

Source: own compilation

APPENDIX 2

List of overperforming and underperforming Central and Eastern European regions

NUTS Code	*Name*	*NUTS Code*	*Name*
Bulgaria			
BG31	Severozapaden	**BG34**	**Yugoiztochen**
BG32	Severen tsentralen	**BG41**	**Yugozapaden**
BG33	**Severoiztochen**	BG42	Yuzhen tsentralen
Czechia			
CZ01	**Praha**	CZ05	Severovýchod
CZ02	**Střední Čechy**	**CZ06**	**Jihovýchod**
CZ03	**Jihozápad**	CZ07	Střední Morava
CZ04	Severozápad	CZ08	Moravskoslezsko
Hungary			
HU11	**Budapest**	HU23	Dél-Dunántúl
HU12	**Pest**	HU31	Észak-Magyarország
HU21	**Közép-Dunántúl**	HU32	Észak-Alföld
HU22	**Nyugat-Dunántúl**	HU33	Dél-Alföld
Poland			
PL21	**Małopolskie**	**PL63**	**Pomorskie**
PL22	**Śląskie**	**PL71**	**Łódzkie**
PL41	**Wielkopolskie**	PL72	Świętokrzyskie
PL42	Zachodniopomorskie	PL81	Lubelskie
PL43	Lubuskie	PL82	Podkarpackie
PL51	**Dolnośląskie**	PL84	Podlaskie
PL52	Opolskie	**PL91**	**Warszawski stołeczny**
PL61	Kujawsko-pomorskie	PL92	Mazowiecki regionalny
PL62	Warmińsko-mazurskie		
Romania			
RO11	**Nord-Vest**	RO31	Sud-Muntenia
RO12	**Centru**	**RO32**	**Bucureşti-Ilfov**
RO21	Nord-Est	RO41	Sud-Vest Oltenia
RO22	**Sud-Est**	**RO42**	**Vest**
Slovakia			
SK01	**Bratislavský kraj**	SK03	Stredné Slovensko
SK02	**Západné Slovensko**	SK04	Východné Slovensko

Source: own compilation

Note: The bold line indicates the overperforming regions

APPENDIX 3

Attributes of factors of overperforming regions

Latent variable	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Agglomeration economies	0.917	0.942	0.803
Human capital	0.908	0.937	0.79
Leadership and institutions	0.943	0.956	0.812
Physical capital	0.818	0.885	0.671
R&D	0.749	0.861	0.655
Regional competitiveness	0.953	0.966	0.877

Source: own compilation

APPENDIX 4

Attributes of underperforming regions

Latent variable	Cronbach's Alpha	Composite reliability	AVE
Agglomeration economies	0.721	0.837	0.665
Human capital	0.755	0.841	0.573
Leadership and institutions	0.858	0.888	0.620
Physical capital	0.704	0.836	0.588
Regional competitiveness	0.902	0.935	0.786

Source: own compilation

APPENDIX 5

Correlations among the latent variables of underperforming regions

	Agglomeration economies	Human capital	Leadership and institutions	Physical capital	Regional competitiveness
Agglomeration economies	1.000				
Human capital	0.611	1.000			
Leadership and institutions	-0.665	-0.704	1.000		
Physical capital	0.802	0.786	-0.794	1.000	
Regional competitiveness	0.819	0.713	-0.917	0.842	1.000

Source: own compilation