Global value chains and middle-income trap: skills, innovation, and integration in Central and Eastern Europe

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Abstract

The countries in Central and Eastern Europe (CEE) are at risk of getting stuck in an income trap. The paper explores, whether increased involvement in global value chains (GVCs) could serve as a means to overcome this challenge. It is proposed that involvement in GVCs is positively related to skills and innovation. The analysis is based on pooled panel data for 11 CEE countries, focusing on the 2008-2014 period at country-sector level. The results suggest that there is a positive relationship between skills and innovativeness, but the links between involvement in GVCs and R&D activities are lacking. At the same time, participation in GVCs was found to be positively associated with the share of innovative companies. Contrary to the Western European countries, the positive relationship between GVCs involvement and skills has not been identified, suggesting a potential mid-section participation.

1. Introduction

Participation in global value chains (GVCs) can help facilitate country's development. It may be especially important for countries with lower average income per capita, serving as a means to escape the potential middle-income trap. GVCs could help a country to improve the skills of the labour force and lead to higher innovativeness. The paper looks at these relationships.

In order to study the links between GVCs, innovation, and skills, and whether they can help escape income traps, we analyse country-sectors at Central and Eastern Europe (CEE). These countries serve as a good case for the analysis for two reasons. First, due to their historical experience, the CEE countries have begun global economic integration relatively recently and from a very low starting level. Therefore, it is possible to track the building of links with global value chains as well as monitor the other processes of interest. Second, the European Bank for Reconstruction and Development (2017) still sees the region as being at risk of getting stuck in the middle-income trap. In order to escape it, the region needs higher reorientation towards growth led by increasing productivity and innovation. However, in the context of the European Union, the CEE countries are still lagging behind, whether we look at the situation painted in the European Innovation Scoreboard 2019 (Hollanders, Es-Sadki, & Merkelbach, 2019) or at the lack of convergence between the so-called Innovation Leaders in the North, and the so-called Innovation Laggards in the South and East (Veuglers, 2017).

Using panel data we look at the relationship between skills, innovativeness, and GVC involvement at the country-sector level of 11 CEE countries, which are also the EU Member States. The following section outlines the theoretical background for the study. The Section 3 gives an overview of materials and methods used. The Section 4 describes the results of the analysis, while the final section provides a discussion on the implications of the results of the analysis.

2. Theoretical background

Researchers have found that CEE countries suffer from the regional innovation paradox (Muscio et al, 2015), which could be one of the explanations for potentially being caught in the middle income trap. It suggests that CEE region, not being highly productive, may lack capacities to use available opportunities for innovation. We argue that involvement in GVCs may help to satisfy two requirements for country-sector's development – capacity building and access to knowledge – while also providing a window to escape the regional innovation paradox and, consequently, the middle-income trap. To our best knowledge, the existing research on GVCs at country-sector level in post-transition countries has not connected all three elements together: involvement in GVCs, skills of the employees, and innovation in particular sectors.

There are grounds to expect that these relationships are important for country's development. Timmer et al., (2014) and Giuliani et al. (2005) found that positions in GVCs are related to skills; while Amador & Cabral (2014), Morrison et al. (2008) and others linked GVC positions with innovation. However, to our best knowledge, previous research failed to integrate all these factors together. This can be considered an important gap in understanding the relationship the role of GVCs in countries' development.

2.1 Involvement in GVCs and innovation

The role that GVCs can play in improving innovativeness has been discussed in literature, and the pressures for sector's entities to innovate can be both external and domestic. First, the relationships between foreign and local firms in GVCs enable knowledge transfer. Entering a GVC can open new sources of knowledge that hitherto have been unavailable. The analysis by De Marchi et al (2016) suggest that there are three types of GVC participation, based on their innovativeness:

- GVC-led innovators, intensively using knowledge obtained through GVCs
- independent innovators, using knowledge from sources other than GVCs
- weak innovators, using knowledge from GVCs, but non-intensively, and with few resulting innovations

Thus, involvement in GVCs may be an important factor in providing knowledge needed to innovate. Without GVCs, only independent innovators could exist. Meanwhile, GVCs open a new way to innovate. Given this, it could be expected that the more a sector integrates into GVCs, the more innovative it becomes. However, De Marchi et al (2016) also distinguish two types of innovators in relation with GVCs, which includes weak innovators. Thus, even if there are increased opportunities for innovation due to involvement in GVCs, they may remain unused, if the entering firms are not innovation-oriented.

In addition to direct use of knowledge enabled by entering GVCs, there are plenty of other mechanisms through which GVC participation can encourage innovation. Taglioni and Winkler

(2016) list a variety of effects of GVC participation that can impact innovativeness or at least productivity. They include increased competition, demand for higher-quality inputs and their increased availability, assistance to local firms, diffusion of knowledge and technology spillovers, opportunities for imitation, market restructuring through favouring firms with innovation capacities, and increased innovation through upgrading within GVCs. Therefore, there is a broad variety of channels through which innovation activities can be strengthened as a result of participation in GVCs.

Importantly, the push to innovate affects not only firms that participate in GVCs, but also other domestic companies, even if they have no relationship with GVCs whatsoever. Therefore, increased involvement in GVCs should be related to higher innovativeness even if a smaller number of firms in a country-sector are actually involved.

2.2 Involvement in GVCs and skills

The effect of participation in GVCs on skills comes from the need for increased capacity to meet the requirements set by the partners in the GVC. The pressure for firms to remain competitive to maintain positions in GVC pressures them to ensure having adequate human capital, while upgrading in GVCs helps to upgrade the skills of the employees (Cattaneo et al, 2013; Gereffi et al, 2011). Again, a variety of mechanisms might be used to achieve this, such as demand for production of high quality outputs (requiring sufficient skills), labour turnover (sector/ economy-wide effect emerging through diffusion of knowledge due to employees changing jobs), and others (Taglioni and Winkler, 2016). In other words, as in the case of innovation, the effect of GVCs can impact both the participating firms, but other firms in the country-sector as well. Therefore, we expect that the relationship between involvement in GVCs and skills will be positive.

The positive effect of GVCs on skills, could also lead to indirect effect on innovation. Human capital/ higher skills have been linked to higher innovativeness in literature (cf. Dakhli & De Clercq, 2004; Madsen, 2014). We do not expect to get results that contradict the dominant position in literature. Therefore, we propose that skills will be positively related to innovativeness, and that involvement in GVCs can thus indirectly impact innovativeness through the effect on skills.

However, the interaction between skills and the effect of GVCs on innovation is likely to be more complicated. We propose the following additional framework. The economic history of the CEE region suggests that it is likely that firms in CEE countries have entered GVCs initially after the end of the Cold War by providing cheap low-skilled labour required by multinational corporations to carry out mid-chain tasks, such as assembly. Low labour costs and geographic position could give CEE firms an advantage to outcompete other destinations for low value-added GVC activities, and could have ensured that the integration of CEE countries into the global economy was rather rapid. In line with the arguments provided above. Such involvement might be accompanied by some knowledge spillovers, acquisition of new machinery, or adopting (mostly already existing) innovations that improve firm activities. However, such firms could be expected to be less likely to actively carry out R&D activities or introduce new (especially new

to the market) products or services. Therefore, we expect that the effect of GVCs differs based on the level of skills in the sector. On the one hand, if a country-sector is on average more highly skilled, its involvement in GVCs is more likely to be associated with better innovation performance than in the case. On the other hand, if a country-sector has a relatively low-skilled workforce, its GVCs involvement would likely increase its innovativeness to a lower extent (though we still expect the relationship to remain positive). In other words, we hypothesise that skills can be seen as a mediating variable between GVCs and innovation.

2.3 Hypotheses

Given the two pathways for the effect of skills to affect innovation, and the impact of involvement in GVCs on innovation, we propose two pathways of effects to be analysed. The first one is mediation, which covers the direct impact of involvement in GVCs on innovativeness and its indirect impact through skills. The second one is moderation, which covers the effect of skills on the effect of involvement in GVCs on innovativeness. Consequently, the following hypotheses can be raised:

- H1. Involvement in GVCs positively is positively related to innovation at the country-sector level
- H2. Involvement in GVCs is positively related to skills at the sector country-sector level
- H3. Higher skills are positively related to innovation at the country-sector level
- H4. Higher involvement in GVCs has a stronger positive relationship with innovativeness at the sector level, when skills are higher

Section 3 further in the paper presents the methods to assess the hypotheses. T

2.4 CEE participation in GVCs

Before focusing on the methodology and data, it is worth briefly discussing existing research on CEE region's participation in GVCs and the reason for it being particularly relevant for such research. CEE countries serve as a good sample for the analysis of the effect of GVCs due to their unique historical experience. Up until the early 1990s the countries in the region have been closely integrated into the Eastern bloc, and the economy of the Soviet Union, while pursuing planned economy. Only after the end of the Cold War these countries gained opportunities to freely integrate into the global economic processes. The collapse of the Soviet Union also meant that CEE economies had to restructure and to reorientate themselves, finding new partners outside the Eastern bloc.

This experience of the CEE region enables a look at:

- the trends in region's integration into GVCs from low level of globalised trade in intermediaries, possibly highlighting the process of entering and upgrading in GVCs for other regions
- the effects of integration into GVCs given that the process of integration is developing and the participation has not reached stable levels allows to assess the outcomes of the increased involvement in GVCs
- the sectoral strengths that can be utilised for countries to enter GVCs, by identifying country-sectors, which have been the most successful

Although in order to focus the present paper, it looks only at the relationship between involvement in GVCs, skills, and innovativeness, other areas are no less interesting or important to study. However, despite the high potential for insights on the integration and impact into GVCs, current research on the CEE region at the sector or country level is limited. It mostly focuses on the upstream and downstream orientation of region's country-sectors, using international input-output data. Thus, Cieślik (2014, 2016) concludes that having links with Western European countries increases GVC participation by CEE countries and that CEE region is relatively more downstream compared to Western Europe. Meanwhile Hagemejer and Ghodsi (2017) find that some countries are more upstream (the Czech Republic, Hungary, Poland, Slovakia, Slovenia), while others specialise downstream (Romania, Bulgaria).

Therefore, so far, the effects of GVCs integration in CEE countries have been missing in literature, and even the analysis of integration has focused on relatively limited indicators. This is an important gap to be addressed, due to the above listed reasons for the particular role that the CEE region could play in the analysis of GVCs. Therefore, the contribution of the present paper is twofold. First, it provides the assessment of the links between GVC participation, skills, and innovation, which is important globally. Second, it improves the understanding of the CEE region integration into GVCs nearly 'from scratch', thus by way of example also providing insights into how economic globalization may unfold in other developing countries.

3. Materials and methods

3.1 Sample and data

The proposed hypotheses are tested using regression-based analysis conducted with the data of eleven countries from the CEE region, namely, Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Poland, Romania, Slovakia, and Slovenia. These countries have been selected based on them also being the Member States of the European Union. The analysis is also facilitated by the readily available sector level data for each of these countries.

Data used for research comes from three sources. For GVC indicators we use World Input-Output Database (WIOD; Timmer et al., 2015) and University of International Business and Economics (UIBE) GVC index database (for more information see: http://rigvc.uibe.edu.cn/english/D_E/database_database/index.htm), which uses WIOD for calculating specific GVC indicators (Wang et al., 2017a; Wang et al., 2017b). The data covers 43 countries and 56 economic sectors. The time-series dimension covers years from 2000 to 2014 and provides annual information.

For skills and innovation indicators we use Eurostat data from the Community Innovation Survey and Structural Business Statistics. In this case, the aggregation of economic sectors is different for some cases (or data is not available for all sectors) from the WIOD database. Therefore, the number of sectors for the actual study varies for year and country. However, the more important issue for data availability is the length and structure of the time-series. For skills

data (see Table 1 below for the specific indicator), available years are 2008 to 2014 (annual). For innovation data, the time-series covers years 2008-2014, but it is collected bi-annually. Therefore, the general structure of the empirical study includes observations at four different points in time. This limits the size of the available panel data.

In order to assess the hypotheses, a variety of indicators have been selected. Table 1 below defines the indicators used for the analysis.

Table 1. Used indicators and their data sources

Indicator	Explanation	Source
GVC indicators		
PART	An indicator measuring country-sector's participation in GVCs. Calculated as the ratio between domestic VA in intermediary products and total domestic VA for a country-sector.	UIBE GVC index, based on WIOD data
RCA	An indicator measuring country-sector's revealed comparative advantage (RCA) in terms of domestic value added in intermediate products' export. It is calculated as: $$RCA_{c,s} = \frac{DVA\_int_{c,s}/DVA\_int_{c}}{DVA\_int_{s}/DVA\_int}$$ Where *RCA* stands for revealed comparative advantage in terms of *DVA_int*, *DVA_int* is domestically created value added in intermediary outputs, *c* – country, *s* – sector.	Calculated based on UIBE GVC index, based on WIOD data
Innovation indicators		
INNO	Share of innovative enterprises in a country-sector.	Eurostat
INHOUSE	Expenditures on in-house R&D as share in total turnover of a country-sector.	Eurostat
EXTERNAL	Expenditures on external R&D as share in total turnover of a country-sector.	Eurostat
Skills indicator		
PERSCOST	Average personnel cost per employee at country-sector level.	Eurostat

The selection of indicators rests on the following logic:

- Two measures of GVCs help capture two different elements – the relative involvement of country-sectors in GVCs, and the comparison with the structure of the world economy, providing two perspectives.
- Three measures of innovation help to understand the relationship of involvement in GVCs with the sector firms' propensity to: 1) create and/or adopt innovations (the share of innovative companies); 2) carry out R&D activities internally; 3) acquire R&D services from external sources (GVCs could provide more opportunities for such acquisition).
- One proxy measure of skills, which shows the willingness of employers to hire employees for the particular cost. This proxy can help to understand the factual skills rather than potential, which would be captured by educational attainment variables.

3.2 Mediation analysis

Mediation analysis addresses the hypotheses listed below, by looking at the direct and indirect links between the variables:

- H1. Involvement in GVCs positively is positively related to innovation at the country-sector level
- H2. Involvement in GVCs is positively related to skills at the sector country-sector level
- H3. Higher skills are positively related to innovation at the country-sector level

We test the hypotheses using regression-based (pooled OLS) path analysis, implemented in R. Due to the short length of time-series and gaps in the data of skills and innovation variables, we do not use models fixed effects or other models. We estimate two functions in the following form:

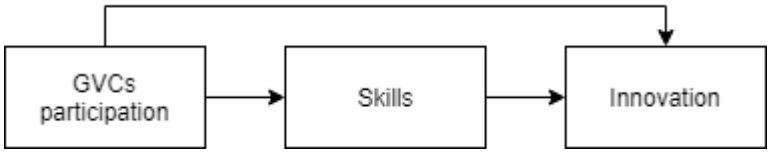
$$Innovation\ indicator = f(Skills\ indicators, GVC\ indicators)$$
$$Skills\ indicator = f(GVC\ indicators)$$

Such approach allows us to test the hypotheses and also identify different paths through which the effects emerge:

- the direct effect of skills on innovation
- the direct effect of GVCs participation on innovation
- the direct effect of GVCs participation on skills
- the indirect effect of GVCs participation on innovation through effects on skills

The general structure of the studied relationships is show in Figure 1 below.

Figure 1. The estimated links between GVCs participation, skills, and innovation with mediation



The regression equations with the used variables are listed below:

$$INNO_{c,s,i} = \beta_0 + \beta_1 GVC\_PART_{c,s,i} + \beta_2 GVC\_RCA_{c,s,i} + \beta_3 PERSCOST_{c,s,i} + \varepsilon_{c,s,i}$$
$$PERSCOST_{c,s,i} = \beta_0 + \beta_1 GVC\_PART_{c,s,i} + \beta_2 GVC\_RCA_{c,s,i} + \varepsilon_{c,s,i}$$

Here, *INNO* stands for one of the three innovation variables, *GVC_PART* is GVC participation, *GVC_RCA* is revealed comparative advantage in GVCs, *PERSCOST* is personnel costs (a proxy for skills), *c* is country, *s* is sector, *i* is year, and ε is the error term.

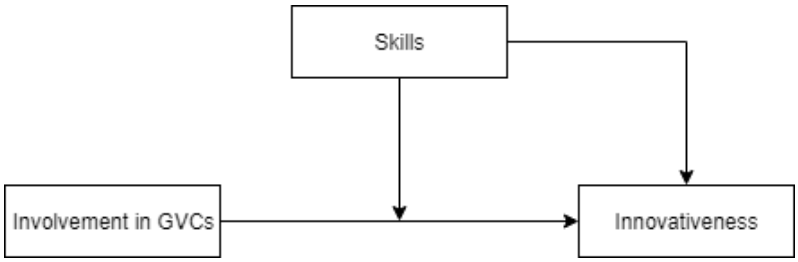
3.3 Moderation analysis

The moderation analysis addresses hypotheses listed below:

- H1. Involvement in GVCs positively is positively related to innovation at the country-sector level
- H2. Involvement in GVCs is positively related to skills at the sector country-sector level
- H4. Higher involvement in GVCs has a stronger positive relationship with innovativeness at the sector level, when skills are higher

The analysis is based on panel data. We use pooled OLS estimation techniques in order to establish the relationships between the selected independent and dependent variables. We use heteroskedasticity and autocorrelation corrected standard errors estimations (HAC). In addition to individual indicators listed in Table 1 above, we add interaction variables as products obtained from multiplying average personnel costs per employee (a proxy for skills) and GVCs involvement variables (participation and revealed comparative advantage). This helps to assess the fourth hypothesis (H4) that higher skills are also an important determinant of the effect of involvement in GVCs. Moderation analysis expects the "effects on effects", as indicated in Figure 2 below.

Figure 2. The estimated links between GVCs participation, skills, and innovation with moderation



Given the used indicators, the regression analysis can written as below:

$$INNO_{c,s,i} = \beta_0 + \beta_1 GVC\_PART_{c,s,i} + \beta_2 GVC\_RCA_{c,s,i} + \beta_3 PERSCOST_{c,s,i} + \beta_4 GVC\_PART * PERSCOST_{c,s,i} + \beta_5 GVC\_RCA * PERSCOST_{c,s,i} + \beta_6 SURPLUS_{c,s,i} + \beta_7 PRODUCT_{c,s,i} + \varepsilon_{c,s,i}$$

Here, *INNO* stands for one of the three innovation variables, *GVC_PART* is GVC participation, *GVC_RCA* is revealed comparative advantage in GVCs, *PERSCOST* is personnel costs (a proxy for skills), *SURPLUS* is gross operating surplus/turnover, *PRODUCT* – apparent labour productivity, *c* is country, *s* is sector, *i* is year, and *ε* is the error term.

3.4 Methodological limitations

Limitations coming from the approach and available data are several and should be acknowledged. The main challenges are as follows:

- missing values and bi-annual nature of innovation indicators limits the length of the time-series and leads to a lower reliability of the model
- the length of time-series varies between one and four observations, and given other gaps in the data, we use pooled OLS as an estimation method, not fully accounting for the longitudinal dimension
- the data on innovation has been collected via Community Innovation Survey, therefore, it may have additional variation at the sector level due to the data collection process and possible higher confidence intervals at the sector level

These limitations must be taken into account, when interpreting the results. We also use the $p<0.1$ level as the threshold for statistical significance, which should be kept in mind.

4. Results

Based on the used methodology, we obtained two sets of results. One accounts for mediating, the other for moderating relationships. The discussion of results and their implications are structured around the used dependent innovation variables.

4.1 Dependent variable – share of innovative enterprises

The first discussed innovation variable is the share of innovative enterprises. It is expected, that it will be positively related to both skills and innovation indicators. Tables 2 and 3 below provide the results of the estimation, while Figure 3 depicts the identified statistically significant links.

Table 2. The results of the mediation analysis (pooled OLS, innovation variable share of innovative enterprises)

Dependent variable	Independent variable	Estimate	Std. error	z-value	p-value	R^2
Share of innovative enterprises	GVC_PART	0.036	0.015	2.412	0.016	0.092
	GVC_RCA	-0.015	0.004	-4.162	0.000	
	PERSCOST	0.007	0.001	8.234	0.000	
PERSCOST	GVC_PART	0.142	0.572	0.248	0.804	0.003
	GVC_RCA	-0.230	0.140	-1.648	0.099	

Number of observations – 918.
Source: authors' calculations based on UIBE GVC, WIOD, and Eurostat data.

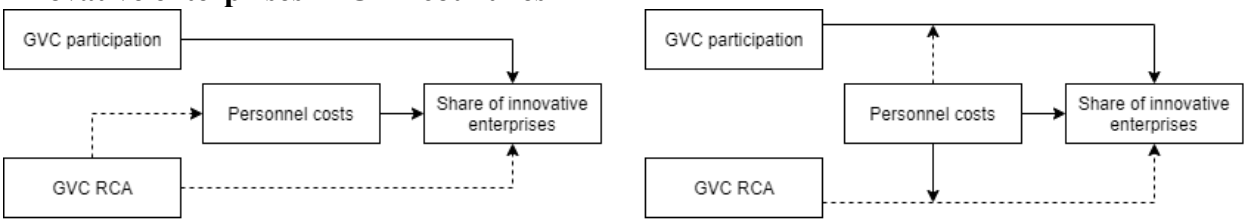
Table 3. The results of the moderation analysis (pooled OLS, innovation variable share of innovative enterprises)

Independent variable	Coefficient	Standard error	t-ratio	p-value
CONSTANT	0.263791	0.0490658	5.376	<0.0001
SURPLUS	0.00104779	0.00139121	0.7532	0.4521
PERSCOST	0.00937449	0.00416971	2.248	0.0254
PRODUCT	0.000304619	0.000560795	0.5432	0.5875
GVC_RCA	−0.0405335	0.0172948	−2.344	0.0199
GVC_PART	0.195241	0.0953533	2.048	0.0416
GVC_RCA*PERSCOST	0.00221408	0.00126537	1.750	0.0814
GVC_PART*PERSCOST	−0.0137965	0.00789610	−1.747	0.0818

Adjusted R^2	0.114920
P-value(F)	3.41e-07
Number of observations	917
Number of cross-sectional units	255
Time-series length	1-4

Note: robust (HAC) standard errors. Statistically significant relationships (at 90% level) are marked in bold. Source: authors' calculations based on WIOD, UIBE GVC, and Eurostat data.

Figure 3. The relationship between involvement in GVCs, skills, and the share of innovative enterprises in CEE countries



Source: author's work. Note: the figure on the left shows the results of the mediation analysis, the figure on the right shows the results of the moderation analysis. Straight lines show positive statistically significant relationship, while dashed lines show statistically significant negative relationship.

Several conclusions can be drawn from results. First, personnel costs are associated positively with the share of innovative enterprises. That is, the more skilled the workforce is, the more enterprises in a country-sector tend innovate. This is in line with the hypothesised positive link between skills and innovativeness. Second, GVC participation seems to be positively associated with the share of innovative enterprises. However, as the model with moderation suggests, higher personnel costs means that the positive effect of participation in GVCs diminishes. Third, the results suggest that RCA has an opposite effect compared to GVC participation. It is negative at low personnel costs but may become positive with increase in personnel costs. Fourth, the mediation model shows that RCA negatively affects personnel costs, and thus affects the share of innovative enterprises negatively indirectly as well.

The main implication of the results is that skills are positively related to the share of innovative enterprises, but they negatively affect the importance of GVC participation. Thus, with higher skills the role of GVC participation is less important for innovating. This may indicate that country-sectors with high skills have less to take from GVCs, while country-sectors with lower skills benefit more from GVC participation, as they have more innovations to borrow (e.g. process innovations new to firm), as also evidenced by the positive link between personnel costs and the share of innovative enterprises. The introduction of GVCs-based innovations in firms, which already innovate, would also not affect the value of the variable, when longitudinal dimension is taken into account. Therefore, such highly skilled sectors would already be closer to innovation frontier and would develop rather adopt new technologies/processes, etc. This could lead to a lower total number of innovative firms.

Results also show, that with higher RCA, the share of innovative companies is lower. This finding suggests that CEE countries tend to have higher RCA in sectors with a lower share of

innovative enterprises. However, if a sector has higher skills, the negative effect can become weaker or even positive. Thus, if a country-sector with high skills has high RCA, it means, that it is also likely to be more innovative, suggesting a dependence of the type of participation based on the available skills.

4.2 Dependent variable – in-house R&D

The first discussed innovation variable is the in-house R&D spending as share of country-sector's turnover. It is expected, that it will be positively related to both skills and innovation indicators. Tables 4 and 5 below provide the results of the estimation, while Figure 3 depicts the identified statistically significant links.

Table 4. The results of the mediation analysis (pooled OLS, innovation variable in-house R&D)

Dependent variable	Independent variable	Estimate	Std. error	z-value	p-value	R^2
In-house R&D	PART	-0.094	0.016	-5.865	0	0.050
	RCA	-0.002	0.002	-1.158	0.247	
	PERSCOST	0.001	0	1.394	0.163	
PERSCOST	PART	0.309	1.115	0.277	0.782	0.006
	RCA	-0.314	0.146	-2.155	0.031	

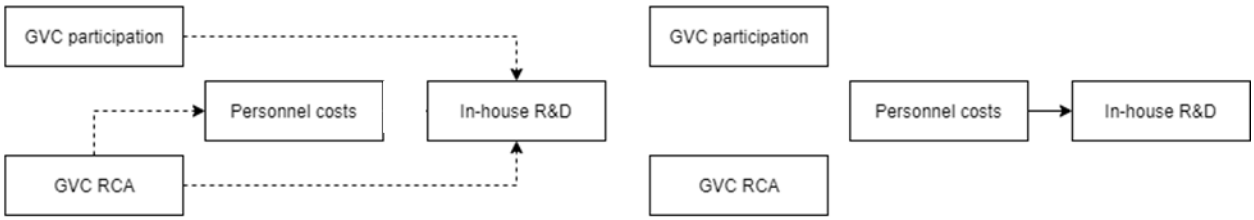
Number of observations – 864.
Source: authors' calculations based on UIBE GVC, WIOD, and Eurostat data.

Table 5. The results of the moderation analysis (pooled OLS, dependent variable in-house R&D)

Independent variable	Coefficient	Standard error	t-ratio	p-value
CONSTANT	0.962868	2.91066	0.3308	0.7410
SURPLUS	0.0386992	0.0524237	0.7382	0.4610
PERSCOST	0.363213	0.186856	1.944	0.0529
PRODUCT	−0.0329926	0.0216240	−1.526	0.1282
GVC_RCA	0.177413	0.277293	0.6398	0.5228
GVC_PART	−2.39611	6.02078	−0.3980	0.6910
GVC_RCA*PERSCOST	−0.0424336	0.0301359	−1.408	0.1602
GVC_PART*PERSCOST	−0.433694	0.332358	−1.305	0.1930
Adjusted R^2	0.051521			
P-value(F)	0.233942			
Number of observations	863			
Number of cross-sectional units	280			
Time-series length	1-4			

Note: robust (HAC) standard errors. Statistically significant relationships (at 90% level) are marked in bold. Source: authors' calculations based on WIOD, UIBE GVC, and Eurostat data.

Figure 4. The relationship between involvement in GVCs, skills, and in-house R&D activities in CEE countries



Source: author's work. Note: the figure on the left shows the results of the mediation analysis, the figure on the right shows the results of the moderation analysis. Straight lines show positive statistically significant relationship, while dashed lines show statistically significant negative relationship.

Results have several implications. First, personnel costs are associated positively with the amount of in-house R&D in both models. That is, if the employees are better remunerated, a country-sector spends a larger share of its turnover on in-house R&D activities. RCA is found to have a negative relationship with personnel costs in the model with mediation. The model with moderation identifies no links between the used GVC variables and in-house R&D expenditure. However, the F-statistic also suggests that the model is not adequate.

As the main implication of these results, skills are positively related to the amount of in-house R&D. There is some evidence that GVC participation and GVC RCA are negatively linked to in-house R&D. It could be the case that companies joining GVCs enter them at the mid-end, where the need for R&D is lower; as such activities are carried out in the upstream. It would support the often held assumption that the integration of CEE countries into GVCs first of all comes from the low value added activities.

4.3 Dependent variable – external R&D

The first discussed innovation variable is external R&D contracting as share of country-sector's turnover. It is expected, that it will be positively related to both skills and innovation indicators. Tables 6 and 7 below provide the results of the estimation, while Figure 3 depicts the identified statistically significant links.

Table 6. The results of the mediation analysis (pooled OLS, innovation variable external R&D)

Dependent variable	Independent variable	Estimate	Std. error	z-value	p-value	R^2
External R&D	PART	-0.008	0.001	-6.114	0	0.056
	RCA	0	0	-0.135	0.893	
	PERSCOST	0	0	2.652	0.008	
PERSCOST	PART	0.211	1.129	0.187	0.852	0.005
	RCA	-0.297	0.152	-1.952	0.297	

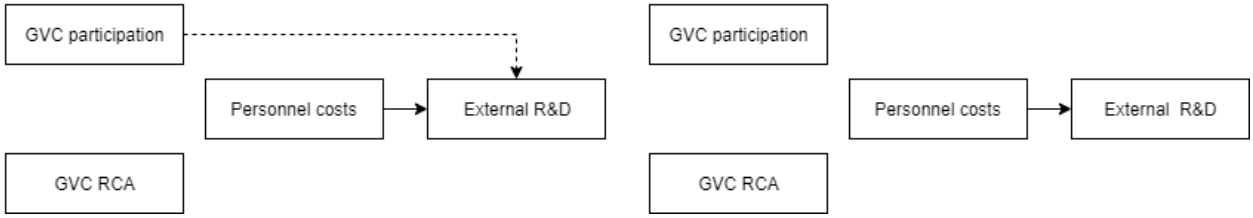
Number of observations – 823.
Source: authors' calculations based on UIBE GVC, WIOD, and Eurostat data.

Table 7. The results of the moderation analysis (pooled OLS, dependent variable external R&D)

Independent variable	Coefficient	Standard error	t-ratio	p-value
CONSTANT	0.0983548	0.286613	0.3432	0.7317
SURPLUS	−0.00438972	0.00473984	−0.9261	0.3552
PERSCOST	0.0404619	0.0218522	1.852	0.0651
PRODUCT	−0.00226379	0.00154842	−1.462	0.1448
GVC_RCA	−0.00739299	0.0311080	−0.2377	0.8123
GVC_PART	−0.00516255	0.601182	−0.008587	0.9932
GVC_RCA*PERSCOST	0.000274472	0.00350632	0.07828	0.9377
GVC_PART*PERSCOST	−0.0605090	0.0400734	−1.510	0.1322
Adjusted R^2	0.061440			
P-value(F)	0.010262			
Number of observations	822			
Number of cross-sectional units	286			
Time-series length	1-4			

Note: robust (HAC) standard errors. Statistically significant relationships (at 90% level) are marked in bold. Source: authors' calculations based on WIOD, UIBE GVC, and Eurostat data.

Figure 5. The relationship between involvement in GVCs, skills, and external R&D activities in CEE countries



Source: author's work. Note: the figure on the left shows the results of the mediation analysis, the figure on the right shows the results of the moderation analysis. Straight lines show positive statistically significant relationship, while dashed lines show statistically significant negative relationship.

The results are as follows. First, personnel costs are positively associated with externally contracted R&D. Second, participation in GVCs is negatively related external R&D spending in the mediation, therefore, a conclusion could be drawn that higher skills lead to more spending on externally contracted R&D. However, such evidence is not found in the moderation model, suggesting that the result from the mediation model should be taken with a grain of salt. The lack of clear links between involvement in GVCs and externally contracted R&D services could imply that firms in these country-sectors enter at a stage, where there is no need for R&D to be implemented. This interpretation is also consistent with the results obtained in the models with in-house R&D as the dependent variable.

5. Conclusion and discussion

The implications of results in the light of hypotheses are provided Table 8 below.

Table 8. Assessment of hypotheses

Hypothesis	Mediation models	Moderation models
H1. Involvement in GVCs positively is positively related to innovation at the country-sector level	The hypothesis holds only, when the dependent variable is the share of innovative companies in the country-sector, and the GVC variable is participation but not RCA. It does not hold, when R&D indicators are used.	The hypothesis holds only, when the dependent variable is the share of innovative companies in the country-sector, and the GVC variable is participation but not RCA. It does not hold, when R&D indicators are used.
H2. Involvement in GVCs is positively related to skills at the sector country-sector level	The hypothesis is rejected in the used sample of CEE countries, across all models. Instead, there is evidence that involvement in GVCs can even be negatively linked to skills in this region.	The hypothesis was not tested with moderation models.
H3. Higher skills are positively related to innovation at the country-sector level	The majority of models identify a positive link between the used skills indicator and innovation variables (with the exception of in-house R&D).	All models support the hypothesis.
H4. Higher involvement in GVCs has a stronger positive relationship with innovativeness at the sector level, when skills are higher	The hypothesis was not tested with moderation models.	The results provide mixed results, but generally do not support the hypothesis. Only in the instance of the effect of GVC RCA and the share of innovative companies, are higher skill associated with positive effect.

In order to assess, whether the identified links (or lack thereof) are specific to the CEE countries or to Western economies as well, we have carried out similar calculations. The main differences in results are outlined below:

- GVC participation and RCA are positively associated with skills (insofar as measured by the proxy of personnel costs). This suggests that Western European country-sectors are more likely to participate in GVCs (at a larger scale), if skills are higher or the effect is positive in further improving skills there. Meanwhile, country-sectors in CEE do not benefit from involvement in GVCs in terms of skills, suggesting that they enter GVCs in activities, where higher skills are not needed.
- GVC participation is positively associated with contracting external R&D services in Western Europe at low skills levels, while no statistically significant relationship is found in the CEE countries. This may indicate that enterprises in Western Europe are in GVC positions, where they can and need to contract R&D from external suppliers. The negative moderating effect of skills can come from firms' capabilities to carry out in-house R&D activities themselves.

The main difference between the CEE and Western European regions is the relationship between GVCs and skills. CEE country-sectors have lower skills if they have higher revealed comparative advantage. GVC participation and skills do not appear to be directly related. Meanwhile, in the Western Europe, these indicators are positively related, suggesting higher involvement by country-sectors, where the labour force is highly skilled.

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