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Position in Global Value Chains and Wages in Central and Eastern European Countries

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Abstract

This paper examines the relationship between the relative position of industries in Global Value Chains and wages in ten Central and Eastern European countries. We combine GVC measures of global import intensity of production, upstreamness and the length of the value chain with micro-data on workers. We find that the wages of CEEC workers are higher when their industry is at the beginning of the chain or at the end than in the middle. Secondly, wage changes depend on the interplay between upstreamness and GVC intensity. In sectors close to final demand, greater production fragmentation is associated with lower wages.

JEL
F14, F16, J31

Keywords
wage, GVC, upstreamness, production fragmentation, CEEC

Introduction

The phenomena of international production fragmentation and task relocation have gained a good deal of attention in studies on the labour market implications of trade links due to offshoring (see e.g. Hummels et al., 2018, for a review). In the early literature, international production fragmentation was typically seen as a threat to low-skilled native workers, especially in the developed countries, as production was transferred to countries with cheaper labour (among many others: Feenstra and Hanson, 1999). Over time, with the theoretical and methodological advances in offshoring research, this view has evolved. The theoretical ambiguity of production fragmentation effects on wages (the seminal model of Grossman and Rossi-Hansberg, 2008) is accentuated by the increasing complexity of production – inputs are now likely cross more than one border, and the share of value added produced outside the country of completion, mainly added outside that country's region, has risen, giving us what has been dubbed the 'Factory World' (Los et al., 2015).

There has also been significant progress in the measurement of production fragmentation (Feenstra, 2017; Hummels et al., 2018). Where the traditional indices measure offshoring as the ratio of imported intermediate inputs to the output of domestic industry (Feenstra and Hanson, 1999), a new generation of statistics utilises input-output data and breaks gross trade down into the foreign and domestic components of value added embodied in exports (among others: Wang et al., 2018). The literature considers both involvement in GVC, for instance the intensity of production fragmentation as gauged by international input-output data (Timmer et al., 2016) and industry-level measures of relative production line position (e.g. Antràs et al., 2012). Recent empirical works on the linkages between production fragmentation and labour market outcomes indicate not only that involvement in fragmentation is important *per se*, but also that a country or sector's position in the production chain is relevant. In other words, it is important to verify both how long the production chain is and where a given country/industry is within it, i.e. how far from final demand (see, e.g., Chen, 2017).

This is the aspect we emphasise here, namely the position of industries in the production chain and how this affects wages. We focus on the case of workers in Central and Eastern European countries (CEEC). Although the forms of integration into European production networks have major implication for the social and employment policies of these countries (Bohle and Greskovits, 2012) as well as for the ways multinational companies operate in them (Meardi et al. 2009), the GVC literature on this region is still thin. The results established for highly developed countries (Western Europe, U.S. – analysed in, among others, Hummels et al., 2014; Shen and Silva, 2018) cannot be directly translated to this particular case. CEEC entered the global structure of production starting from a different position than Western European countries (Hagemejer and Ghodsi, 2017) and have distinct characteristics in terms of GVC participation (see Figure 2C). After opening to trade in the mid-1990s CEEC became new sources for goods and services offshoring for the old EU. According to World Bank Group (2017), 11% of intra-European intermediate good exports in 2015 came from by Poland, Czech Republic and Hungary, a fourfold increase from 1995. Some of CEEC managed to upgrade their position along the chain (World Bank Group, 2017), and the Visegrád countries (Czech Republic, Hungary, Poland and Slovakia) converged in their production structure with the EU-15 (Hagemejer and Ghodsi, 2017). The effects of GVC participation on their economies may differ from those observed in Western European countries due to diminishing marginal returns to globalization (Lang and Tavares, 2018) and different positions occupied along the value chain – typically more downstream for developed and more upstream for developing countries. Consequently, it seems reasonable to analyse separately the CEEC case in order to complete the European picture of GVC activity – wages nexus.

To the best of our knowledge there is no specific empirical evidence on the relationship between wages and GVC position in CEEC. We seek to fill this gap by referring to the 'smile' curve approach. We obviously expect a negative correlation between wages and the level of job routinization (a well-established result in the related literature, e.g. Hummels et al., 2014). However, given that 'it is necessary to take into account input-output linkages between industries as well as the position of industries in the value chain when analysing the effect of trade on labour markets' (World Bank and WTO, 2019: 47), the

leading hypothesis is that the impact of GVC participation on wages depends on the level of upstreamness. Thus the key effect which we expect to confirm through our empirical analysis is the significance of relative country-sector position along the value chain in determining workers' wages.

To test the research hypothesis, we utilise the measures of production-line position of an industry (Antràs et al., 2012; Fally, 2012). Additionally, we consider measure of the global import intensity of production, GII (Timmer et al., 2016), which captures all the stages backward up the production chain (the code used to compute GII is accompanying our paper). We correlate these industry-level measures of GVC intensity and upstreamness with micro-level data on the wages of workers in ten CEEC, testing the 'smile' curve.

The structure of our paper is as follows. Section 2 reviews the literature, and Section 3 gives an overview of GVC indicators. Section 4 reports the estimate of the augmented wage regression and the results, and Section 5 concludes.

Literature review and explanations of GVC-wages nexus

The literature on the labour market outcomes of production fragmentation is obviously very abundant (see, e.g., Hummels et al., 2018, for review). However, the contributions bearing specifically on Central and Eastern European countries are scarce. If anything, CEEC tend to appear in comparative studies of larger groups of European countries, and for the most part in an industry-level setting (e.g. Polgár and Wörz, 2010).

The studies explicitly relating GVC with labour market outcomes have essentially begun to emerge only in recent years. Parteka and Wolszczak-Derlacz (2019) quantify the wage consequences of increasingly substantial GVC ties using microdata for workers in a good many industries in nine European countries and the United States. The share of foreign value added in output is found to correlate negatively (albeit weakly) with wage levels. This concords with an earlier work (Parteka and Wolszczak-Derlacz, 2017) in which the adverse wage effect of GVC involvement is found to depend on workers' skill and tasks, affecting mostly workers in routine jobs.

A few papers have addressed the issue of measuring industries' position in terms of upstreamness/downstreamness. Chen (2017) studies firm-level data on domestic value chains in Chinese manufacturing from 2000 to 2007. Wage inequality proves to be greater in upstream than in downstream industries, and in the firms more exposed to trade. However, exporting firms in upstream industries have less wage inequality than their counterparts in downstream industries. Shen and Silva (2018) analyse the effects of rising value-added trade from China on U.S. labour market outcomes, finding that the effects of intra-GVC trade depend on how far downstream the exporting industry is. For instance, the increase in U.S. exposure to value-added exports from China in downstream industries leads to negative employment effects.

This is why in our study of wage determinants we utilise the 'smile' curve approach (World Bank and WTO, 2019), rooted in the management literature (Mudambi, 2008) and for the first time observed in the '90s by Shih (1996). Value added and, consequently, labour compensation tend to be higher at the ends of the production chain (either closer to final demand, like marketing, or closer to the initial production stage design, like R&D). Intermediate production stages, like assembly, have a relatively small share in the creation of value added. The initial and final production stages contribute more to the product's value, driving higher compensation for the employees working at these stages. Nowadays the 'smile' curve concept can be found, for instance, in both firm-level and sector-level studies on GVC (e.g. Aggarwal, 2017) or on inequality and uneven distribution of gains from globalization (e.g. Lang and Tavares, 2018). The implications of the 'smile' curve in terms of inequality stem mostly from the specialization of countries/industries in specific production stages located in distinct parts of the chain. World Bank Group (2017) study argues that since value chains globalized, the curvature of the 'smile' curve increased, differentiating stronger high ends from the low and middle end which may lead to increasing labour markets polarization.

The evidence on our topic of interest in the new EU member states, essentially CEEC, is scanty and for the most part not related to labour market-GVC interactions. Hagemejer (2018) analyses the interaction between upstreamness and value added or productivity growth in the EU new member states (1995-2009). Productivity growth tended to be higher in sectors importing or exporting intermediate goods and positioned further from final demand. This may be explained by higher specialization of sectors located more upstream and by productivity gains related to the specific pattern of task specialization. Hagemejer and Tyrowicz (2017), using firm-level data from 2000 to 2011, find that GVC position matters for employment levels, job creation and destruction, but with different impacts in different CEEC. The differences in labour market reaction along the production chain may be explained by so-called bullwhip effect. Demand shocks are not uniformly transmitted to employment shocks, as they are amplified through inaccurate inventory decisions. Parteka and Wolszczak-Derlacz (2019) incorporate three CEEC in their study on the interactions between GVC and wages, but they examine GVC involvement in general, not the relative position of industries within the chain. By their estimates, workers in the EU15 are more in danger of unfavourable wage effects of GVC than those in the new member states. Some workers in the new member states - in jobs low in routine and high in abstractness and service tasks – even appear to benefit from greater involvement of their industries in GVC. The dissimilarity between old and new EU countries could be possibly explained by assessing their position along the production chain – typically more downstream for developed and more upstream for developing countries. Hence, they experience different labour market effects of increasing participation in GVC. We are not aware of any study that uses micro-level data and explicitly relates industries' upstreamness with wage developments in a larger sample of CEEC.

Important insights are provided by the recent World Bank and World Trade Organization GVC report (World Bank and WTO, 2019): the impact of GVC participation on labour market outcomes (e.g. wages) depends on the level of upstreamness. The mechanism is driven jointly by two forces: the allocation of tasks and production stages to different tiers of GVC and the uneven distribution of production value added along the chain. Country-sectors engage in different parts of the global structure of production (for instance, specializing either in the high-ends intangible production activities, such as R&D, marketing etc. or in lower value-added activities, such as assembling). Due to strong GVC ties the propagation of trade shocks is not limited to workers in import-competing industries anymore. Labour markets adjust in response to all these forces and the effect of GVC participation on workers is affected by the relative position of industries in the chain.

Theoretical predictions on the empirically observed relationship between GVC involvement and wages are far from straightforward. In line with Feenstra and Hanson (1999), offshoring increases the relative demand for skilled workers in less-developed economies, so wage effects are likely to differ across skill groups of workers. The most prominent model of task-based production fragmentation (Grossman and Rossi-Hansberg, 2008) explains wage effects of offshoring as an interplay of productivity effects, relative price effect and labour-supply effect. However, conceptually, GVCs are much more complicated than pure offshoring as they 'entail a finer international division of labour but also involve: matching between importers and exporters, relationship-specific investments by all parties, inter-firm and intra-firm flows of goods, technology, and credit; incomplete contract enforcement' (Antràs, 2021: 4). Moreover, GVC-related trade flows are often more skilled-labour intensive; firms in GVCs tend to adopt more capital-intensive techniques (Bernard et al., 2018), provoking changes in the relative labour demand, favouring the skilled group and putting downward pressure on wages of other workers.

In our empirical analysis, taking advantage of micro level data and thus controlling for individual and job characteristics, we concentrate on the GVC-wage nexus looking from the perspective of sectors' relative position along the value chain to capture the whole picture of the 'smile' curve.

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Trends in production fragmentation and GVC position in CEEC[1]

Global Import Intensity of Production

The classic import-based offshoring measure (*OFF*) is computed as the ratio of the value of imported intermediates to the industry's value added or total output (Feenstra and Hanson, 1999) so it counts only the imports involved in the last observed stage of production. Such approach, ignoring previous production stages, may well omit a large part of the complex value chain structure. The idea of global import intensity (GII) of production, proposed by Timmer et al. (2016), is to measure the imports needed along the entire chain, not only one stage previous. The GII index represents the sum of all GVC imports over the value of the final product.[2]

GII takes values between 0 and 1, where 0 means a purely domestic production process. Timmer et al. (2016) show that greater GII is due to more production stages or more imported inputs at given stages and means a greater probability that any link between two stages will involve cross-border trade. Figure 1 shows the difference between GII and the index based on imports from first tier suppliers only. While first tier imports (the classic gauge of offshoring) usually account for a significant share of GII, they do not cover even half of the total GII value.

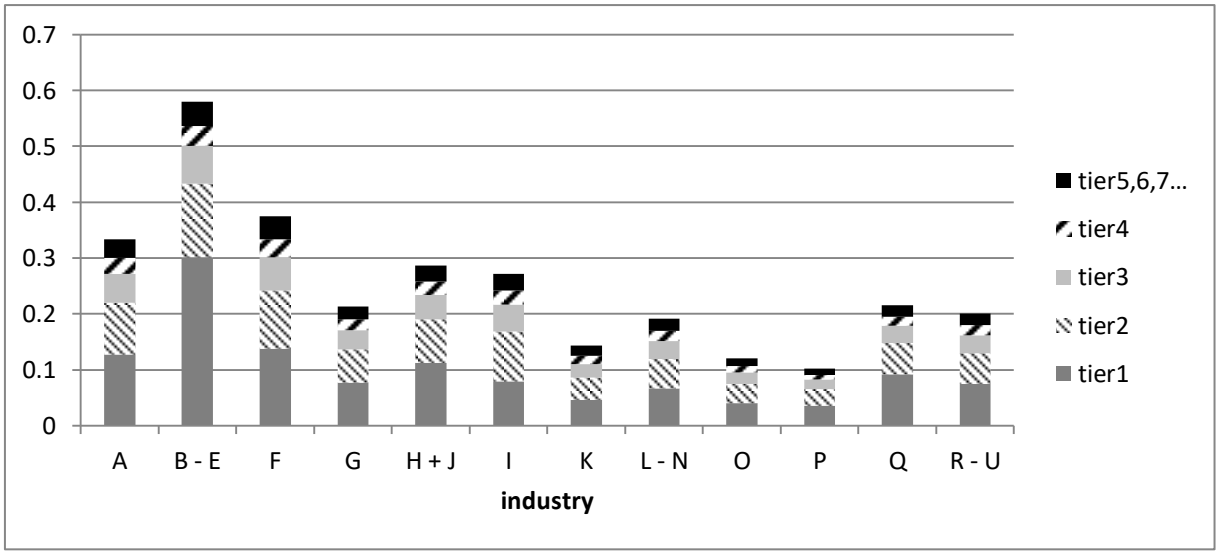

Figure 1. The shares of last four import stages (tiers) in GII index, CEEC, 2014
Notes: mean values over countries, observations weighted by value added. Sample: 10 CEEC.
Industries: A-Agriculture; B-E-Mining, Manuf., Gas&Water; F-Construction; G-Wholesale; H+J-Transport & Telecommunication; I-Accommodation & Food services; K-Finance; L-N-Real estate, Professional & Scientific activities; O-Public administration; P-Education; Q-Health; R-U-Other services. The detailed list of industries in supplementary materials in Table SM1.
Source: own elaboration based on WIOD (2016).

In the supplementary materials we illustrate the course of production fragmentation in CEEC between 2000 and 2014 as measured both by the classic offshoring index (*OFF*) and by GII (see Figure SM4). For additional robustness check of the results we also use in our study two alternative measures of cross country-industry production sharing, based on the framework introduced by Wang et al., (2018). These are the share of foreign value added embodied in exports (FVA) in gross exports (FVA/EXP) and vertical specialization (VS) share in gross exports (VS/EXP).

GVC position and length

To check the average industry position in GVC, we use the upstreamness index introduced by Antràs et al. (2012). The index describes an industry's average distance from the final stage of production. The greater the degree of upstreamness, the further the industry is from final demand. A strictly downstream industry (one whose output is the final good) will have an upstreamness index equal to 1.

In a similar way Fally (2012) proposed the formula of the average number of stages embodied in industry's production (the backward GVC length): if a good's production does not involve any previous stages, then the length (*L*) equals 1.

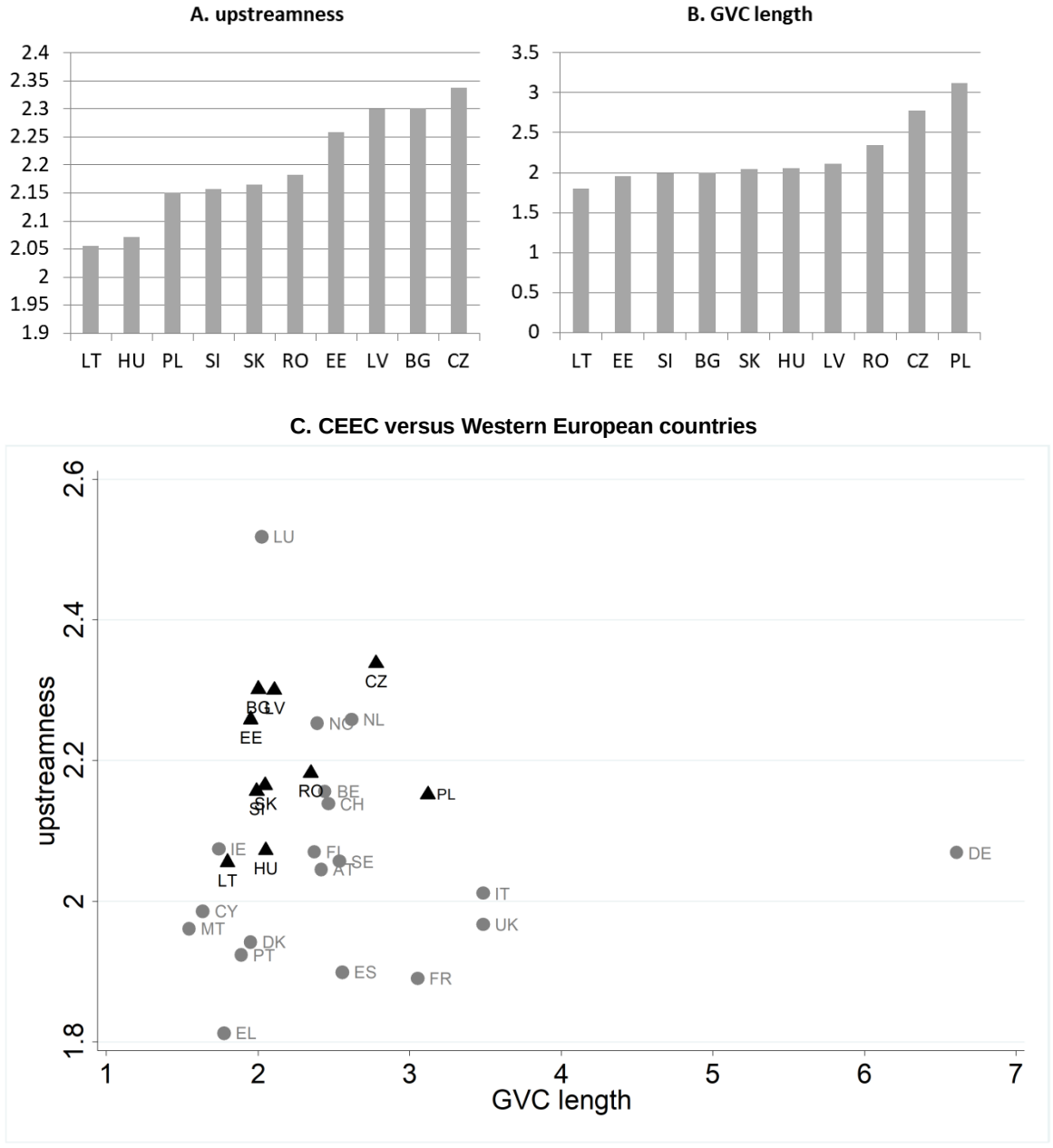

Figure 2. Upstreamness and GVC length, CEEC, 2014

Notes: mean values over industries, observations weighted by industry value added. CEEC marked as triangles.
Source: own elaboration based on WIOD (2016).

Upstreamness and GVC length are useful tools as they describe the relative positon of a unit (industry or country) in a production line. Figures 2A and 2B show the average of the values for individual industries, of upstreamness and GVC length in CEEC in 2014. Additionally, to show the peculiarities of CEEC, in chart 2C we confront upstreamness and GVC length typical for CEEC and for Western European countries in 2014. In terms of upstreamness CEEC place further away from the final demand than many Western European countries. It supports our belief that the case of CEEC deserves separate attention. In the supplementary materials (Figure SM5) we also show how CEE countries' average positions within GVC changed between 2000 and 2014.

The response of wages in Central and Eastern Europe to international production fragmentation

The data

The micro data are drawn from the EU-SILC database (Statistics on Income and Living Conditions, EUSILC UDB 2015, version 1, August 2016), available from Eurostat[3]. We combine individual files with household information using year, country, individual ID and household ID as matching variables.[4] We use cross-sectional data (longitudinal files lack the information about the sector of employment necessary to match microdata with sector-level indices). The analysis covers pooled waves of EU-SILC data for 2005-2014[5] in ten CEEC (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia).

We calculate gross hourly wages from gross annual employee income, number of months worked during the year, and number of weekly hours in the main job, assuming 4.2 weeks per working month.[6] Gross annual employee income corresponds to gross cash or near cash income (monetary compensation payable by an employer to an employee), i.e.: wages and salaries paid in cash for time worked or work done, holiday payments, payments for overtime, and additional payments (thirteenth month, productivity pay, commissions, tips, gratuities). Wages are in euros (exchange rates from EU-SILC) and are in real terms, deflated by the HICP (2015 = 100) from Eurostat.

EU SILC is also the source for other individual characteristics that play a role in determining wages, namely sex, age, marital status, education (the highest ISCED level attained, reclassified into status groups: high, or level 6, 7 or 8, and medium-low, level 0 to 4), and work experience (the number of years spent in paid work). The job characteristics considered are: company size (small for fewer than 11 employees, medium for 11-49, large for 50 or more), type of contract (permanent or temporary, including fixed-term), managerial position (if there are supervisory duties), sector (NACE Rev.2). Summary descriptive statistics of crucial micro-level variables for our sample are reported in Table SM6 in the supplementary materials.[7] The country-specific average hourly wages of workers characterized by different levels of education are presented in Figure SM7.

We also have data on individuals' occupations (2 digit ISCO-88 classification through 2011, ISCO-08 afterwards), which we map with country-specific indices of Routine Task Intensity (RTI), which reflect differences in routinization between occupations but also between countries (Lewandowski et al., 2019).[8] The higher the index, the more routine the job.

Model specification

Our empirical analysis is directed to determining whether wages in CEEC are associated with industry's position within a GVC[9], once the other factors in wage determination are accounted for. We build our model of wages on the basis of the Mincer model and its extensions (Mincer, 1958). To this end we merge

micro-level data on workers' characteristics with the industry-level upstreamness indicator (*UP*) for the sector in which the worker is employed and estimate the basic model:

$$\ln wage_{ijct} = \alpha + \beta X_{it} + \gamma Prod_{jct} + \theta UP_{jct-1} + \vartheta UP_{jct-1}^2 + D_t + D_j + D_c + \varepsilon_{ijct} \qquad (1)$$

where *i* denotes workers; *j*, sector (industry) of employment; *c*, country; and *t*, time. We regress the log of the gross hourly wage (ln*wage*) on a set of demographic and job characteristics *X* (sex, age, age^2, marital status, education, RTI, company size, contract type, managerial position). Industry-level covariates are productivity (*Prod*), measured as value added per hour worked, and the industry's upstreamness *(UP*).

In line with widely documented evidence on the gender wage gap, we expect a positive sign for the *Sex* variable (coded as 0 for female and 1 for male). The relation between age and wages tends to be a concave function, so *Age* enters the equations in the squared term. Marital status serves as a proxy for sex-specific role differentiation connected to labour force participation, but here the expected sign is unclear (Hill, 1979). Finally, we expect a positive relationship between education and wages, as earnings are proportional to the previously accumulated human capital (Freeman, 1986).

According to the concept of the routine-biased technical change and task-based framework of labour-market implications of technology (Acemoglu and Autor, 2011), the probability of workers' substitution by machines is related to the task content of their occupations. Therefore, more routine jobs are easier to substitute, which may affect labour demand and pose a threat to wages. A positive sign is expected for productivity, as productivity improvements may lead to changes in producers' effective prices and, consequently, a rise in wages.

Given possible nonlinearities we introduce UP^2 and apply lagged values of *UP* and UP^2 to capture the interval required for wage effects to materialize[10]. The marginal effect of *UP* on wages is $\frac{\delta lnwage}{\delta UP} = \theta + 2\vartheta$. The model also incorporates time effects D_t (controlling for time-specific economic fluctuations, e.g. the crisis of 2008/2009); industry dummies D_j (allowing for all the remaining industry-specific characteristics or wage regulations); and country dummies D_c (picking up all country-specific labour market conditions and wage-setting mechanisms).

The model is developed further. Empirically, we test the ambiguous wage predictions of theoretical models of offshoring and GVC by using different measures of GVC participation (*GVC*) and introducing the interaction term to account for the possible moderating effect of GVC position on fragmentation – wage nexus. The effect of *GVC* on wages can vary with upstreamness, so in the augmented regression we consider interactions between *GVC* and *UP* (UP^2):

$$\begin{aligned} ln\text{wage}_{ijct} &= \alpha + \beta X_{it} + \gamma Prod_{jct} + \theta UP_{jct-1} + \vartheta UP_{jct-1}^2 + \mu GVC_{jct-1} + \\ &+ \rho GVC_{jct-1} \times UP_{jct-1} + + \sigma GVC_{jct-1} \times UP_{jct-1}^2 + D_t + D_j + D_c + \varepsilon_{ijct} \end{aligned} \qquad (2)$$

and, alternatively, between *GVC* and chain length (*L*):

$$\begin{aligned} ln\text{wage}_{ijct} &= \alpha + \beta X_{it} + \gamma Prod_{jct} + \theta L_{jct-1} + \vartheta L_{jct-1}^2 + \mu GVC_{jct-1} + \\ &+ \rho GVC_{jct-1} \times L_{jct-1} + + \sigma GVC_{jct-1} \times L_{jct-1}^2 + D_t + D_j + D_c + \varepsilon_{ijct} \end{aligned} \qquad (3)$$

Considering the potential problem of endogeneity it should be noted that our research design is based on linking microdata on wages with sector-level measures of GVC. Thus, it is different from the specification in which wages are measured at a more aggregated level. We argue that the procedure of linking microdata on wages with sector-level measures of GVC, unlike that of measuring wages at say, sectoral level, is most unlikely to produce a situation in which the wage of an individual worker can influence the decision of an entire industry concerning production fragmentation or GVC involvement[11]. Additionally, GVC measures are introduced in the estimated models as lagged variables which should

help to resolve the problem of potential endogeneity. Nevertheless, the causal interpretation of results should be made with caution.

The results

The estimation results for models (1) and (2) are reported in Table 1. The estimates use weighted regression (with normalized weights[12]) and robust standard errors clustered at country-sector level. Every one of the individual characteristics is statistically significant and has the expected sign: on average male, older, married, highly educated workers earn more than their opposite categories. The coefficient of *RTI* is highly significant: the more routine the job, the lower the wage.

We are especially interested in the coefficients of our measures of international production fragmentation and GVC position. The first column of Table 1 corresponds to eq. 1. We confirm the 'smile' curve illustrated in Figure 3, which plots predicted wages (vertical axis) as a function of *UP*. The wages of CEEC workers are higher at the beginning of the chain (high *UP*) and at the end, closer to final demand (low *UP*) than in the middle. The graph presents also the concentration of sample points along the upstreamness axis. Most observations are concentrated above 1 and then around *UP* values of 2.2–2.6. However, there is a bunch of observations at both ends of the curve. The lowest wages are paid in sectors with *UP* around 2 (the mean). To give an idea on specific activities involved, in 2014 in most of the analyzed countries sectors such as *Public administration and defence; compulsory social security* or *Human health and social work activities* were situated near the final demand, *Mining and quarrying* was the most upstream sector with manufacturing in the middle.

Columns 2-9 of Table 1 correspond to eq. 2; they show the results from augmented model specifications where *UP* is interacted with alternative measures of GVC participation. In specifications (2) and (3) the regression is augmented by the traditional offshoring measure (*OFF*); in specifications (4) and (5), by global import intensity of production (*GII*), and in (6)-(9), by export-based fragmentation measures shown here for additional comparison: namely share of foreign value added in exports (*FVA/EXP*) and vertical specialization, also expressed as share in total exports (*VS/EXP*).

The non-linear effect of *UP* on wages always stands confirmed. When measures of *GVC* are introduced without interactions with *UP*, they are not among the statistically significant determinants of wages in our sample countries. Nor do we find a statistically significant correlation of the traditional offshoring measure (*OFF*) with wages (column 3). However, taking the interactions of the input-output measure of *GVC* with upstreamness (UP) alters the situation. When production fragmentation is measured by *GII* (thus counting not only the last stage of production but also all the previous tiers), the coefficients for *GII* and for its interaction with *UP* and UP^2 are statistically significant (columns 4 and 5). For export based measures, the results are not so strong: *FVA /EXP* is not related to wages (columns 6 and 7), and for *VS/EXP* we find statistically significant results only for conditional coefficients (column 9).

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Table 1. Estimation results – wage regression, including the interaction between fragmentation and upstreamness (eq.1 and 2)

Dep.var.: ln*wage*	eq.1	Measure of *GVC* – eq.2							
		OFF		*GII*		*FVA/EXP*		*VS/EXP*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Sex	0.211***	0.211***	0.211***	0.211***	0.211***	0.211***	0.211***	0.211***	0.211***
	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]	[0.009]
Age	0.030***	0.030***	0.029***	0.030***	0.029***	0.030***	0.029***	0.030***	0.029***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
Age^2	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Marital status	0.028***	0.028***	0.028***	0.028***	0.028***	0.028***	0.028***	0.028***	0.028***
	[0.005]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Higheduc	0.265***	0.265***	0.265***	0.265***	0.265***	0.266***	0.265***	0.266***	0.265***
	[0.012]	[0.012]	[0.011]	[0.012]	[0.011]	[0.012]	[0.011]	[0.012]	[0.011]
RTI	-0.417***	-0.417***	-0.418***	-0.417***	-0.418***	-0.417***	-0.418***	-0.417***	-0.418***
	[0.013]	[0.013]	[0.013]	[0.013]	[0.013]	[0.013]	[0.013]	[0.013]	[0.013]
Prod	0.046	0.046	0.044	0.047	0.042	0.047	0.041	0.047	0.042
	[0.029]	[0.028]	[0.027]	[0.029]	[0.027]	[0.029]	[0.027]	[0.029]	[0.027]
UP	-0.299**	-0.319**	-0.494***	-0.302**	-0.741***	-0.308**	-0.656***	-0.306**	-0.767***
	[0.139]	[0.138]	[0.163]	[0.139]	[0.235]	[0.138]	[0.238]	[0.139]	[0.240]
UP^2	0.068**	0.073**	0.114***	0.069**	0.168***	0.071**	0.144**	0.070**	0.174***
	[0.031]	[0.031]	[0.038]	[0.031]	[0.055]	[0.031]	[0.056]	[0.031]	[0.057]
GVC		0.04	-0.695	0.04	-1.777*	0.096	-2.598	0.065	-2.524*
		[0.031]	[0.751]	[0.085]	[0.943]	[0.146]	[1.729]	[0.116]	[1.334]
GVC×UP			0.671		1.653**		2.339		2.352**
			[0.630]		[0.827]		[1.557]		[1.163]
$GVC \times UP^2$			-0.151		-0.368**		-0.495		-0.522**
			[0.133]		[0.182]		[0.353]		[0.255]
R^2	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
N	562584	562584	562584	562584	562584	562337	562337	562337	562337

Notes: Time, country and sector dummies included. Normalized weighted regression with robust standard errors clustered at the country-sector level (in parentheses), the weights are based on personal cross-sectional weights (from EU-SILC) normalized by the number of observation per country (see main text for the details); *p ≤ .10, **p≤ .05, ***p ≤.01.
Source: own elaboration based on data from EU-SILC and WIOD.

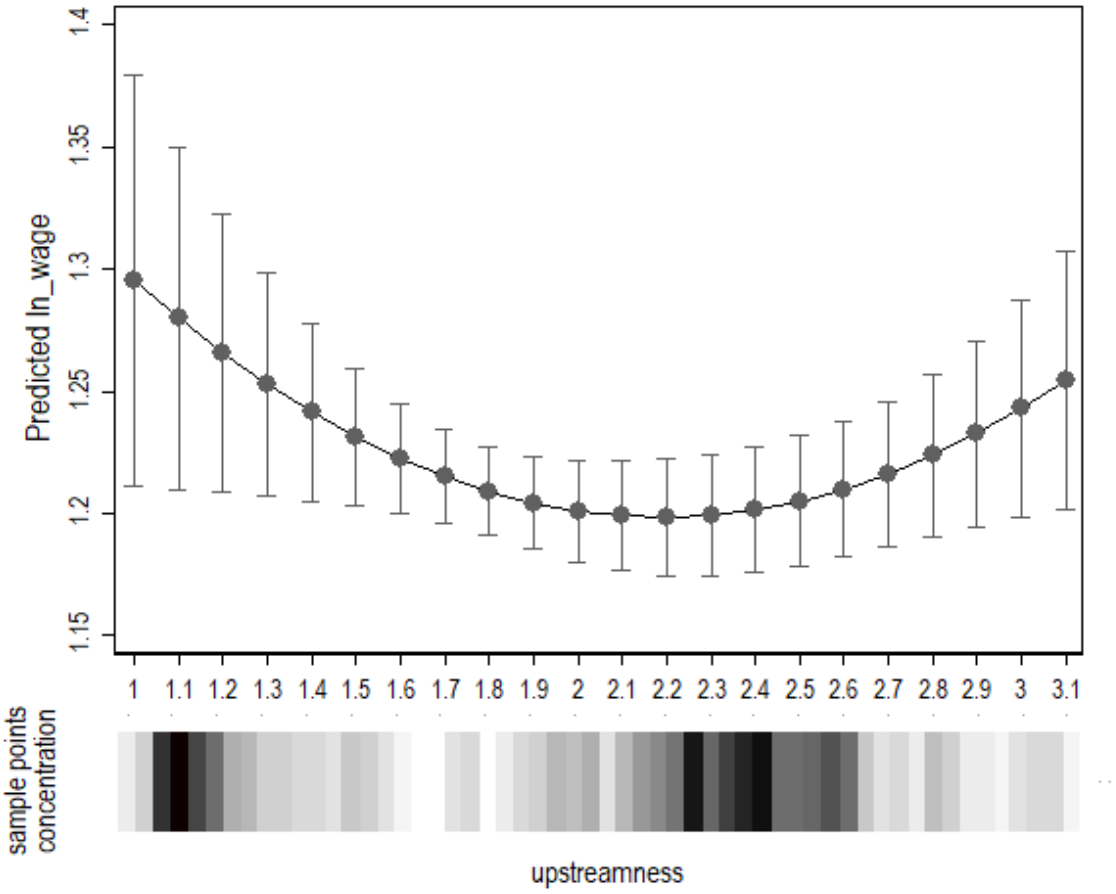

Figure 3. "Smile curve" - wages along the GVC
Note: Sample of 10 CEEC (2005-2014).
Source: own elaboration based on the estimation results of specification (1) reported in Table 1.

Since the augmented model comprises different interaction terms, to assess the impact of *GVC* on wages one must calculate the predictive margins. Accordingly in the Figure 4 we present plots of predicted wages (and, alternatively, contour plots in supplementary materials, see Figure SM8), which show how the wage level changes depending on the interplay between upstreamness and *GVC* intensity (four different measures of fragmentation). For sectors near final demand (*UP*=1), greater production fragmentation, measured either by *GII* or *VS/EXP*, is associated with lower wages. For higher values of *UP*, this effect is not sustained. If we look for a specific country-sector, for instance in 2014 in Poland, *Real estate activities* is the one with relatively low upstreamness and low production fragmentation; *Manufacture of textiles, wearing apparel and leather products* is placed near the final demand but it is characterized by relatively high level of production fragmentation (based on GII values), while *Manufacture of coke and refined petroleum products* has high upstreamness and high *GII*.

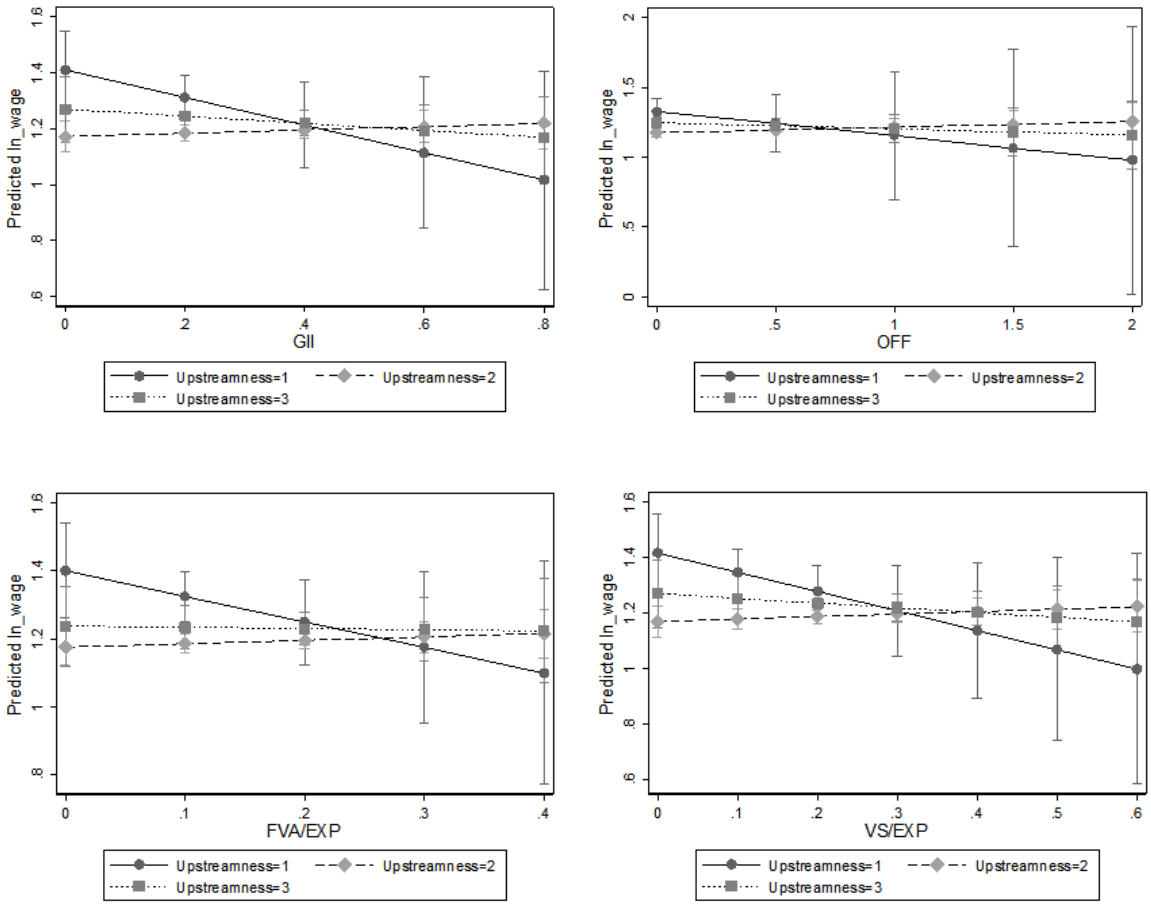

Figure 4. Predicted wages due to the changes in GVC at different values of *UP* (illustrating the results from Table 1)

Source: own elaboration based on data from EU-SILC and WIOD.

In order to illustrate the results of the regressions we have performed a counterfactual analysis which answers the question what would have happened to the level of wages if globalization had not progressed in the analysed period. We take point estimates from Table 1 (e.g. for *GII* from Column 5) and actual changes in GVC participation in the analyzed period to calculate the marginal effect of GVC on wages as: $\frac{\delta lnwage}{\delta GVC} = \mu + \rho UP + \sigma UP^2$. On average, *GII* rose from 0.247 in 2004 to 0.298 in 2013; hence the change in *GII* was equal to 0.051. For *VS/EXP*, the change was equal to 0.024, on average. The average real hourly wage in 2014 was EUR 4.33.

Using the formula for marginal effect of GVC on wages, for sectors near the final demand (*UP*=1), the expected wage could be 2.5% higher if the globalization (measured by GII) had not progressed, so the 2014 average real hourly wage would have been around EUR 4.44. For more upstream sectors (e.g. *UP*=3), we found 0.7% and EUR 4.36, respectively. Using the model with *VS/EXP* as a measure of globalization, one could expect wage to be 1.7% higher for UP=1 and 0.4% higher for UP=3, which corresponds to the hypothetical hourly wage of EUR 4.41 and EUR 4.35, respectively. Bearing in mind that wage in 2014 was equal to EUR 4.33, we interpret these effects as economically modest.

In a series of analogous estimations the explanatory variable hypothesized is *L* (the length of the production chain) rather than *UP*. The results are presented in the supplementary materials (Table SM9, Figures SM10 and SM11). In the basic regressions (without interactions), the nonlinearities are not confirmed. However, the estimates for the interaction terms indicate that the effect of *GVC* on wages varies with the length *L*. For short and long chains, an increase in fragmentation is associated with declining wages, but for chains of average length it is associated higher wages. These results do not conflict with those obtained on the basis of upstreamness: recall that *L* refers to the number of previous stages of production.

Extensions and robustness checks

The detailed results corresponding to this section are available as supplementary materials. The basic specification can be augmented with information on various aspects of labour market institutions. The information comes from ICTWSS: Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts (Visser, 2016). In a separate estimation, we add information on: coordination in wage setting (*Coord*), minimum wages (*MW*), sectoral organization of employment relations (*SECTOR*), union negotiation agreements (*Unagr*), works councils and employee representation in the enterprise (*WC*). Adding in the labour market institutional variables, the results show their importance for the wages of individual workers in the more highly regulated countries (where wage coordination relies on centralized bargaining, the minimum wage is set by government, sectoral institutions are of at least medium strength, and works councils are mandatory). In these countries wages are higher, on average: see Tables SM12-SM16 and SM21-SM25. Where the chief mechanism is decentralized bargaining, individual wages are lower. However, adding these additional labour market variables does not alter our main conclusion on the effect of production fragmentation along GVC.

Another extension involves adding other country- or sector-specific variables (Tables SM17-SM20 and Tables SM26-SM29). Here we find, for instance, that wages in more open countries are generally lower (with negative and significant coefficients for the ratios of both exports and imports to GDP), while more export-intensive sectors are characterized instead by higher individual wages. Typically, industries more involved in export activity pay more due to positive productivity effects of selection to exporting, so more export intensive sectors have higher wages (sector specific results should not be automatically extended to the case of the whole economy, though). Again, as in previous examples, these additional variables do not change the conclusion concerning *GVC*.

In addition, we repeat the estimation for workers in manufacturing and non-manufacturing industries separately. In Table SM30 we show the results, confirming that the wage effect of GVC position materializes mainly for workers in manufacturing (larger *UP* and higher *GVC* coefficients). For non-manufacturing industries, however, the nonlinear relationship between wages and upstreamness is sustained. In the regressions with interaction between *GVC* and *L* (Table SM31) the differences between manufacturing and non-manufacturing industries are less pronounced. To make sure our results are not driven by some specific industry or country, we run the estimation eliminating one industry/country at a time (Tables SM32-SM35).

Another sensitivity check involves including additional firm level variables (Tables SM36-SM37). Again the main results stand confirmed. The impact of *GVC* on wages depends on the position of a given sector in the value chain. Finally, we run the models with different dummies settings (country-year and/or sector-year fixed effects) and with an additional variable *year* (see Tables SM38 and SM39 in the supplementary materials).

Conclusions

This paper contributes to the literature by examining the relationship between industries' upstreamness (relative position in global value chains) and wages in ten Central and Eastern European countries in the period 2005-2014. The previous empirical literature on GVC-labour market interactions had not analysed this set of countries thoroughly, despite their increasing involvement in global production networks and the presumed labour market impact. The crucial feature of our paper is a test of a non-linear relationship between production fragmentation and wages, underlying the role played by the level of industries' upstreamness.

Specifically, we built a rich database with over half a million observations, merging micro-level wage data and a set of individual wage determinants in the spirit of Mincer, with recently elaborated GVC measures of sector-level global import intensity of production, upstreamness and production chain length. We also compared the results with those obtained using 'classic' indices of offshoring. This allowed complete assessment of the wage response to recent developments in international production fragmentation in CEEC.

The essential conclusion is that the wages of CEEC workers are higher when their industry is at the beginning of the production chain (high upstreamness) or at the end (low upstreamness, close to final demand) than in the middle. Second, wage changes depend on the interplay between upstreamness and GVC intensity. For sectors that are near the final demand, an increase in production fragmentation, measured either by global import intensity or by vertical specialization, is associated with a decline in wages. For those farther upstream, this effect is not observed.

Direct comparison with other studies is difficult, because the latter typically focus on the wage effects of classically measured offshoring, not GVC, or else use industry rather than individual wage data. Parteka and Wolszczak-Derlacz (2019), in an analysis based on observations for 110,000 workers in nine European countries and the United States, found that it is hard to attribute lower wages to the involvement of countries or industries in GVC. However, that work does not consider the possible effect of the particular position of industries in the chain and the smile curve, as we do in this paper. We have thus extended the empirical setting, demonstrating that at least in our sample of CEEC, the interaction between GVC intensity and position within the production chain is important. In our view, this analysis represents a significant step forward, enriching the literature on the GVC-wage nexus.

As far as the interpretation of the core findings is concerned, we believe that the effects vary across sectors (differentiated by the degree of upstreamness), due to the variation in the type of jobs and the type of activities undertaken along the value chain. Given the natural relationship between wages and productivity, our results can be interpreted in connection with uneven productivity gains materialized in different parts of the chain. The distribution of productivity improvements and employment shocks in the CEEC depends on GVC position (Hagemejer and Tyrowicz, 2017). Moreover, in sectors relatively close to the final demand, and thus located at the end of the chain, the effect of an increase in production fragmentation on wages is likely to be magnified through indirect GVC linkages: these transmit other sectors' responses in terms of relative demand and/or productivity via international production links. We are aware of the limits of our empirical findings - they should be interpreted in the light of CEECs peculiarities, in particular the relatively high degree of upstreamness. Moreover, we have limited our analysis to wages but further research could include other potential channels of GVC's impact on labour market outcomes, such as job opportunities, working conditions etc. – all of them can vary along the chain.

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Supplemental material

Supplemental material for this article is available online.

Notes

[1] All the measures in this section are calculated using the World Input-Output Database, WIOD (2016 release, Timmer et al., 2015) for 56 industries (for the list, see Table SM1 in the supplementary materials). Average national values of all the indices and the correlations between them are reported in Table SM2 and Table SM3 in the supplementary materials.

[2] The code in R concerning the calculation of GII and elaborated for the purpose of this paper is available for download as supplementary material.

[3] Data granted on the basis of an individual research proposal: 225/2016-EU-SILC-SES. The responsibility for all conclusions drawn from the data lies entirely with the authors.

[4] To convert the original EU-SILC data into a format suitable for our analysis, we used tools and routines from GESIS (http://www.gesis.org/en/services/data-analysis/official-microdata/european-microdata/eu-silc/).

[5] Since we use cross-sectional microdata in our analysis we are not able to trace the time trends of wages for individual workers, and we can only compute the average wages across sectors and countries to examine how they change over time.

[6] Poland, Hungary and Bulgaria provide data on monthly gross earnings and number of hours worked per week, from which gross hourly wages can be calculated (Schäfer and Gottschall, 2015). The correlation between gross hourly wages calculated from annual income and from monthly earnings is high (0.78), meaning that these calculations of wages are good proxies of salaries.

[7] In our sample we retain only full-time workers aged 18-65 and exclude military personnel. We set a cut-off at 1/100 of the country-specific mean wage and set any wages higher than ten times the national median to that value. The trimming is performed separately for each year and each country.

[8] The authors thank Piotr Lewandowski (IBS Warsaw) for sharing country-specific RTI indices (Lewandowski et al., 2019), available for 42 countries. For those CEEC for which RTI is not available, we

use the values of the most similar country (in terms of economic development, location, and size); specifically, for Bulgaria, Hungary and Romania we used the Polish RTI, for Latvia the Lithuanian.

[9] Concerning the GVC participation measures, we have formally checked the stationarity of variables using Im-Pesaran-Shin (2003) unit root test. The null hypothesis is rejected for all GVC measures at standard significance levels.

[10] Table SM3 in the supplementary materials presents correlations between different measures of GVC participation and GVC position. It is evident that alternative GVC participation measures are highly correlated. However, in the regression model, we include only one of these indices at a time, together with only one of the two alternative GVC position measures, and the pairwise correlation here is weak.

[11] The reverse causality has been checked by estimating an inverted model in which GVC (including GVC position measures) is a dependent variable while wages of individual workers are explanatory variables: GVC=f(wage). Such a reverse mechanism turned out not to be statistically significant.

[12] We use the original country-specific personal cross-sectional weights provided by EU-SILC to calculate normalized weights that always sum to 10,000 within each country. We thank Piotr Paradowski from the Luxembourg Income Study (LIS) for giving us the STATA codes.

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