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THE ROLE OF GLOBAL VALUE CHAINS FOR WORKER TASKS AND WAGE INEQUALITY[•]

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Abstract

This paper studies the relationship between global value chain (GVC) participation, worker-level routine task intensity (RTI), and wage inequality within countries. Using survey data from 34 countries and instrumenting for GVC participation, we find that higher GVC participation contributes to higher wage inequality in high-income countries and lower wage inequality in middle- and low-income countries. We distinguish between two opposite-working channels. Firstly, participation in GVCs directly reduces wage inequality, suppressing wages in offshorable occupations that tend to earn above the country-specific median, and increasing wages of non-offshorable occupations. Secondly, it indirectly widens within-country wage inequality by increasing the gap in RTI, which is negatively associated with wages, between offshorable and non-offshorable occupations. The direct effect prevails in most low- and middle-income countries that receive offshored jobs, and the indirect effect prevails in high-income countries that offshore jobs.

Keywords: routine task intensity, global value chains, globalisation, cross-country division of work, wage inequality

JEL: J21, J24, J31, F66

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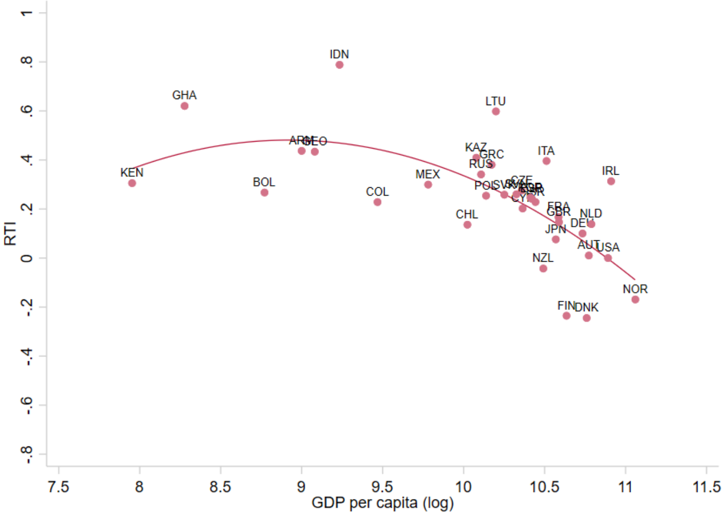
1. Introduction

Traditional trade theory predicted that countries' specialisation in trade affects the international division of labour, with implications for within-country wage inequality. Wealthier countries, which tend to be relatively more endowed with skilled labour and technology, have had a comparative advantage in the exports of skill- and technology-intensive goods and services. In contrast, developing nations have been relatively more abundant in low-wage labour and natural resources, thus specialising in labour- and resource-intensive goods exports. Relative output prices for goods and services with comparative advantage and relative wages for factors more intensively used in their production are expected to rise under increased trade (Stolper and Samuelson, 1941). However, rather than exporting final goods and services, countries now specialise in the exports of tasks they have a comparative advantage in (Grossman and Rossi-Hansberg, 2008). Global value chains (GVCs) consist of a series of value-adding tasks, from inception to selling a product or service for final consumption (World Bank, 2020). Technological change and trade liberalisation have fostered the possibility of trading tasks, offering opportunities to developing countries to participate and upgrade in GVCs (Taglioni and Winkler, 2016). The "second unbundling" of corporate tasks has intensified this division of labour (Baldwin, 2014), as routine tasks are easier to offshore (Blinder and Krueger, 2013), especially in manufacturing (Rodrik, 2013). The decline in routine jobs in the United States, the European Union, and some emerging countries since the late 1980s contributed to the polarisation of job opportunities within countries (Autor and Dorn, 2013; Cortes et al., 2017; Goos et al., 2014; Jensen and Kletzer, 2010; Michaels et al., 2014; Reijnders and de Vries, 2018; Spitz-Oener, 2006). This article is concerned with the contribution of participation in global value chains (GVCs) to within-country wage inequality across the development spectrum.

In this paper, we evaluate the GVCs contribution to within-country wage inequality (measured by the Gini coefficient), directly (through wages) and through its impact on the domestic labour markets' task structures. Drawing on a survey dataset covering 34 countries across all developmental stages, we highlight a novel, indirect channel of GVCs' contribution to wage inequality through worker-level routine task intensity (RTI). Conceptually, the relationship between trade and factor prices can go both ways. A country's initial factor endowment determines its type of comparative advantage and engagement in GVCs. However, trade liberalization can induce changes in relative factor prices and thus affect wage inequality within countries, as predicted by the Stolper-Samuelson theorem (Stolper and Samuelson, 1941). The focus of our paper is on the latter. Acknowledging that workers' RTI and average wages can influence a country and sector's type of GVC participation, our regression analysis applies an instrumental variables (IV) approach to instrument for possible endogeneity of GVC participation.

Previous research highlights that a higher RTI is strongly associated with lower earnings (Autor and Handel, 2013; de la Rica et al., 2020), thus indirectly affecting wage inequality within countries. Richer countries perform more non-routine tasks that require creativity, data analytics, or guiding people. In contrast, poorer countries specialise in routine-intensive tasks that are often repetitive, well-structured, and require being exact and accurate rather than creative (Figure 1). In addition, some jobs are easier to offshore while others cannot readily move between borders (Blinder and Krueger, 2013). What is the contribution of GVCs to between- and within-country differences in job tasks, and therefore to within-country wage inequality? Do various forms of GVC participation and the offshorability of occupations matter in this regard? Specifically, in this paper we systematically assess how the nature of GVCs mediates this relationship, accounting for differences across sectors and types of occupations, particularly offshorable and non-offshorable occupations.

Figure 1. The average routine task intensity (RTI), by countries' development level (GDP per capita), accounting for cross-country occupational task differences.



Note: for each task content, the 0 is set at the United States average value, and 1 corresponds to one standard deviation of RTI in the United States. GDP per capita in PPP, current international $, country averages for 2011–2016.
Source: Lewandowski et al. (2022).

The relationship between GVC participation and RTI depends on a country's factor endowments, which determine its type of task specialisation in GVCs. In developing countries such as Indonesia, a higher backward GVC participation, i.e., the share of imported inputs used in export production, may be associated with a higher worker-level RTI. Such countries tend to have abundant low-wage labour and specialise in the production tasks of basic manufacturing GVCs, typically in the final assembly stage. Thus, they rely strongly on imported inputs they process for their semi-final or final exports. However, high backward GVC integration also characterises countries specialising in more advanced manufacturing and services GVCs. Such countries are endowed with skilled labour and perform some routine tasks (e.g. customer service or accounting) and some non-routine tasks (e.g., IT support) (World Bank, 2020). Examples include Central Eastern European countries (Czech Republic, Hungary, Poland).[1]

The type of GVC participation in East Asian and Central Eastern European countries contrasts sharply with that of many Sub-Saharan African or Latin American countries specialising in commodities – agriculture and mining (Hanson, 2017). These countries show low backward GVC participation as they predominantly export upstream GVC tasks with low reliance on imported inputs and fewer opportunities to innovate and upgrade (Fernandez-Stark et al., 2011; Taglioni and Winkler, 2016; World Bank, 2020). They typically exhibit high forward GVC participation, namely a high share of domestic value added embodied in their direct partner countries' exports (Borin and Mancini, 2019, 2015). As a result, higher forward GVC participation in commodity-exporting countries may be associated with a higher RTI, as upstream tasks in agricultural or small-scale mining GVCs are more likely to be routine-

[1] For instance, some East Asian countries that initially specialised in blue-collar jobs managed to increase their workforce's skill supply, upgraded in GVCs, and shifted towards more upstream and downstream activities (de Vries et al., 2019). Similarly, some Central Eastern European countries (Czech Republic, Hungary, Poland, Slovenia) have been upgrading from an assembly-line specialisation towards more advanced activities (Kordalska and Olczyk, 2022; Timmer et al., 2019).

intensive.[2] A high level of forward GVC participation also characterises countries specialised in innovative GVC tasks (World Bank, 2020), but its expected relationship with RTI contrasts that of commodity exporters. In innovative countries, high value-added upstream tasks, such as research and design services, make up a larger portion of their domestic value added that is re-exported by their bilateral trading partners. These tasks tend to be non-routine. These country examples illustrate that the relationship between GVC participation and RTI may vary across sectors and countries with different development levels and models. It may also differ between backward and forward GVC participation.

To account for the endogeneity of GVCs, we build on the previous work of Fernandes et al. (2022) and instrument for GVC participation with sectoral elasticities to country-level endowments that are critical for the emergence of GVC linkages, such as factor endowments, geographical aspects, industrial capacity, trade policy, institutional quality, and macroeconomic factors. Instrumenting GVC participation with such endowments helps to capture the GVC component which is plausibly exogenous to countries' labour costs and comparative advantages in performing routine tasks, but the cross-sectional character of our data still makes our results largely about characterising equilibrium allocations of tasks and wages across GVCs.

We make three key contributions to the literature. First, we assess the relationship between GVC participation and wage inequality, measured with the Gini coefficient of hourly wages, in 34 countries across the development spectrum. Globalisation may shape the allocation of job tasks across occupations and thus contribute to earnings inequality, as workers performing less routine-intensive tasks tend to earn more (Autor and Handel, 2013; de la Rica et al., 2020). Our study confirms the negative association between RTI and wages and shows it is the strongest in tradable sectors. Consequently, GVC participation can contribute to wage inequality through two channels: (i) indirectly through its relationship with RTI, (ii) and directly through its relationship with wages that can differ between different types of workers, especially offshorable and non-offshorable occupations.

Second, we quantify the indirect channel of GVCs' contribution to wage inequality through worker tasks, which remains under-researched (Marcolin et al., 2016). We account for two key factors: the offshorability of occupations (Blinder and Krueger, 2013) and sectoral differences in GVC participation, specifically between manufacturing, tradable, and non-tradable services (Hanson, 2017).[3] The relationship between GVC participation and RTI may be particularly strong among workers performing offshorable tasks in tradable sectors.[4]

We reveal important heterogeneity between occupation types, sectors, and countries in the role of GVCs for worker tasks. Higher GVC participation corresponds to a larger RTI gap between offshorable and non-offshorable occupations, especially in less developed countries. Backward GVC participation is associated with higher RTI in

[2] In agribusiness, for instance, routine tasks include seed sowing and harvesting. More downstream tasks, such as washing, chopping, packing, and applying bar codes on fruits and vegetables, are also routine. Assigning one specialised task to each worker, rather than having one worker perform a series of consecutive tasks, increases the RTI.

[3] Studying labour market effects of GVC participation in services is important – in the 21st century, the export share of services grew much faster than the share of manufacturing, and services become more globally tradable than manufacturing (Bohn et al., 2018). For instance, services offshoring increased sectoral labour productivity but decreased employment in manufacturing in Germany (Winkler, 2010).

[4] Lewandowski et al. (2022) found that the relationship between backward GVC participation and worker-level RTI is the strongest among workers in low-skilled occupations.

offshorable occupations in industry and tradable services but not in non-offshorable occupations. Similarly, forward GVC participation relates to higher RTI, but this relationship is stronger among workers in offshorable occupations.

Moreover, higher GVC participation is associated with a larger distance between low- and middle-income (LMIC) and high-income countries (HIC) regarding workers' RTI, especially in offshorable occupations. While we find strong and positive associations between GVC participation and workers' RTI in LMICs, they are zero or negligible in HICs. This disequalising pattern is the most pronounced in sectors with the highest employment share of offshorable occupations, namely industry and tradable services.

Third, we quantify labour market channels of globalisation's contribution to within-country wage inequality in a cross-country setting that covers both developed and developing countries and accounts for occupations' offshorability. Importantly, we focus on GVC participation instead of relying on multifactor globalisation indices. The direct contribution – driven by GVCs' associations with wages of different types of workers – reduces wage inequality in most countries except for those most developed, while the indirect contribution – through linkages with RTI – increases it in countries at all development stages. The relative strengths of these contributions differ between countries at different development levels. We show that in LMIC countries that primarily receive offshored jobs, GVC participation reduces wage inequality despite widening the gap in RTI between offshorable and non-offshorable occupations. However, in rich countries that mostly offshore jobs, it widens wage inequality as GVC participation mainly benefits workers in non-offshorable services occupations.

Our study enhances the understanding of relationships between globalization and jobs by using more detailed GVC participation and RTI measures than in past literature. The PIAAC and STEP survey data cover 34 countries across all development levels and types of integration into GVCs. We measure RTI at a worker level, applying the method proposed by Lewandowski et al. (2022) to account for cross-country task differences in comparable occupations. This is vital as theory suggests that offshoring polarises tasks within occupations in different countries (Grossman and Rossi-Hansberg, 2008), and occupational task demands indeed differ between countries (Caunedo et al., 2023; de la Rica et al., 2020; Lewandowski et al., 2022; Lo Bello et al., 2019).[5] We also control for worker-level skills (reading proficiency), which allows us to capture differences in education quality. Lacking direct export measures at the task level,[6] we link sectoral measures of GVC participation to workers' RTI in a given sector, drawing on the methodology of Borin and Mancini (2019) based on the EORA data, and instrument for GVC participation with countries' endowments (Fernandes et al., 2022). We also control for technology use with a country-sector share of workers who use computers at work which is plausibly exogenous to the decisions of individual firms and workers.[7]

[5] Other strands of literature relating globalisation to the demand for workers in routine jobs study the effects of global trade (Autor et al., 2015), the China trade shock on local labour markets (Aghelmaleki et al., 2022; Autor et al., 2016, 2013), as well as offshoring (Autor et al., 2016; Baumgarten et al., 2013; Ebenstein et al., 2014; Goos et al., 2014; Hanson, 2017).

[6] To understand how GVCs shape the division of tasks across countries, research would ideally relate measures of task exports to data on tasks' routine intensity. GVC participation measures to date are only available at the sector or firm level for a given country. However, recent work has introduced new measures of income and job activities in exports where an activity is defined as a sector-occupation pair (Kruse et al., 2023).

[7] The closest study to ours is Lewandowski et al. (2022), but we use much more disaggregated measures of GVC participation (especially in manufacturing) and assess the relative role of forward and backward linkages. Reijnders and de Vries (2018) also studied the role of offshoring and technological change in GVCs in explaining the demand increase for non-routine occupations in a sample of 37 advanced and emerging countries. They decomposed changes in occupational labour demand along the value chain, but their methodology did not allow differentiation between intensities of GVC participation. They assumed that

Extensive literature studied the effects of offshoring on the relative demand for different occupations at the sectoral level, usually finding demand shifts with implications for inequality. It primarily differentiated between production and non-production workers, and captured relative demand for particular worker types with their share in the sector's wage bill. It initially focused on goods offshoring in manufacturing – see the seminal studies on the United States by Feenstra and Hanson (1999, 1996), and the broader literature review in Crinò (2009) – generally finding an increase in the relative demand for non-production workers. Focusing on services offshoring, some studies found it increased the relative demand for skills in the United States and Western Europe (Crinò, 2012, 2010), or lowered the relative demand for non-production workers in German manufacturing (Winkler, 2013). At the same time, globalisation is associated with a higher demand for low-educated workers in low-income countries (Reijnders et al., 2021). Several studies focused on worker-level adjustments to trade and offshoring found a downward pressure on wages in low-skilled occupations and upward pressure on wages in high-skilled occupations in the United Kingdom and Germany (Geishecker and Görg, 2013; Koerner, 2022). Ebenstein et al. (2014) showed that offshoring negatively affects individuals' wages in the United States due to relocating workers from higher-wage manufacturing jobs to other sectors and occupations. Existing cross-country studies (Wolszczak-Derlacz and Parteka, 2018) find minor adverse effects of offshoring on the wages of low- and middle-skilled workers, but they focus on high-income countries. In the meta-analysis of within-country studies, Cardoso et al. (2021) showed that offshoring benefits high-skilled workers and harms low-skilled workers, especially in the origin countries.

A related strand of literature focused on globalisation's distributional effects. Gonzalez et al. (2015) found that GVC participation has a relatively small impact on wage distributions and can reduce wage inequality among low-skilled segments of the labour force. Duarte et al. (2022) showed that countries with medium levels of GVC participation tend to record higher income inequality than those with low or high levels of GVC participation. Heimberger's (2020) meta-analysis pointed out that financial globalisation has a more sizeable and inequality-increasing impact than trade globalisation.

This paper is structured as follows. Section two introduces the data, measurements, and descriptive analysis. Section three describes the methodology. Section four presents our econometric results. Section five concludes and outlines policy implications.

2. Data and descriptive evidence

2.1. Data and measurement

Our worker-level dataset covers 34 countries at different development levels (Table A4 in Appendix A). Most of the country's coverage comes from the OECD's Programme for the International Assessment of Adult Competencies – PIAAC (2019). During three rounds of the study (2011-2012, 2014-2015, and 2017-2018), data, including wage data, were collected in 31 countries. The sample sizes amount to a few thousand 16-65 years old individuals. We complement PIAAC with the Skills Towards Employment and Productivity – STEP (World Bank, 2017) survey data from seven low- and middle-income countries. STEP data were collected in 2012-2014 among urban residents aged 15-64, covering a few thousand respondents in each country. As the STEP surveys are urban surveys, we omit farmers and skilled agricultural workers (ISCO 6 from the sample in all countries) for comparability.

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occupations are identical worldwide and measured occupational task contents with American data (the Occupation Information Network – O*NET), while we account for cross-country differences in job tasks in comparable occupations.

Following Lewandowski et al. (2022), we create a worker-level task measure of routine task intensity in the spirit of Acemoglu and Autor (2011). It increases with the importance of routine tasks (structured, repetitive) and declines with the importance of non-routine tasks (analytical, aimed at solving problems, and interpersonal aimed at supervising or presenting). It is based on country-specific surveys, but for the sake of comparability, we standardise the pooled sample using the US average and standard deviation of task measures. For methodological details, see Lewandowski et al. (2022).

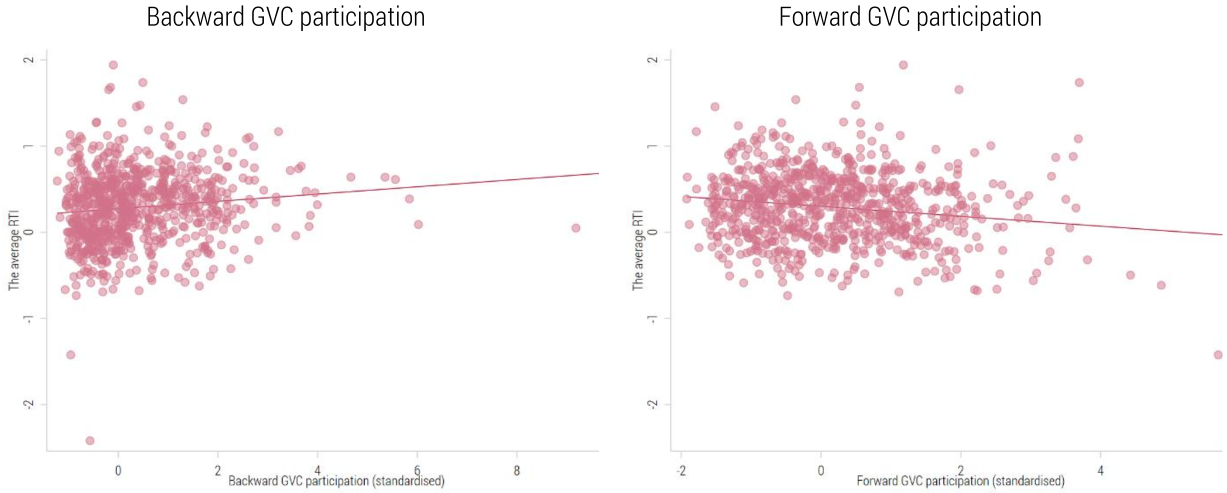
We use hourly wages in US dollars, adjusted for purchasing power parity, with a 99% winsorisation.

The country-sector level measures of GVC participation are based on the EORA database (Lenzen et al., 2013, 2012) and computed with the method of (Borin and Mancini, 2019, 2015).[8]We use backward and forward GVC participation measures. Both quantify value-added flows that cross at least two country borders. Backward GVC participation measures the share of imported inputs used in export production (% of total exports). Forward GVC participation captures the share of domestic value added embodied in a country's bilateral partners' exports (% of total exports).[9]

2.2. Descriptive analysis

We begin with visually exploring the relationship between GVC participation and RTI at the country-sector level. There is a weak correlation between the average RTI and backward GVC participation (11%, left panel of Figure 2), and a weak, negative correlation with forward GVC participation (-16%, right panel of Figure 2). The definition of GVC participation does not specify the type of value-added crossing borders – ranging from low (e.g., raw materials) to high high-value-added tasks (World Bank, 2020). These weak relationships could thus mask heterogeneity across types of countries, sectors, and occupations.

Figure 2. The correlation between GVC participation and the average routine task intensity (RTI), by country and sector.

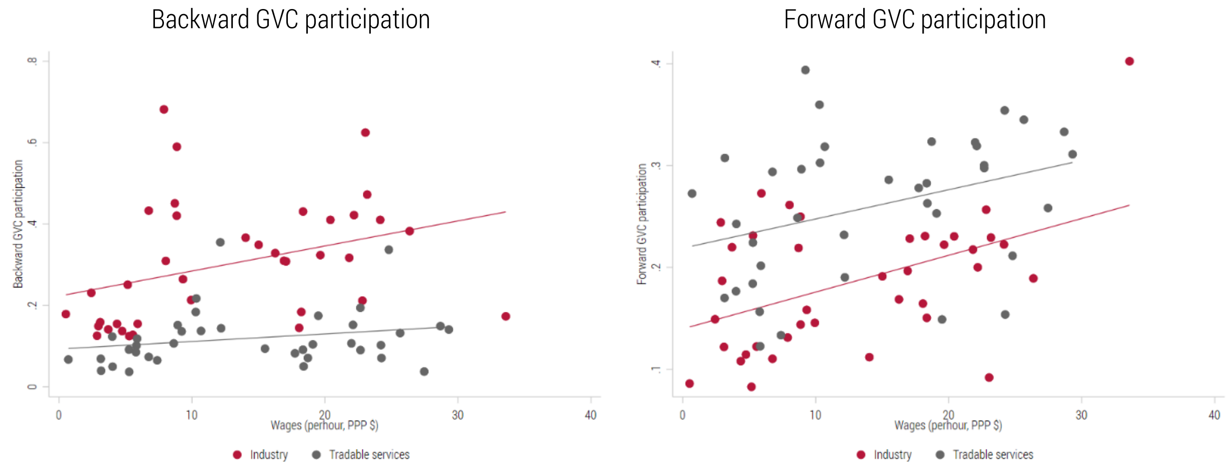


Note: for each task content, the 0 is set at the United States average value and 1 corresponds to one standard deviation of this particular task content value in the United States. Country-sector RTIs are calculated as the average for workers in a particular country-sector cell, weighted with PIAAC weights. GDP per capita in PPP, current international $, country averages for 2011–2016. For presentation purpose, we removed outlier from left panel.
Source: Authors' calculations based PIAAC, STEP, World Bank, and EORA data.

[8] For sectoral variation of GVC measures, see Table A2 in Appendix.
[9] This measure avoids a double-counting problem prevalent in alternative measures of forward GVC participation.

Next, we relate GVC participation to average wages at the country-sector level, differentiating between the industrial and tradable services sectors. Overall, both GVC participation measures positively correlate with average hourly wages at the country-sector level (Figure 3), suggesting positive productivity spillovers from firms participating in GVCs for workers. In the case of backward GVC participation, the correlation with wages in the industrial sector (35%) is stronger relative to the tradable services sector[10] (23%, Figure 3, left panel). It is in line with the intuition that high backward GVC participation in the industrial sector (driven mainly by manufacturing sectors) is associated with assembly tasks of specialised sectors where hourly wages can be expected to be higher (think of, e.g., technicians in the automotive sector). There is, however, high dispersion because high backward GVC participation can characterise low-wage countries specialised in limited manufacturing GVCs, but also richer countries specialised in more sophisticated GVCs. In the case of forward GVC participation, the opposite finding holds. The correlation with average hourly wages in the tradable services sector (46%) is higher than in the industrial sector (35%, Figure 3, right panel). High forward GVC participation in tradable services is associated with high-value-added tasks such as product design or R&D, which earn higher hourly wages. The high dispersion also suggests that high forward GVC participation is associated with lower-wage commodity exporters and innovative countries.

Figure 3. The correlation between GVC participation and hourly wages, by country and broad sector.



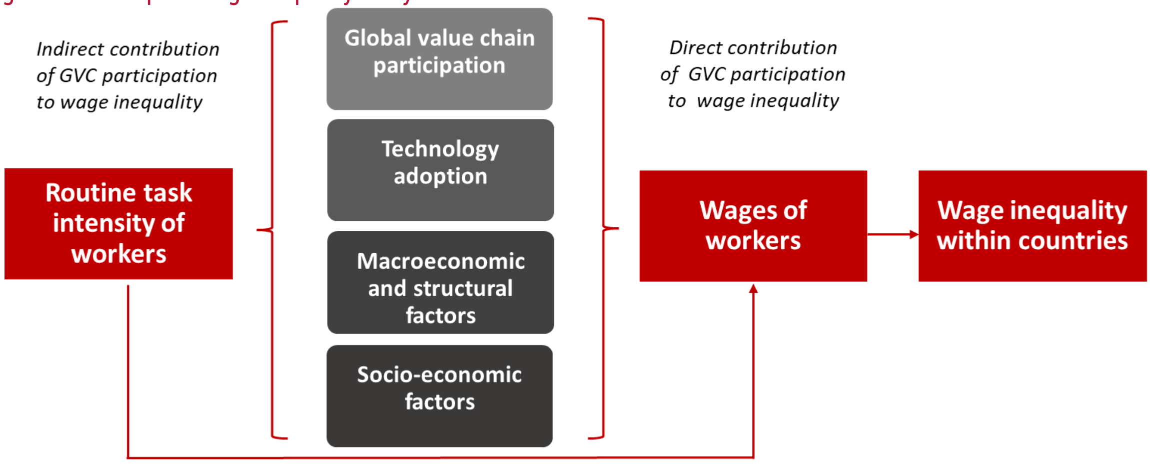
Note: Hourly wages are in PPP US $, top 1% of earners are excluded. Average wages are weighted with sectors' output.
Source: Authors' calculations based on PIAAC, STEP, and EORA data.

3. Methodology

We study the contribution of GVC participation to wage inequality within countries. As a higher RTI is negatively correlated with wages, both at the occupation and worker level (Autor and Handel, 2013; de la Rica et al., 2020), GVC participation may widen wage inequality between workers in offshorable occupations and those in non-offshorable occupations. Hence, we distinguish between two channels: (1) the direct contribution of GVC participation to individual wages, and (2) the indirect contribution of GVC participation through its relationship with workers' RTI. Diagram 1 exemplifies our reasoning. Our analysis can be divided into two parts: first, modelling RTI, second, modelling wages, and third, modelling inequality measured with the Gini coefficient of hourly wages. As GVC participation can be partly determined by labour supply and cost, raising concerns about reverse causality, we will instrument for GVC participation (details in subsection 3.3).

[10] For details, see Table A1 in Appendix A.

Diagram 1. Concept of wage inequality analysis.



Source: Own elaboration.

3.1. Econometric model – routine task intensity (RTI)

Our first regression quantifies the relationship between GVC participation and the average RTI of workers and exploits the variation between countries within sectors (especially within manufacturing). It broadly follows the specification of Lewandowski et al. (2022). Specifically, we estimate pooled regressions of the following form:

$$RTI_{ijsc} = \beta_0 + \beta_1 G_{sc} + \beta_2 G_{sc} * GDP_c^{PC} + \beta_3 Z_{sc} + \beta_4 X_{ijsc} + \lambda_s + \epsilon_{ijsc} \quad (2)$$

where RTI_{ijsc} is the RTI of individual i in occupation j in sector s in country c; G_{sc} measures GVC participation in sector s in country c; Z_{sc} captures technology in sector s in country c; X_{ijsc} are individual skills of worker i in occupation j in sector s in country c; and λ_s are sector fixed effects. We interact GVC participation, G_{sc}, with GDP per capita GDP_c^{PC} to control for potential differences between countries.

We extend the approach of Lewandowski et al. (2022) and distinguish between backward and forward GVC participation in sector s and country c. The measures are standardised within the sample to allow for interpretation regarding their relative economic magnitudes. Importantly, they vary between narrowly defined sub-sectors within manufacturing. Additionally, we control for foreign direct investment (FDI) as a share of GDP to capture globalisation more broadly.

We control for key factors behind the global allocation of routine and non-routine work: technology use and (worker-level) skill supply (Lewandowski et al., 2023, 2022; Martínez-Matute and Villanueva, 2023). To capture technology, we use the share of workers in sector s and country c who use computers at work, calculated with the PIAAC and STEP survey questions about a worker's personal computer use. We aggregate this worker-level information to the sector level to address potential endogeneity concerns, as the performance of particular tasks may require computers. Following Lewandowski et al. (2022), we include a quadratic term, allowing for possible non-linear linkages between computer use and RTI. We also include sector-level fixed effects (18 sectors of 1-digit International Standard Industrial Classification, ISIC rev. 4) and their interactions with a country's GDP per capita (log, demeaned) to control for structural differences between countries.

To control for individual characteristics and skill levels, we include indicator variables for age (10-year age groups), gender, education level (primary, secondary, tertiary), and a test-based measure of literacy skills (four proficiency levels). The literacy test comprehensively quantifies individuals' skills to understand, evaluate, use, and engage with written texts in personal, work-related, societal, and educational contexts (PIAAC Literacy Expert Group, 2009).

As we are interested in the effects of GVC participation on workers' RTI, we define subsample of workers performing offshorable and non-offshorable occupations rather than according to skill level associated with particular occupations (Lewandowski et al., 2022).[11] We apply the allocation proposed by Blinder and Krueger (2013). Depending on data availability, we assign occupations to groups starting at the 4- and 3-digit ISCO-08 codes. Table A3 in Appendix A enlists occupations with assigned offshorability groups (at the 2-digit ISCO level for the sake of brevity). We also distinguish between three broad sectors: industry, tradable services, and non-tradable services, drawing on World Bank's method (Nayyar et al., 2021). Table A1 in Appendix A shows the assignment of specific NACE / ISIC sectors to these three broad sectors. In all worker-level regressions, standard errors are clustered at the country-sector level.

3.2. Econometric model – wages

We divide our sample into six subsamples by broad sector (industry, tradable services and non-tradable services) and occupation (offshorable and non-offshorable). For each subsample, we estimate the following Mincerian wage regression:

$$w_{ijsc} = \beta_0 + \beta_1 G_{sc} + \beta_2 G_{sc} * GDP_{sc}^{PC} + \beta_3 Z_{sc} + \beta_4 X_{ijsc} + \beta_5 RTI_{ijsc} + \lambda_j + \epsilon_{ijsc} \quad (3)$$

where, w_{ijsc} is the wage of individual i in occupation j in sector s in country c. In wage models, we interact GVC participation, G_{sc}, with GDP at sectoral level GDP_{sc}^{PC} instead of country level, as in model (2). This is required to control for average wage differences between countries and sectors. The rest of the notation follows equation (2). Our key coefficients of interest in the wage regression are β_5 pertaining to worker-level RTI, and β_1 and β_2 which capture the role of GVCs across the development spectrum.

3.3. Instrumental variable strategy

It is highly challenging to find reasonable instruments for GVC participation in a cross-country setting. We draw on Fernandes et al. (2022) who quantified the determinants of GVC participation at the country level and used an IV approach to establish a causal relationship between backward GVC participation and country-level determinants. Specifically, they distinguished six groups of determinants of GVC participation – factor endowments, geography, domestic industrial capacity, trade policy and FDI, institutional quality, and macroeconomic factors.

In the absence of sector-specific measurements of such variables, we generalise the method of Fernandes et al. (2022). We instrument for sector-level GVC participation with the interactions of the aforementioned determinants with sector-level fixed effects. We treat coefficients of those interaction terms as sectoral elasticities to country-level endowments. Exploiting variation between sector elasticities allows us to instrument for potential endogeneity in GVC participation. In particular, we use data provided by Fernandes et al. (2022) and control for land and natural resources, capital, low-, medium- and high-skilled workers supply (factor endowments), distance to GVC hubs

[11] We believe that dividing jobs by offshorability is more accurate for our research question. For instance, factory assembly line workers and truck drivers, who belong to offshorable and non-offshorable occupations, respectively, may be affected differently by globalisation despite both being low-skilled occupations.

(geography), value added of manufacturing (domestic industrial capacity), average tariffs, statutory corporate tax, FDI inflows, import elasticity (trade policy and FDI), political stability (institutional quality), exchange rate appreciation, transitional economy status, and population (macroeconomic factors). We apply this approach to estimate equations (2) and (3) with 2SLS.

3.4. Counterfactual decomposition of wage inequality

Quantifying the direct and indirect – through RTI – contribution of GVC participation to countries' wage inequality involves four steps. Appendix A gives a more detailed description, including formulas for the underlying methodology, which we outline below.

First, based on the model (3) estimated coefficients, we predict workers' wages in each of the six subpopulations. We then calculate the Gini coefficient for each country, our *baseline scenario*.

Second, we calculate the indirect contribution of GVC participation to wage inequality. For each of the six sub-samples, we use the model (2) estimated coefficients to calculate counterfactual worker-level RTI under the scenario of no GVC integration, i.e., assuming GVC participation values equal to zero ($G_{sc} = 0$). We then use the model (3) estimated coefficients to predict wages conditional on these counterfactual RTI values. To isolate the indirect contribution of GVC participation to wages through its relationship with workers' RTI, we use the observed values of GVC participation in this calculation (rather than setting their values to zero). We define *the indirect contribution of GVC participation to wage inequality* as a difference between the Gini coefficient of wages calculated in the baseline scenario and the Gini coefficient of wages obtained in this counterfactual scenario.

Third, we assess the direct contribution of GVC participation to wage inequality. We use the model (3) estimated coefficients for each of the six sub-samples to calculate counterfactual wages assuming GVC participation values equal to zero. We define *the direct contribution of GVC participation to within-country wage inequality* as the difference between the Gini coefficient of wages calculated in the baseline scenario and the Gini coefficient of wages obtained in this counterfactual scenario.

In the fourth step, we calculate the *total* contribution of GVC participation to wage inequality. We use the model (2) estimated coefficients for each of the six sub-samples to calculate counterfactual worker-level RTI, assuming GVC participation values equal to zero (as in the indirect contribution calculation). Then we use the model (3) estimated coefficients to calculate wages conditional on these counterfactual values of RTI and no GVC integration ($G_{sc} = 0$). We define *the total contribution of GVC participation to wage inequality* as the difference between the Gini coefficient of wages in the baseline scenario and the Gini coefficient of wages in this final scenario.

4. Results

4.1. GVC participation and workers' tasks

We start by regressing worker-level RTI against backward and forward GVC participation at the country-sector level and a set of controls (model 2). We focus on the IV results, but as our instruments are weaker for services than for industry (Tables 2 and 4), we also show OLS results. However, in the post-estimation analysis (Figures 4-5 and subsection 4.4) we use the IV results which capture the effects of plausibly exogenous components of GVC participation.

We find barely any effects of GVC participation on workers' RTI in the pooled sample of all occupations and sectors (Table 1, column 1). However, there is important heterogeneity between sectors, with industry and tradable services being most interesting as sectors highly integrated into GVCs (Table 1, Panel A, columns 2-4). Further distinguishing between offshorable and non-offshorable occupations reveals clear correlation patterns between GVC participation type, sector of employment, and occupation type. Overall, GVC participation is associated with higher RTI among offshorable occupations but not among non-offshorable occupations. As backward and forward GVC participation measures are standardised within the sample, the coefficients' similar size (in absolute terms) suggests that both participation types are equally important for workers' RTI, especially among offshorable occupations.[12] Moreover, the relationship between GVC participation and RTI is mediated by development level, especially in industry. To illustrate this, we show the relationship between GVC participation and RTI in an average low- or middle-income country and an average high-income country in our sample (Figure 4).

In industry, both types of GVC participation are associated with higher RTI among workers in offshorable occupations. Hence, workers in industrial sectors and countries specialised in smaller segments of GVC (e.g., assemblers of final products) tend to perform more routine-intensive tasks. IV estimates are slightly larger in absolute terms than the OLS estimates, especially in pooled sample and in offshorable occupations. This suggests the GVC participation may indeed be partly driven by countries' comparative advantages in performing routine and non-routine tasks, and corroborates our focus on the IV results. Countries' development level mediates the relationship between forward GVC participation and RTI, though the IV estimate is noisy (Tables 1 and 2, Panel B, column 2). Nonetheless, this relationship is stronger in LMICs (0.13 in OLS and 0.38 in IV of the US std. dev. in RTI) than in HICs (Figure 4).[13] In contrast, among workers in non-offshorable occupations, the relationship between RTI and backward and forward GVC participation is insignificant (Tables 1 and 2, panel C, column 2).

In tradable services, the relationship between GVC participation and workers' RTI in offshorable occupations differs substantially between LMICs and HICs (Tables 1 and 2, Panel B, column 3). In LMICs, we find imprecise association between RTI and backward GVC participation (0.08 in OLS and -0.07 in IV estimation) and a strong positive association with forward GVC participation (0.19 in OLS and 0.33 in IV estimation, Figure 4). In HICs, both are insignificant. Similarly to industry, there is no association between RTI and backward GVC participation among workers in non-offshorable occupations (Table 1, panel C, column 3). Still, we find a small, positive relationship between workers' RTI and forward GVC participation in LMICs (0.13 in OLS and 0.14 in IV estimation, Figure 4).

In non-tradable services – much less integrated into GVCs than the other two broad sectors[14] – we find a positive association between RTI and backward (0.03-0.16 in OLS and 0.06-0.18 in IV estimation, imprecise) and forward (0.08-0.10 in OLS and 0.11-0.15 in IV estimation, Figure 4) GVC participation among workers in offshorable occupations (Table 1, panel B, column 4). However, this segment is small – on average, offshorable occupations account for 7% of non-tradable services employment, equivalent to 4% of total employment. In contrast with industry and tradable services, the results do not significantly differ between LMICs and HICs (Figure 4). In the case

[12] As a robustness check, we run models for backward and forward GVC participation measures separately, rather than combining them in one joint regression, and obtain similar results (Table B1 in Appendix B).

[13] We obtain similar results for manufacturing (ISIC rev. 4 section C) rather than industry – results are available upon request.

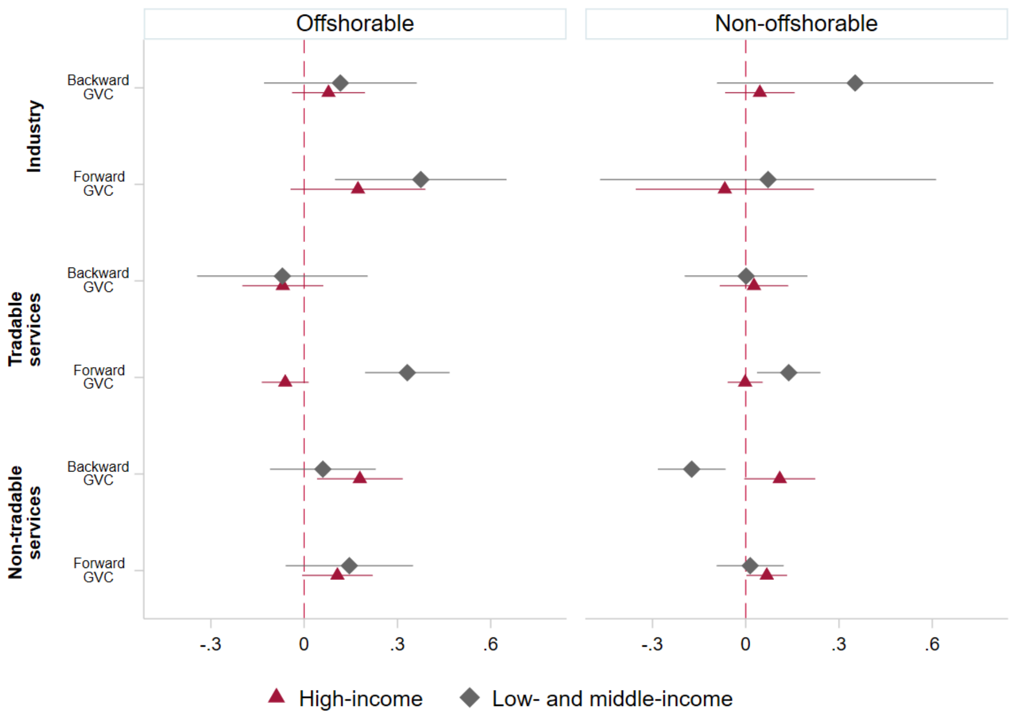
[14] On average, backward GVC participation in non-tradable services is 17.4 pp lower than in industry, and forward GVC participation is 3.3 pp lower (estimated as sector indicator variables in regressions on GVC participation, controlling for country dummies).

of non-offshorable occupations, we find a positive association between workers' RTI and backward GVC participation in HICs and a negative one in LMICs (Figure 4). The relationship with forward GVC participation is insignificant (Table 1, panel C, column 4).

We draw two main conclusions. First, participation in GVC widens the gap in workers' RTI between countries at different development levels. Especially in offshorable occupations, the impacts of GVC participation on workers' RTI tend to be strong and positive in LMICs, while they are zero or negligible in HICs. This divergence of RTI is most pronounced in sectors with the highest share of offshorable occupations – industry and tradable services. Our findings align with the theory: manufacturing low-value-added, basic intermediates that require more routine-intensive work tends to be outsourced to less developed countries (factory economies), while the performance of non-routine tasks remains in countries at higher development levels (Baldwin, 2013).

Second, participation in GVC widens the RTI gap between offshorable and non-offshorable occupations, especially in LMICs. Backward GVC participation correlates positively with workers' RTI in offshorable occupations, such as plant and machine operators, but not in non-offshorable occupations, such as truck drivers (see the list of occupations by offshorability in Table A3). Similarly, a positive correlation between forward GVC participation and workers' RTI is stronger among workers in offshorable occupations. Higher RTI is linked to lower wages, so this divergence of workers' tasks in offshorable and non-offshorable occupations can indirectly contribute to wage inequality. We explore this mechanism in Subsection 4.4

Figure 4. The estimated relationship between GVC participation and workers' RTI in high-income and low- and middle-income countries, by employment sectors, occupation, and participation type, IV estimation



Note: Figure presents the marginal effects of GVC participation based on regressions presented in Table 1, for the average GDP per capita of high-income and low- and middle-income countries. High-income country closest to the average is Italy, and low- middle-income country is Macedonia. For corresponding relationships estimated with OLS see Figure B1 in the Appendix.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table 1. The relationship between GVC participation and RTI, total and by occupation type, standardized – OLS

Dependent variable: worker level RTI	(1) Total economy	(2) Industry	(3) Tradable services	(4) Non-tradable services
Panel A: all workers				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.004	0.015	0.013	0.032
	(0.017)	(0.020)	(0.028)	(0.026)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.034	-0.026	-0.026	0.102***
	(0.023)	(0.031)	(0.033)	(0.025)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.005	0.030	0.036*	-0.027
	(0.012)	(0.019)	(0.020)	(0.028)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.042***	-0.038**	-0.082***	0.015
	(0.013)	(0.019)	(0.022)	(0.026)
Observations	106,080	16,857	27,684	61,539
Panel B: offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.059***	0.058***	0.013	0.108***
	(0.018)	(0.022)	(0.040)	(0.034)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.038	-0.046	-0.057	0.071*
	(0.024)	(0.031)	(0.046)	(0.043)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.075***	0.073***	0.043	0.082**
	(0.014)	(0.017)	(0.030)	(0.040)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.071***	-0.050***	-0.121***	-0.006
	(0.017)	(0.018)	(0.034)	(0.043)
Observations	16,601	6,461	5,700	4,440
Panel C: non-offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	-0.009	-0.016	0.015	0.025
	(0.018)	(0.022)	(0.031)	(0.027)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.044*	-0.018	-0.016	0.104***
	(0.023)	(0.035)	(0.037)	(0.025)
Forward Global Value Chain participation (GVCF) share in exports (std.)	-0.012	0.001	0.036	-0.038
	(0.013)	(0.025)	(0.022)	(0.029)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.035***	-0.034	-0.073***	0.019
	(0.014)	(0.025)	(0.023)	(0.026)
Observations	89,479	10,396	21,984	57,099

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table 2. The relationship between GVC participation and RTI, total and by occupation type, standardized – IV

Dependent variable: worker level RTI	(1) Total economy	(2) Industry	(3) Tradable services	(4) Non-tradable services
Panel A: all workers				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.036	0.117*	-0.006	0.017
	(0.030)	(0.067)	(0.057)	(0.042)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.079**	-0.100	0.002	0.145***
	(0.034)	(0.093)	-0.045	(0.042)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.070***	0.124	0.048*	0.056*
	(0.023)	(0.098)	(0.025)	(0.032)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.058**	-0.119	-0.096***	0.024
	(0.026)	(0.108)	(0.030)	(0.031)
Observations	106,080	16,857	27,684	61,539
Kleibergen–Paap Wald test for weak IV	41.24	86.07	5.85	7.95
Panel B: offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.098***	0.087**	-0.069	0.137***
	(0.035)	(0.040)	(0.072)	(0.052)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.062	-0.029	0.001	0.063
	(0.043)	(0.085)	(0.075)	(0.063)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.146***	0.224***	0.078**	0.121**
	(0.032)	(0.079)	(0.035)	(0.057)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.171***	-0.147	-0.208***	-0.020
	(0.037)	(0.098)	(0.042)	(0.059)
Observations	16,601	6,461	5,700	4,440
Kleibergen–Paap Wald test for weak IV	19.79	100.95	3.44	41.06
Panel C: non-offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.018	0.145	0.015	0.009
	(0.031)	(0.090)	(0.060)	(0.043)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.100***	-0.143	0.015	0.150***
	(0.033)	(0.111)	(0.049)	(0.042)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.053**	0.047	0.048*	0.049
	(0.023)	(0.115)	(0.027)	(0.032)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.036	-0.052	-0.074**	0.028
	(0.026)	(0.119)	(0.031)	(0.031)
Observations	89,479	10,396	21,984	57,099
Kleibergen–Paap Wald test for weak IV	38.39	71.44	7.37	10.88

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.

Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

4.2. Robustness check: occupations by skill intensity

As a robustness check for differences between occupational groups, we re-estimate model (2) distinguishing between occupational groups that differ in skill levels rather than between offshorable and non-offshorable occupations. We distinguish between by high-skilled (managers, professionals, technicians – ISCO 1-3), medium-skilled (clerical workers, sales and services workers – ISCO 4-5) and low-skilled (craft and related trades workers, plant and machine operators, elementary occupations – ISCO 7-9) occupations. This classification of occupations follows the standard typology of the International Labour Organisation, and was used by Lewandowski et al. (2022). These occupational groups perform tasks with different routine intensities. On average, workers in high-skilled occupations perform relatively non-routine tasks, workers in middle-skilled occupations moderately routine-intensive tasks, and workers in low-skilled occupations more routine-intensive tasks.

Results for high- and middle-skilled occupations somewhat resemble those for non-offshorable occupations, while results for low-skilled occupations resemble those for offshorable occupations (see Table B2 in Appendix B). Importantly, we observe almost identical patterns in correlations between GVC participation and RTI for specific sectors. It confirms that distinguishing between industries is crucial for studying the relationship between GVC participation and labour market outcomes. Our results suggest that the relationship between GVC participation and RTI differs substantially between the industrial and tradable services sectors. In the industrial sector, higher GVC participation is associated with more routine intensive work in offshorable occupations that usually demand low to medium levels of skills. In tradable services, it is associated with less routine intensive work in non-offshorable occupations, which often require higher skills.

4.3. GVC participation and wages

Next, we study the relationship between GVC participation and workers' wages, using Mincerian wage regressions (model 3) estimated for each of the six subpopulations by broad sector and occupation type (Tables 3 and 4).[15]

Results consistently show a significant negative association between workers' RTI and hourly wages in all occupation types and sectors; that is, more routine intensive tasks pay less.[16] However, the RTI wage penalty differs between sectors: it is the largest in tradable services and the smallest in non-tradable services (Tables 3 and 4). In tradable services, it is also larger for workers in offshorable occupations than for workers in non-offshorable occupations. In the other two sectors, there are no differences between occupational groups (Tables 3 and 4).At the same time, higher GVC participation is associated with lower wages among workers in offshorable occupations and with higher wages among non-offshorable occupations, except for the industry. Again, the IV results tend to be slightly larger in absolute terms than the OLS ones. Specifically, a higher GVC participation is strongly associated with lower wages among workers in offshorable occupations in tradable services (backward GVC, 0.48-1.14 in OLS and 1.20-1.91 $ per hour in IV estimation, Figure 5, and Tables 3 and 4). In contrast, higher GVC participation is associated with higher wages among workers in non-offshorable occupations in tradable services (forward GVC, 0.97- 1.33 in OLS and 1.56-1.93 $ per hour in IV estimation), non-tradable services (backward GVC, 0.64-0.95 in OLS

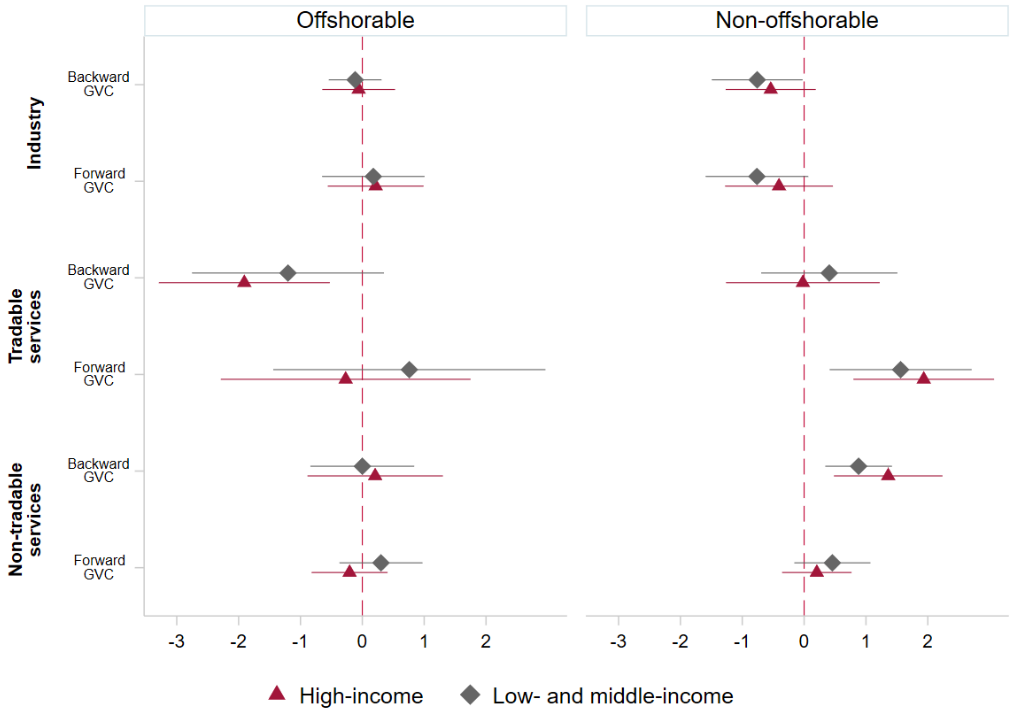
[15] Some individuals do not report wages, so the sample sizes in wage regressions are slightly smaller than sample sizes in RTI regressions (see Tables 1 and 2).

[16] Robust, negative association between worker-level RTI and wages was also identified by Autor and Handel (2013) in the US and de la Rica et al. (2020) in the group of OECD countries.

and 0.88-1.36 $ per hour in IV estimation), and with lower wages in industry (backward, 0.51-0.54 in OLS and 0.54-0.76 $ per hour in IV estimation, Figure 5 and Tables 3 and 4).

Our results are in line with demand-side explanations, for instance, GVC participation reducing the bargaining power of workers whose jobs can easily be offshored, and increasing premium for performing high-value-added tasks in occupations which cannot easily move out of HICs.

Figure 5. The estimated relationship between GVC participation and workers' wages in high-income and low- and middle-income countries, by employment sectors, occupation and participation type, IV estimation



Note: Figure presents the marginal effects of GVC participation based on regressions presented in Table 1, for the average GDP per capita of high-income and low- and middle-income countries. High-income country closest to the average is Italy, and low- middle-income country is Macedonia. For corresponding relationships estimated with OLS see Figure B2 in the Appendix.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table 3. The relationship between RTI, GVC participation, and wages, by sector and occupation type, standardised – OLS

Dependent variable: worker-level wages	Industry		Tradable services		Non-tradable services	
	(1) Offshorable	(2) Non-offshorable	(3) Offshorable	(4) Non-offshorable	(5) Offshorable	(6) Non-offshorable
Routine Task Intensity (RTI, std)	-1.665***	-1.777***	-2.380***	-1.928***	-1.285***	-1.385***
	(0.247)	(0.205)	(0.283)	(0.131)	(0.184)	(0.083)
Backward GVC participation (GVCB) share in exports (std.)	-0.085	-0.518**	-0.910*	0.275	0.224	0.842***
	(0.210)	(0.246)	(0.476)	(0.360)	(0.357)	(0.252)
GVCB share (std.) * [Ln(output) – mean(Ln(output)]	0.021	0.016	-0.349*	-0.061	0.018	0.165*
	(0.082)	(0.120)	(0.201)	(0.140)	(0.120)	(0.098)
Forward GVC participation (GVCF) share in exports (std.)	0.097	-0.473	-0.198	1.205**	0.044	0.306
	(0.296)	(0.347)	(0.735)	(0.485)	(0.278)	(0.232)
GVCF share (std.) * [Ln(output) – mean(Ln(output)]	0.045	0.196**	-0.403*	0.190	-0.248**	-0.118
	(0.052)	(0.087)	(0.222)	(0.121)	(0.097)	(0.073)
Ln(output) –mean(Ln(output))	0.393	0.428	0.816**	-0.062	-0.115	0.391*
	(0.331)	(0.308)	(0.397)	(0.214)	(0.249)	(0.200)
Observations	5,846	9,005	5,055	19,318	3,971	51,183

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. We use sectoral output instead of countries' GDP per capita to control for between-country, between-sector wage differences. However, regressions, including GDP per capita yield similar results. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), skills, education, age, gender, sector FE, and country FE.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table 4. The relationship between RTI, GVC participation, and wages, by sector and occupation type, standardised – IV

Dependent variable: worker-level wages	Industry		Tradable services		Non-tradable services	
	(1) Offshorable	(2) Non-offshorable	(3) Offshorable	(4) Non-offshorable	(5) Offshorable	(6) Non-offshorable
Routine Task Intensity (RTI, std)	-1.666***	-1.779***	-2.391***	-1.924***	-1.279***	-1.385***
	(0.242)	(0.201)	(0.280)	(0.130)	(0.181)	(0.083)
Backward GVC participation (GVCB) share in exports (std.)	-0.079	-0.617*	-1.658**	0.131	0.134	1.190***
	(0.259)	(0.352)	(0.706)	(0.589)	(0.493)	(0.376)
GVCB share (std.) * [Ln(output) – mean(Ln(output)]	0.030	0.116	-0.374	-0.226	0.110	0.253*
	(0.098)	(0.135)	(0.233)	(0.173)	(0.169)	(0.133)
Forward GVC participation (GVCF) share in exports (std.)	0.202	-0.532	0.096	1.802***	-0.026	0.295
	(0.401)	(0.429)	(1.040)	(0.572)	(0.310)	(0.288)
GVCF share (std.) * [Ln(output) – mean(Ln(output)]	0.020	0.188**	-0.545**	0.198*	-0.268***	-0.133*
	(0.062)	(0.092)	(0.248)	(0.119)	(0.103)	(0.081)
Ln(output) –mean(Ln(output))	0.374	0.329	0.764*	-0.103	-0.126	0.463**
	(0.309)	(0.312)	(0.440)	(0.222)	(0.258)	(0.210)
Kleibergen–Paap Wald test for weak IV	7.54	3.04	24.98	10.56	37.70	7.62
Observations	5,846	9,005	5,054	19,314	3,971	51,182

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. We use sectoral output instead of countries' GDP per capita to control for between-country, between-sector wage differences. However, regressions, including GDP per capita yield similar results. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), skills, education, age, gender, sector FE, and country FE.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

4.4. Direct and indirect contribution of GVC participation to wage inequality

Here, we explore the contribution of GVC participation to within-country wage inequality, distinguishing between its direct and indirect contributions through workers' RTI. We use the IV coefficients. Nevertheless, our approach likely provides an upper bound, as we use cross-sectional regression that describes the equilibrium allocation of tasks and wages across workers in different countries. GVC participation may be partly endogenous to comparative advantage in tasks and pre-existing wage-level differences. For this reason, we focus on within-country wage inequality rather than cross-country differences in wage levels. Moreover, only a minor share of cross-country differences in RTI can be attributed to globalisation, as differences in technology use and skill supply play a much larger role (Lewandowski et al., 2022). Note that the decomposition provides suggestive evidence of the economic significance of the estimated effects as it only provides point estimates.

We find that the direct contribution of GVC participation to wage inequality is negative in most countries, with a clear U-shaped relationship between GDP per capita and this contribution (Figure 6a). In other words, higher GVC participation is directly linked to reduced wage inequality within countries, to the largest extent in upper-middle-income and bottom-high-income countries. Notable exceptions include the US and small countries intensively integrated into GVC, such as Norway (high forward GVC participation), and developing economies with high GVC participation only in selected sectors (e.g., Ghana). The wage regressions suggest that the direct contribution reflects the positive role of backward GVCs for workers' wages in non-offshorable occupations in industry and non-tradable services sectors (Table 4). Furthermore, GVC participation tends to be negatively correlated with workers' wages in offshorable jobs, especially in tradable services (Figure 5). Importantly, in most countries, the majority of workers in offshorable jobs earn above the country-specific median (see Figure B5 in Appendix B). Therefore, a negative relationship between GVC participation and wages in offshorable jobs compresses wage distribution.

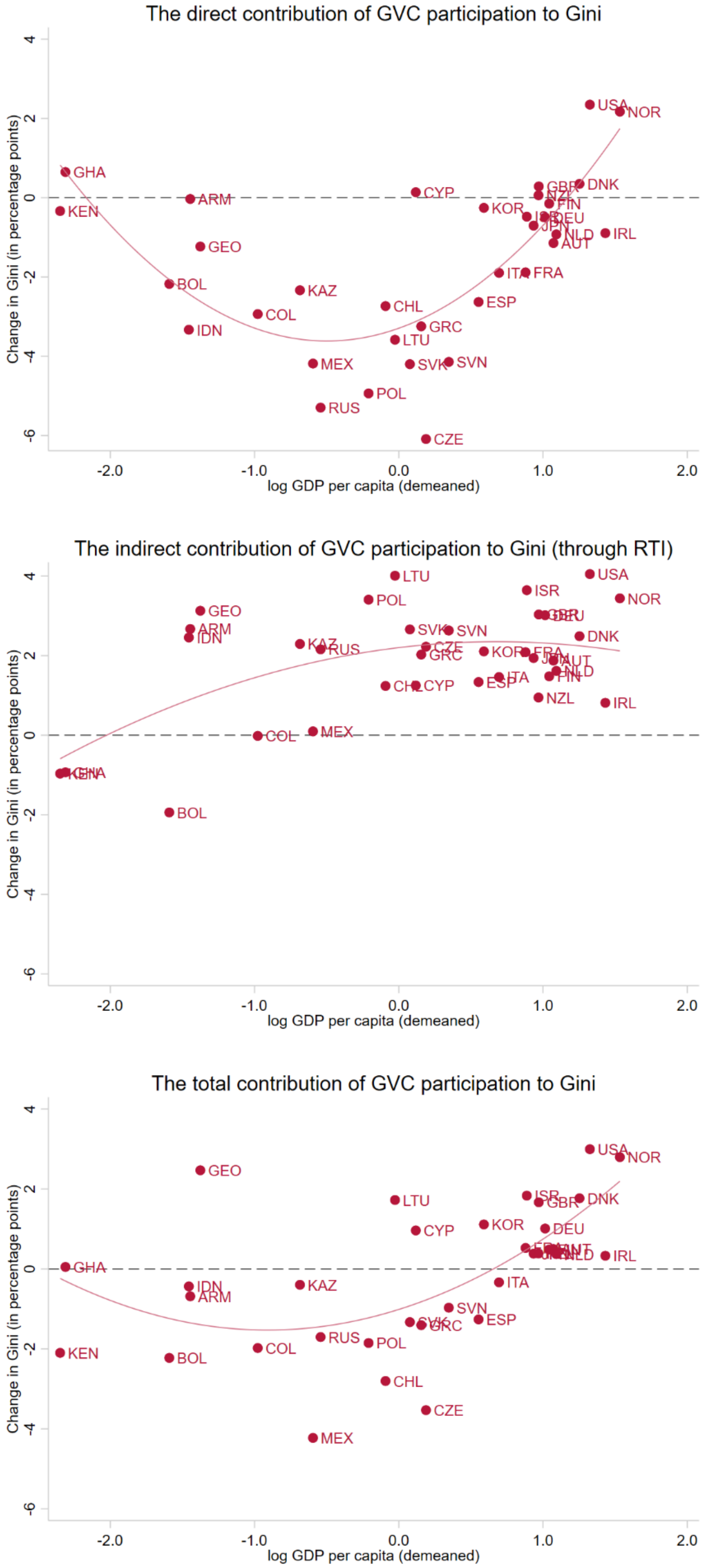
In sharp contrast, the indirect contribution of GVC participation to wages through its link with workers' RTI generally widens wage inequality (Figure 6b). Contrasting associations between GVC participation and RTI among different groups of workers drive this pattern. The relationship between workers' RTI and individual wages is negative in all sectors and occupation types (Table 4). Higher GVC integration is associated with larger RTI gaps between workers in offshorable and non-offshorable occupations (Figure 4), indirectly widening the within-country wage inequality. In most countries, the indirect contribution is smaller in absolute terms than the direct contribution.

Finally, we assess the total (net) contribution of GVC participation to wage inequality within countries (Figure 6c).[17] We find that GVC participation links with higher wage inequality in the high-income countries, in most cases driven by the indirect contribution of GVCs through workers' RTI. At the same time, GVC participation is associated with reduced wage inequality in most low- and middle-income countries (e.g., Latin American countries in the sample), as well as the bottom high-income countries (Central Eastern and Southern Europe), where the direct reduction in wage inequality is stronger than the indirect contribution.

[17] The Gini coefficient is a non-linear measure, so the sum of Gini coefficients calculated with separate shocks (direct and indirect contribution) may not equal the Gini coefficient calculated with the same two shocks jointly (total contribution). The residual, however, is small compared to the total contribution (see Figure B4 in Appendix B). Moreover, after controlling for industry fixed effects, we find no relationship between GVC participation and the share of workers performing offshorable jobs at the sector level (Table B3 in the Appendix B). Thus, we do not consider the structural effect in the decomposition of GVC contribution to Gini (Figure 6).

Figure 6. The contribution of GVC participation to within-country wage inequality- IV estimation

a) b) c)



Note: For OLS estimates see Figure B3 in Appendix B.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Our results suggest that in countries that mostly receive offshored jobs, GVC participation contributes negatively to wage inequality despite expanding the gap in the RTI of work between offshorable and non-offshorable occupations. However, in rich countries that mostly offshore jobs, GVC participation tends to widen wage inequality as it benefits mainly workers in non-offshorable occupations.[18]

5. Conclusions and policy implications

In this paper, we investigated the relationship between GVC participation and the RTI of workers and its contribution to within-country wage inequality. We used a dataset combining worker-level, country-specific RTI measures based on a pooled sample of survey data for 34 countries at all development levels, applying the methodology of Lewandowski et al. (2022), with measures of backward and forward GVC participation at the country-sector level based on the method of Borin and Mancini (2019, 2015). We showed that GVC participation contributes to wage inequality within countries directly and indirectly through its relationship with workers' RTI. However, the relationship between GVC participation and the RTI of workers is complex and depends on the nature of GVCs, occupations, and sectors. It also differs between countries at different development levels.

We studied the contribution of GVC participation to within-country wage inequality – directly through GVCs' associations with wages and indirectly through its relationship with the workers' RTI. GVC participation is associated with larger wage inequality in HICs but with reduced wage inequality in most LMICs. Its indirect contribution to wage inequality – widening the gap between the RTI of workers in offshorable and non-offshorable occupations– is a crucial disequalising mechanism. It reflects different patterns between GVC participation and workers' RTI across occupation types, sectors, and countries. In countries and sectors with higher GVC participation, workers in offshorable occupations perform more routine-intensive work, particularly in low- and middle-income countries. This relationship is the strongest in tradable sectors, namely industry and tradable services, in line with theories of trading tasks between more and less developed countries (Grossman and Rossi-Hansberg, 2008). At the same time, GVC participation is barely related to RTI of workers in non-offshorable occupations. Since higher RTI is associated with lower wages, GVC participation indirectly widens wage inequality. However, in most countries in our sample, the direct relationship between GVC and wages works in the opposite direction, as GVC participation is associated with lower wages in tradable occupations in services, a high-paying sector. In most countries, the direct contribution to wage inequality dominates over the indirect one, so GVC participation is associated with lower wage inequality. However, in the most advanced HICs, GVC participation is disequalising, as it benefits workers in non-offshorable occupations in tradable services, so the direct contribution amplifies the indirect contribution.

Understanding the differences in the RTI of workers across the development spectrum and its relationship with fundamental factors – technology adoption, skill supply, and globalisation – has important policy implications. The transition from routine to non-routine work has been a key dimension of structural change in labour markets, increasing worker productivity and earnings. Jobs with a higher non-routine content involve higher levels of

[18] To test the robustness of our results, we have estimated a seemingly unrelated regression (SUR) system (Tables B4 and B5 in Appendix B). We find that separate estimation is correct. First, we find no correlation between the residuals from RTI and wage models, suggesting they are unrelated. Error terms have fairly symmetric distributions required for the estimator to be unbiased in small samples. Second, the point estimates are in line with those obtained from separate estimations.

technology, require higher skill levels, and offer higher earnings between and within occupations (Autor and Handel, 2013; de la Rica et al., 2020). Diverging effects of globalisation on the RTI of different types of workers can thus contribute to wage inequality within countries. So far, LMICs have not been catching up with HICs in terms of routine task intensity and providing non-routine work in the global division of labour, and they have not experienced labour market polarization to a comparable extent (Gradin et al., 2023).

We also find that the positive relationship between GVC participation and workers' RTI is much stronger in LMICs than in HICs, widening the RTI gap between these country groups. At the same time, cross-country differences in RTI, especially between high- versus low- and middle-income countries, are larger than implied by mere cross-country differences in skills supply, as they can be mainly attributed to differences in technology use (Lewandowski et al., 2022). Investments in education and skills in developing and emerging economies are frequently cited as necessary conditions to foster shared prosperity (World Bank, 2019). They are also often highlighted to counter the adverse labour market effects of increased technology adoption in developing countries. The mediating role of worker skills becomes even more urgent amidst rapid advances in artificial intelligence, such as recent developments of Chat-GPT and GPT-4. While they are most likely required to achieve these goals, they are unlikely to be sufficient, given that differences in job task content are largely related to differences in technology use and participation in GVCs. Policies to increase technology use and approaches to facilitate upgrading in GVC should complement investments in skills, especially since technological change within GVCs tends to increase the relative demand for non-routine work (Reijnders and de Vries, 2018).

Our study has limitations. First, it does not claim to have determined a causal effect. Since the survey data were collected only once per country, only cross-sectional analysis is possible. The analysis therefore cannot capture wage changes over time or cases where GVC participation created new labour market segments that did not exist before. In the future, the second round of PIAAC data collection will allow running a quasi-panel study to study the relationship between changes in GVC participation, technology use, and the supply of skills, with the RTI of particular occupations in various countries. Second, the survey data do not distinguish between domestic and foreign-owned firms, so it is unclear if FDI correlates with RTI differences within sectors. Lewandowski et al. (2022) showed that FDI is not a significant factor behind RTI differences between sectors, but there may be a relationship within sectors. Third, adult skill surveys have greatly improved our understanding of skills supply and the quality of education worldwide. It is possible, though, that literacy or numeracy measures are insufficient to fully understand factors behind differences in the nature of work, task content of jobs, and productivity. Differences in managerial and interpersonal skills may also contribute to differences in organising and performing work. These skills are unfortunately not measured in the same survey data that capture worker tasks. Finally, the estimated contribution of technology adoption to worker-level RTI may likely increase in the future. Advances in artificial intelligence may more strongly affect business services tasks, the extent of offshoring, and thus the relationship between GVC participation and RTI.

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Appendix A – Methodological details

a. Measurements and classifications

Table A1. EORA and wide sectors aggregation, ISIC rev. 4/ NACE rev. 2

Nace rev.2/ ISIC 4	EORA sectors	Nace rev.1	Title	Wide sector
10	4	C	Manufacture of food products	Industry
11	4	C	Manufacture of beverages	Industry
12	4	C	Manufacture of tobacco products	Industry
13	5	C	Manufacture of textiles	Industry
14	5	C	Manufacture of wearing apparel	Industry
15	5	C	Manufacture of leather and related products	Industry
16	6	C	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Industry
17	6	C	Manufacture of paper and paper products	Industry
18	6	C	Printing and reproduction of recorded media	Industry
19	7	C	Manufacture of coke and refined petroleum products	Industry
20	7	C	Manufacture of chemicals and chemical products	Industry
21	7	C	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Industry
22	7	C	Manufacture of rubber and plastic products	Industry
23	7	C	Manufacture of other non-metallic mineral products	Industry
24	8	C	Manufacture of basic metals	Industry
25	8	C	Manufacture of fabricated metal products, except machinery and equipment	Industry
26	9	C	Manufacture of computer, electronic and optical products	Industry
27	9	C	Manufacture of electrical equipment	Industry
28	9	C	Manufacture of machinery and equipment n.e.c.	Industry
29	10	C	Manufacture of motor vehicles, trailers and semi-trailers	Industry
30	10	C	Manufacture of other transport equipment	Industry
31	11	C	Manufacture of furniture	Industry
32	11	C	Other manufacturing	Industry
33	9	C	Repair and installation of machinery and equipment	Industry
35	13	D	Electricity, gas, steam and air conditioning supply	non-tradable
36	13	E	Water collection, treatment and supply	non-tradable
37	23	E	Sewerage	non-tradable
38	12	E	Waste collection, treatment and disposal activities; materials recovery	non-tradable
39	12	E	Remediation activities and other waste management services	non-tradable
41	14	F	Construction of buildings	non-tradable
42	14	F	Civil engineering	non-tradable
43	14	F	Civil engineering	non-tradable
45	15	G	Wholesale and retail trade and repair of motor vehicles and motorcycles	non-tradable
46	16	G	Wholesale of mining, construction and civil engineering machinery	tradable
47	17	G	Retail trade, except of motor vehicles and motorcycles	non-tradable
49	19	H	Land transport and transport via pipelines	tradable
50	19	H	Water transport	tradable
51	19	H	Air transport	tradable
52	19	H	Warehousing and support activities for transportation	tradable
53	20	H	Postal and courier activities	tradable

55	18	I	Accommodation	tradable
56	18	I	Food and beverage service activities	tradable
58	6	J	Publishing activities	tradable
59	21	J	Motion picture, video and television programme production, sound recording and music publishing activities	tradable
60	21	J	Programming and broadcasting activities	tradable
61	20	J	Telecommunications	tradable
62	21	J	Computer programming, consultancy and related activities	tradable
63	21	J	Information service activities	tradable
64	21	K	Financial service activities, except insurance and pension funding	tradable
65	21	K	Insurance, reinsurance and pension funding, except compulsory social security	tradable
66	21	K	Activities auxiliary to financial services and insurance activities	tradable
68	21	L	Real estate activities	non-tradable
69	21	M	Legal and accounting activities	tradable
70	21	M	Activities of head offices; management consultancy activities	tradable
71	21	M	Architectural and engineering activities; technical testing and analysis	tradable
72	21	M	Scientific research and development	tradable
73	21	M	Advertising and market research	tradable
74	21	M	Other professional, scientific and technical activities	tradable
75	21	M	Veterinary activities	non-tradable
77	21	N	Rental and leasing activities	non-tradable
78	21	N	Employment activities	non-tradable
79	21	N	Travel agency, tour operator reservation service and related activities	non-tradable
80	21	N	Security and investigation activities	non-tradable
81	21	N	Services to buildings and landscape activities	non-tradable
82	21	N	Office administrative, office support and other business support activities	tradable
84	22	O	Public administration and defence; compulsory social security	non-tradable
85	23	P	Education	non-tradable
86	23	Q	Human health activities	non-tradable
87	23	Q	Residential care activities	non-tradable
88	23	Q	Social work activities without accommodation	non-tradable
90	23	R	Creative, arts and entertainment activities	non-tradable
91	23	R	Libraries, archives, museums and other cultural activities	non-tradable
92	23	R	Gambling and betting activities	non-tradable
93	23	R	Sports activities and amusement and recreation activities	non-tradable
94	23	S	Activities of membership organisations	non-tradable
95	23	S	Repair of computers and personal and household goods	non-tradable
96	23	S	Other personal service activities	non-tradable

Source: Authors' elaboration based on Nayyar et al. (2021).

Table A2. EORA sectors list.

EORA sectors	Title
4	Food & Beverages
5	Textiles and Wearing Apparel
6	Wood and Paper
7	Petroleum, Chemical and Non-Metallic Mineral Products
8	Metal Products
9	Electrical and Machinery
10	Transport Equipment
11	Other Manufacturing
12	Recycling
13	Electricity, Gas and Water
14	Construction
15	Maintenance and Repair
16	Wholesale Trade
17	Retail Trade
18	Hotels and Restaurants
19	Transport
20	Post and Telecommunications
21	Financial Intermediation and Business Activities
22	Public Administration
23	Education, Health and Other Services

Source: Authors' elaboration based on Lenzen et al. (2013, 2012).

Table A3. Offshorability and task groups allocation by occupations (ISCO08 2-digit)

ISCO 08 code	Offshorability	Task group	Title
11	not offshorable	NRCP	Chief Executives, Senior Officials and Legislators
12	not offshorable	NRCP	Administrative and Commercial Managers
13	not offshorable	NRCP	Production and Specialized Services Managers
14	not offshorable	NRCP	Hospitality, Retail and Other Services Managers
21	not offshorable	NRCA	Science and Engineering Professionals
22	not offshorable	NRCA	Health Professionals
23	not offshorable	NRCP	Teaching Professionals
24	not offshorable	NRCA	Business and Administration Professionals
25	offshorable	NRCA	Information and Communications Technology Professionals
26	not offshorable	NRCA	Legal, Social and Cultural Professionals
31	not offshorable	NRCA	Science and Engineering Associate Professionals
32	not offshorable	NRCP	Health Associate Professionals
33	not offshorable	RC	Business and Administration Associate Professionals
34	not offshorable	RC	Legal, Social, Cultural and Related Associate Professionals
35	not offshorable	NRCA	Information and Communications Technicians
41	offshorable	RC	General and Keyboard Clerks
42	not offshorable	RC	Customer Services Clerks
43	offshorable	RC	Numerical and Material Recording Clerks
44	not offshorable	RC	Other Clerical Support Workers
51	not offshorable	NRM	Personal Services Workers
52	not offshorable	RC	Sales Workers
53	not offshorable	NRM	Personal Care Workers
54	not offshorable	NRM	Protective Services Workers
61	not offshorable	NRM	Market-oriented Skilled Agricultural Workers
62	not offshorable	NRM	Market-oriented Skilled Forestry, Fishery and Hunting Workers
63	not offshorable	NRM	Subsistence Farmers, Fishers, Hunters and Gatherers
71	not offshorable	NRM	Building and Related Trades Workers (excluding Electricians)
72	not offshorable	RM	Metal, Machinery and Related Trades Workers
73	offshorable	RM	Handicraft and Printing Workers
74	not offshorable	NRM	Electrical and Electronic Trades Workers
75	not offshorable	RM	Food Processing, Woodworking, Garment and Other Craft and Related Trades Workers
81	offshorable	RM	Stationary Plant and Machine Operators
82	offshorable	RM	Assemblers
83	not offshorable	NRM	Drivers and Mobile Plant Operators
91	not offshorable	NRM	Cleaners and Helpers
92	not offshorable	NRM	Agricultural, Forestry and Fishery Labourers
93	not offshorable	NRM	Labourers in Mining, Construction, Manufacturing and Transport
94	not offshorable	RM	Food Preparation Assistants
95	not offshorable	NRM	Street and Related Sales and Services Workers
96	not offshorable	NRM	Refuse Workers and Other Elementary Workers

Note: NRCA- Non-Routine Cognitive Analytical, NRCP- Non-Routine Cognitive Personal, RC- Routine Cognitive, RM- Routine Manual, NRM- Non-Routine Manual.
Source: own elaboration based on Acemoglu and Autor (2011) and Blinder and Krueger (2013).

Table A4. List of countries used in the study

Country name	Country ISO3	Source	Survey year	Development level
Armenia	ARM	STEP	2013	lower-middle income
Austria	AUT	PIAAC	2012	high income
Bolivia	BOL	STEP	2012	lower-middle income
Chile	CHL	PIAAC	2015	high income
Colombia	COL	STEP	2012	upper-middle income
Cyprus	CYP	PIAAC	2012	high income
Czech Republic	CZE	PIAAC	2012	high income
Denmark	DNK	PIAAC	2012	high income
Finland	FIN	PIAAC	2012	high income
France	FRA	PIAAC	2012	high income
Georgia	GEO	STEP	2013	lower-middle income
Germany	DEU	PIAAC	2012	high income
Ghana	GHA	STEP	2013	lower-middle income
Greece	GRC	PIAAC	2015	high income
Indonesia	IDN	PIAAC	2015	lower-middle income
Ireland	IRL	PIAAC	2012	high income
Israel	ISR	PIAAC	2015	high income
Italy	ITA	PIAAC	2012	high income
Japan	JPN	PIAAC	2012	high income
Kazakhstan	KAZ	PIAAC	2017	upper-middle income
Kenya	KEN	STEP	2013	low income
Korea, Rep.	KOR	PIAAC	2012	high income
Lithuania	LTU	PIAAC	2015	high income
Mexico	MEX	PIAAC	2017	upper-middle income
Netherlands	NLD	PIAAC	2012	high income
New Zealand	NZL	PIAAC	2015	high income
Norway	NOR	PIAAC	2012	high income
Poland	POL	PIAAC	2012	high income
Russian Federation	RUS	PIAAC	2012	upper-middle income
Slovak Republic	SVK	PIAAC	2012	high income
Slovenia	SVN	PIAAC	2015	high income
Spain	ESP	PIAAC	2012	high income
United Kingdom	GBR	PIAAC	2012	high income
United States	USA	PIAAC	2012	high income

Source: own elaboration.

b. Wage inequality analysis

Baseline scenario

In a first step, we divide the full sample into six groups by broad sector (industry, business, and other services) and type of occupation (offshorable and non-offshorable) and for each group estimate Mincerian wage regressions of the following form:[19]

$$w_{ijsc} = \beta_0 + \beta_1 RTI_{ijsc} + \beta_2 GVC_{sc}^B + \beta_3 GVC_{sc}^F + \beta_4 GVC_{sc}^B * OUT_{sc} + \beta_5 GVC_{sc}^F * OUT_{sc} + \beta_6 Z_{sc} + \beta_7 X_{ijsc} + \lambda_s + \rho_c + \epsilon_{ijsc} \tag{1}$$

where w_{ijsc} stands for hourly wages of individual i, in occupation j, in sector s, and in country c; GVC_{sc}^B is backward and GVC_{sc}^B forward GVC participation in sector s and in country c; OUT_{sc} is output in sector s and in country c; Z_{sc} measures technology in sector s and in country c; X_{ijsc} are individual skills of worker i, in occupation j, in sector s and in country c; λ_s and ρ_c are, respectively, sector and country fixed effects.

Based on the estimated coefficients from equation (1) and actual values for each right-hand side variables, we can predict wages ($\widehat{w}_{ijsc}^{base}$) for each individual in the six group. Formally:

$$\widehat{w}_{ijsc}^{base} = \beta_0 + \beta_1 RTI_{ijsc} + \beta_2 GVC_{sc}^B + \beta_3 GVC_{sc}^F + \beta_4 GVC_{sc}^B * OUT_{sc} + \beta_5 GVC_{sc}^F * OUT_{sc} + \beta_6 Z_{sc} + \beta_7 X_{ijsc} + \lambda_s + \rho_c \tag{2}$$

For each country, we then calculate the Gini coefficient (ρ_c^{base}) of predicted wages:

$$\rho_c^{base} = gini(\widehat{w}_{ijsc}^{base}) \tag{3}$$

This is our baseline scenario.

Scenario of no GVC participation

In the second step, we assess the direct contribution of GVC participation to wage inequality (E^{direct}). This is based on the estimated models from equation (1), but based on predicted wages conditional on GVC participation values equal to zero ($\widehat{w}_{ijsc}^{direct}$). Formally:

$$\widehat{w}_{ijsc}^{direct} = \beta_0 + \beta_1 RTI_{ijsc} + \beta_2 * 0 + \beta_3 * 0 + \beta_4 * 0 * OUT_{sc} + \beta_5 * 0 * OUT_{sc} + \beta_6 Z_{sc} + \beta_7 X_{ijsc} + \lambda_s + \rho_c \tag{4}$$

For each country, we then calculate the Gini coefficient (ρ_c^{direct}) under the assumption of no integration into GVCs:

$$\rho_c^{direct} = gini(\widehat{w}_{ijsc}^{direct}) \tag{5}$$

We describe the direct contribution of GVC participation to wage inequality (E^{direct}) as the difference between the Gini coefficients of wages calculated in the baseline scenario and in the scenario of no GVC participation:

[19] This model is equivalent to equation (3) in the main body of the paper. However, for simplicity reasons the expression $GVC_{sc}^B + GVC_{sc}^F + GVC_{sc}^B * OUT_{sc} + GVC_{sc}^F * OUT_{sc}$ is noted as G_{sc}.

$$E^{direct} = \rho_c^{base} - \rho_c^{direct} \tag{6}$$

Counterfactual RTI scenario

In a third step, we analyse how GVC participation indirectly contributes to wage inequality through its relationship with workers' RTI ($E^{indirect}$). Specifically, we estimate the model of workers' RTI and then calculate counterfactual worker-level RTI, assuming GVC participation values equal to zero ($\widehat{RTI}_{ijsc}^{indirect}$).[20] Formally:

$$RTI_{ijsc} = \beta_0 + \beta_1 GVC_{sc}^B + \beta_2 GVC_{sc}^F + \beta_3 GVC_{sc}^B * GDP_c^{PC} + \beta_4 GVC_{sc}^F * GDP_c^{PC} + \beta_5 Z_{sc} + \beta_6 X_{ijsc} + \lambda_s + \epsilon_{ijsc} \tag{7}$$

$$\widehat{RTI}_{ijsc}^{indirect} = \beta_0 + \beta_1 * 0 + \beta_2 * 0 + \beta_3 * 0 * GDP_c^{PC} + \beta_4 * 0 * GDP_c^{PC} + \beta_5 Z_{sc} + \beta_6 X_{ijsc} + \lambda_s + \epsilon_{ijsc} \tag{8}$$

We then use the estimated models from equation (1) to predict wages $\widehat{w}_{ijsc}^{indirect}$ conditional on $\widehat{RTI}_{ijsc}^{indirect}$. To isolate the indirect contribution of GVC participation to wage inequality through RTI, we use the observed values of GVC participation in the wage model:

$$\widehat{w}_{ijsc}^{indirect} = \beta_0 + \beta_1 \widehat{RTI}_{ijsc}^{indirect} + \beta_2 GVC_{sc}^B + \beta_3 GVC_{sc}^F + \beta_4 GVC_{sc}^B * OUT_{sc} + \beta_5 GVC_{sc}^F * OUT_{sc} + \beta_6 Z_{sc} + \beta_7 X_{ijsc} + \lambda_s + \rho_c \tag{9}$$

We describe the indirect contribution of GVCs participation to wage inequality ($E^{indirect}$) as the difference between the Gini coefficients of wages calculated in the baseline scenario (ρ_c^{base}) and the Gini coefficients of wages in the counterfactual RTI scenario ($\rho_c^{indirect}$).

$$\rho_c^{indirect} = gini(\widehat{w}_{ijsc}^{indirect}) \tag{10}$$

$$E^{indirect} = \rho_c^{base} - \rho_c^{indirect} \tag{11}$$

Total contribution of GVC participation

In a fourth step, we calculate the total contribution of GVC participation to wage inequality (E^{total}). We set the GVC participation values to zero (as in the calculation of the direct contribution), and we use the counterfactual RTI conditional on zero GVC participation ($\widehat{RTI}_{ijsc}^{indirect}$, as in the calculation of the indirect contribution) to predict wages using the estimated coefficients in the models from equation (1).

$$\widehat{w}_{ijsc}^{total} = \beta_0 + \beta_1 \widehat{RTI}_{ijsc}^{indirect} + \beta_2 * 0 + \beta_3 * 0 + \beta_4 * 0 * OUT_{sc} + \beta_5 * 0 * OUT_{sc} + \beta_6 Z_{sc} + \beta_7 X_{ijsc} + \lambda_s + \rho_c \tag{12}$$

We define the total contribution of GVC participation to wage inequality (E^{total}) as the difference between the Gini coefficient of wages in the baseline scenario (ρ_c^{base}) and the Gini coefficient of wages in this last scenario (ρ_c^{total}).

$$\rho_c^{total} = gini(\widehat{w}_{ijsc}^{total}) \tag{13}$$

$$E^{total} = \rho_c^{base} - \rho_c^{total} \tag{14}$$

[20] Equation (7) is equivalent to equation (2) in the main body of the paper.

Appendix B – Additional results

Table B1. The Correlates of Routine Task Intensity (RTI) at the Worker Level, in the pooled sample, and by broad sectors, standardised (backward and forward GVC)

Panel A: Pooled	(1) Total economy	(2) Industry	(3) Tradable services	(4) Non-tradable services	(5) Total economy	(6) Industry	(7) Tradable services	(8) Non-tradable services
Backward Global Value Chain participation (GVCB) share in exports (std.)	-0.002	0.014	-0.005	-0.001				
	(0.017)	(0.021)	(0.026)	(0.020)				
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.037*	-0.020	0.026	0.065***				
	(0.021)	(0.033)	(0.029)	(0.021)				
Forward Global Value Chain participation (GVCF) share in exports (std.)					0.006	0.025	0.034*	-0.020
					(0.013)	(0.019)	(0.019)	(0.032)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]					-0.047***	-0.035*	-0.077***	-0.001
					(0.014)	(0.019)	(0.019)	(0.031)
Ln(GDP per capita) –mean(Ln(GDP per capita))	1.613***	1.154**	-0.064	-0.235***	1.558***	1.175**	0.090	-0.244***
	(0.174)	(0.481)	(0.067)	(0.064)	(0.170)	(0.463)	(0.070)	(0.065)
Observations	105,917	16,445	27,756	61,716	105,877	16,445	27,756	61,676
Panel B: offshorable occupations								
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.045**	0.049**	-0.007	0.029				
	(0.020)	(0.024)	(0.039)	(0.024)				
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.028	-0.040	-0.010	0.006				
	(0.024)	(0.037)	(0.042)	(0.029)				
Forward Global Value Chain participation (GVCF) share in exports (std.)					0.063***	0.061***	0.038	0.069*
					(0.015)	(0.017)	(0.031)	(0.041)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]					-0.064***	-0.043***	-0.108***	0.005
					(0.017)	(0.016)	(0.034)	(0.044)
Ln(GDP per capita) –mean(Ln(GDP per capita))	0.010	-0.184	-0.034	-0.139	0.010	-0.113	0.154	-0.141
	(0.087)	(0.172)	(0.103)	(0.089)	(0.074)	(0.152)	(0.113)	(0.091)
Observations	16,624	6,428	5,735	4,461	16,616	6,428	5,735	4,453
Panel C: non-offshorable occupations								

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Backward Global Value Chain participation (GVCB) share in exports (std.)	-0.013	-0.015	-0.003	-0.001				
	(0.016)	(0.022)	(0.028)	(0.021)				
GVCB share (std.) * [Ln(GDP pc) −mean(Ln(GDP pc)]	0.046**	-0.010	0.034	0.071***				
	(0.020)	(0.035)	(0.031)	(0.021)				
Forward Global Value Chain participation (GVCF) share in exports (std.)					-0.009	-0.006	0.035*	-0.030
					(0.015)	(0.026)	(0.021)	(0.034)
GVCF share (std.) * [Ln(GDP pc) −mean(Ln(GDP pc)]					-0.044***	-0.033	-0.071***	0.001
					(0.015)	(0.026)	(0.019)	(0.032)
Ln(GDP per capita) −mean(Ln(GDP per capita))	1.568***	0.791	-0.053	-0.271***	1.487***	0.909*	0.090	-0.280***
	(0.177)	(0.555)	(0.071)	(0.079)	(0.173)	(0.539)	(0.076)	(0.078)
Observations	89,293	10,017	22,021	57,255	89,261	10,017	22,021	57,223

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for Computer Use, GVCB share and FDI/GDP are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.

Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table B2. Pooled regression of backward and forward and by wide sectors and occupational groups, standardised (backward and forward GVC)

Panel A: All workers	(1) Total economy	(2) Industry	(3) Tradable services	(4) Non-tradable services
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.004	0.015	0.012	0.032
	(0.017)	(0.020)	(0.028)	(0.026)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.034	-0.025	-0.025	0.103***
	(0.023)	(0.031)	(0.033)	(0.025)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.005	0.026	0.037*	-0.026
	(0.012)	(0.020)	(0.020)	(0.028)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.042***	-0.037**	-0.084***	0.014
	(0.013)	(0.019)	(0.022)	(0.026)
Ln(GDP per capita) –mean(Ln(GDP per capita))	1.655***	1.219***	0.108	-0.243***
	(0.181)	(0.472)	(0.078)	(0.066)
Observations	105,877	16,445	27,756	61,676
Panel B: High-skilled occupations (ISCO 1-3)				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.007	-0.028	0.061**	0.035
	(0.018)	(0.020)	(0.030)	(0.031)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.025	0.049	-0.125***	-0.005
	(0.022)	(0.035)	(0.036)	(0.041)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.009	0.008	0.024	0.001
	(0.012)	(0.026)	(0.023)	(0.025)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.050***	0.024	-0.134***	-0.009
	(0.015)	(0.028)	(0.024)	(0.028)
Ln(GDP per capita) –mean(Ln(GDP per capita))	-0.027	-0.168	0.181**	-0.201***
	(0.060)	(0.103)	(0.091)	(0.078)
Observations	44,115	4,835	12,537	26,743
Panel C: Middle-skilled occupations (ISCO 4-5)				
Backward Global Value Chain participation (GVCB) share in exports (std.)	-0.043**	0.005	-0.081**	-0.009
	(0.018)	(0.036)	(0.033)	(0.033)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.077***	-0.053	0.004	0.129***
	(0.025)	(0.038)	(0.036)	(0.031)
Forward Global Value Chain participation (GVCF) share in exports (std.)	-0.027	-0.046	0.031	-0.072*
	(0.018)	(0.040)	(0.028)	(0.038)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.012	-0.003	-0.065**	0.046
	(0.015)	(0.039)	(0.027)	(0.029)
Ln(GDP per capita) –mean(Ln(GDP per capita))	-0.046	-0.037	0.075	-0.249*
	(0.061)	(0.159)	(0.092)	(0.141)
Observations	33,430	1,985	9,378	22,067
Panel D: Low-skilled occupations (ISCO 7-9)				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.050**	0.044**	0.061*	0.089*
	(0.022)	(0.021)	(0.034)	(0.047)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.020	-0.035	0.056	0.094**
	(0.030)	(0.035)	(0.049)	(0.039)

Forward Global Value Chain participation (GVCF) share in exports (std.)	0.059***	0.054**	0.133***	-0.011
	(0.015)	(0.021)	(0.039)	(0.032)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.040**	-0.063***	0.030	-0.003
	(0.016)	(0.023)	(0.038)	(0.033)
Ln(GDP per capita) –mean(Ln(GDP per capita))	2.509***	2.243***	0.011	-0.186**
	(0.196)	(0.400)	(0.144)	(0.080)
Observations	28,332	9,625	5,841	12,866

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.

Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table B3. The relationship between the share of workers performing offshorable occupations and GVC participation by sectors

Dependent variable: share of workers performing offshorable occupations	(1)	(2)
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.090***	-0.005
	(0.009)	(0.008)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.004	-0.011*
	(0.010)	(0.007)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.031***	-0.004
	(0.008)	(0.008)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.012	-0.003
	(0.008)	(0.005)
Ln(GDP per capita) –mean(Ln(GDP per capita))	-0.037***	-0.025**
	(0.012)	(0.010)
Computer use	0.020	0.036***
	(0.013)	(0.013)
Computer use^2	-0.026***	-0.023***
	(0.010)	(0.008)
Tertiary educated	0.110**	-0.060
	(0.050)	(0.043)
Primary educated	0.024	-0.022
	(0.073)	(0.057)
Literacy skills level: 1 or lower	0.023	-0.061
	(0.104)	(0.092)
Literacy skills level: 3	-0.118	-0.070
	(0.103)	(0.092)
Literacy skills level: 4 and 5	0.134	-0.091
	(0.134)	(0.094)
Sector FE	No	Yes
Observations	759	759

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.

Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Table B4. The relationship between GVC participation and RTI, total and by occupation type, standardized – Seemingly Unrelated Regressions estimation

Dependent variable: worker level RTI Panel A: all workers	(1) Total economy	(2) Industry	(3) Tradable services	(4) Non-tradable services
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.006	0.018	0.018	0.030
	(0.018)	(0.020)	(0.030)	(0.027)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.036	-0.026	-0.019	0.103***
	(0.024)	(0.032)	(0.035)	(0.024)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.009	0.024	0.049**	-0.025
	(0.012)	(0.020)	(0.020)	(0.029)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.042***	-0.034*	-0.083***	0.018
	(0.013)	(0.019)	(0.022)	(0.026)
Observations	94,378	14,851	24,373	55,154
Panel B: offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	0.063***	0.064***	0.011	0.112***
	(0.019)	(0.021)	(0.041)	(0.035)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.037	-0.057*	-0.038	0.076*
	(0.025)	(0.033)	(0.043)	(0.046)
Forward Global Value Chain participation (GVCF) share in exports (std.)	0.081***	0.076***	0.054*	0.089**
	(0.015)	(0.018)	(0.030)	(0.042)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.073***	-0.046**	-0.122***	-0.014
	(0.018)	(0.018)	(0.034)	(0.044)
Observations	14,872	5,846	5,055	3,971
Panel C: non-offshorable occupations				
Backward Global Value Chain participation (GVCB) share in exports (std.)	-0.007	-0.014	0.023	0.023
	(0.019)	(0.021)	(0.034)	(0.028)
GVCB share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	0.047**	-0.012	-0.011	0.105***
	(0.023)	(0.035)	(0.040)	(0.025)
Forward Global Value Chain participation (GVCF) share in exports (std.)	-0.009	-0.013	0.050**	-0.037
	(0.014)	(0.026)	(0.022)	(0.030)
GVCF share (std.) * [Ln(GDP pc) –mean(Ln(GDP pc)]	-0.035***	-0.032	-0.074***	0.024
	(0.013)	(0.025)	(0.024)	(0.027)
Observations	79,506	9,005	19,318	51,183

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), FDI, skills, education, age, gender, sector FE, and sector FE interacted with GDP per capita.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

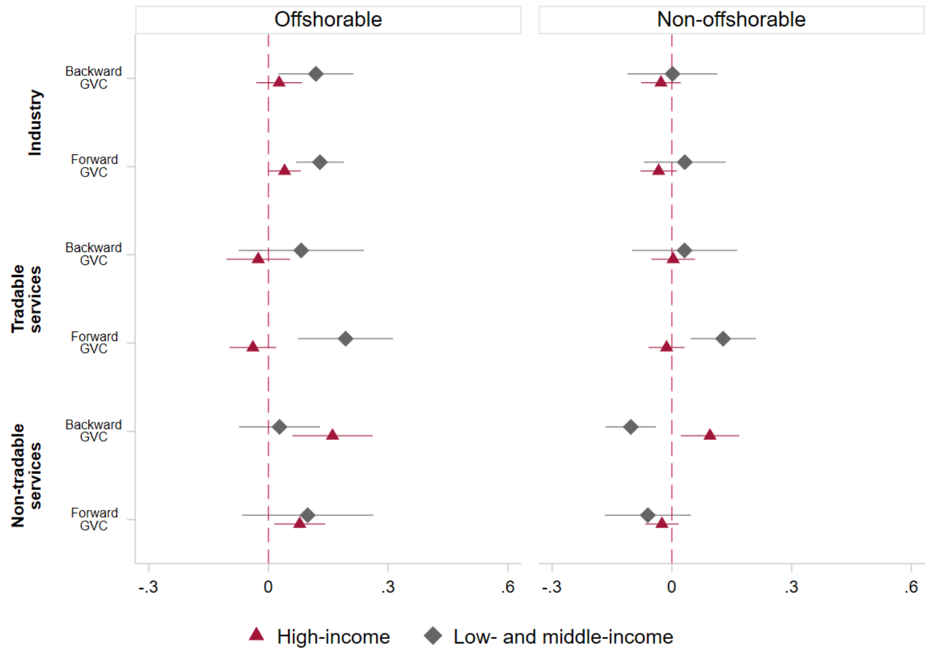
Table B5. The relationship between RTI, GVC participation, and wages, by sector and occupation type, standardised – Seemingly Unrelated Regressions estimation

Dependent variable: worker-level wages	Industry		Tradable services		Non-tradable services	
	(1) Offshorable	(2) Non-offshorable	(3) Offshorable	(4) Non-offshorable	(5) Offshorable	(6) Non-offshorable
Routine Task Intensity (RTI, std)	-1.685***	-1.843***	-2.406***	-1.950***	-1.423***	-1.426***
	(0.245)	(0.208)	(0.279)	(0.131)	(0.178)	(0.083)
Backward GVC participation (GVCB) share in exports (std.)	0.194	0.424*	-1.192***	0.222	0.220	0.776***
	(0.189)	(0.249)	(0.447)	(0.338)	(0.362)	(0.246)
GVCB share (std.) * [Ln(output) – mean(Ln(output)]	0.103	0.171*	-0.327*	-0.032	0.023	0.197**
	(0.092)	(0.104)	(0.193)	(0.142)	(0.119)	(0.098)
Forward GVC participation (GVCF) share in exports (std.)	-0.200*	0.158	-0.356	1.276***	0.132	0.341*
	(0.104)	(0.184)	(0.669)	(0.480)	(0.232)	(0.204)
GVCF share (std.) * [Ln(output) – mean(Ln(output)]	0.002	0.236***	-0.380*	0.253**	-0.209**	-0.119*
	(0.047)	(0.081)	(0.220)	(0.128)	(0.093)	(0.069)
Ln(output) –mean(Ln(output))	0.743***	0.420*	0.635*	0.001	-0.246	0.245*
	(0.285)	(0.231)	(0.339)	(0.191)	(0.175)	(0.138)
Observations	5,846	9,005	5,055	19,318	3,971	51,183

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard errors in parentheses. Standardised weights are used that give each country equal weight. We use sectoral output instead of countries' GDP per capita to control for between-country, between-sector wage differences. However, regressions, including GDP per capita yield similar results. The standard errors are clustered at a sector × country level. Measures for GVCB share and GVCF share are standardised. All regressions include controls for technology (computer use, computer use squared), skills, education, age, gender, sector FE, and country FE.

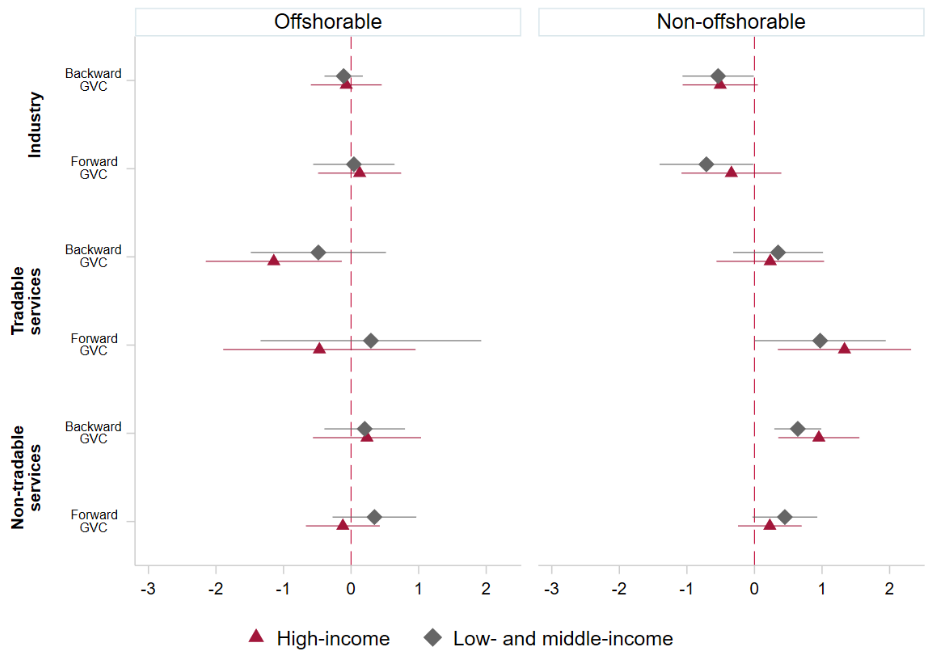
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Figure B1. The estimated relationship between GVC participation and workers' RTI in high-income and low- and middle-income countries, by employment sectors, occupation, and participation type, OLS estimation



Note: Figure presents the marginal effects of GVC participation based on regressions presented in Table 1, for the average GDP per capita of high-income and low- and middle-income countries. High-income country closest to the average is Italy, and low- middle-income country is Macedonia.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

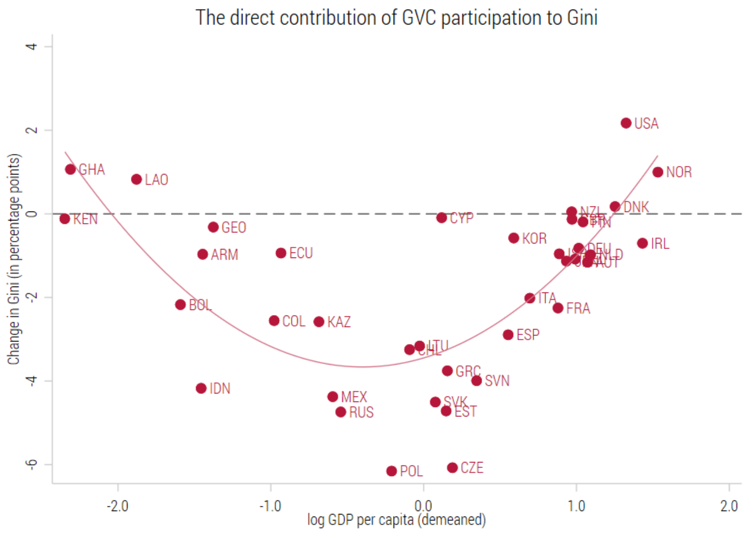
Figure B2. The estimated relationship between GVC participation and workers' wages in high-income and low- and middle-income countries, by employment sectors, occupation and participation type, OLS estimation



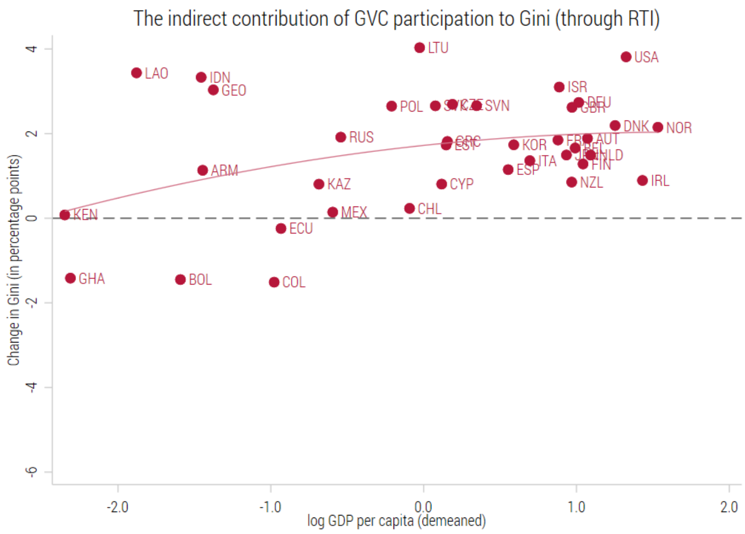
Note: Figure presents the marginal effects of GVC participation based on regressions presented in Table 1, for the average GDP per capita of high-income and low- and middle-income countries. High-income country closest to the average is Italy, and low- middle-income country is Macedonia.
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Figure B3 The contribution of GVC participation to within-country wage inequality- OLS estimation

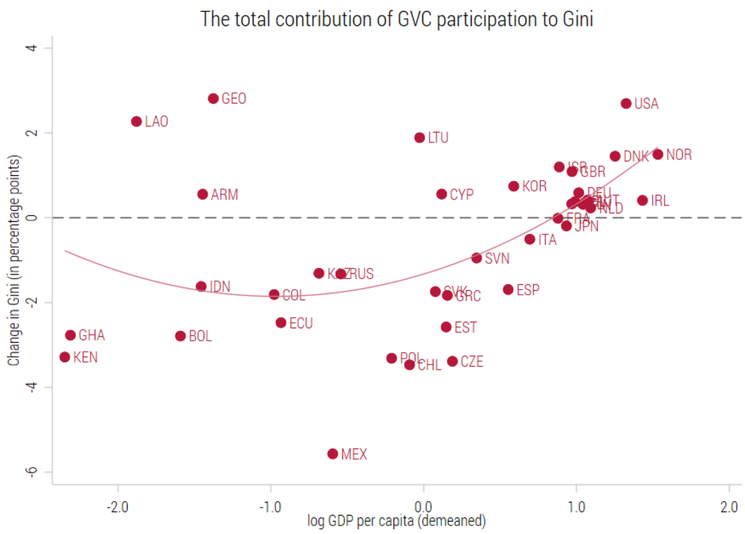
a)



b)



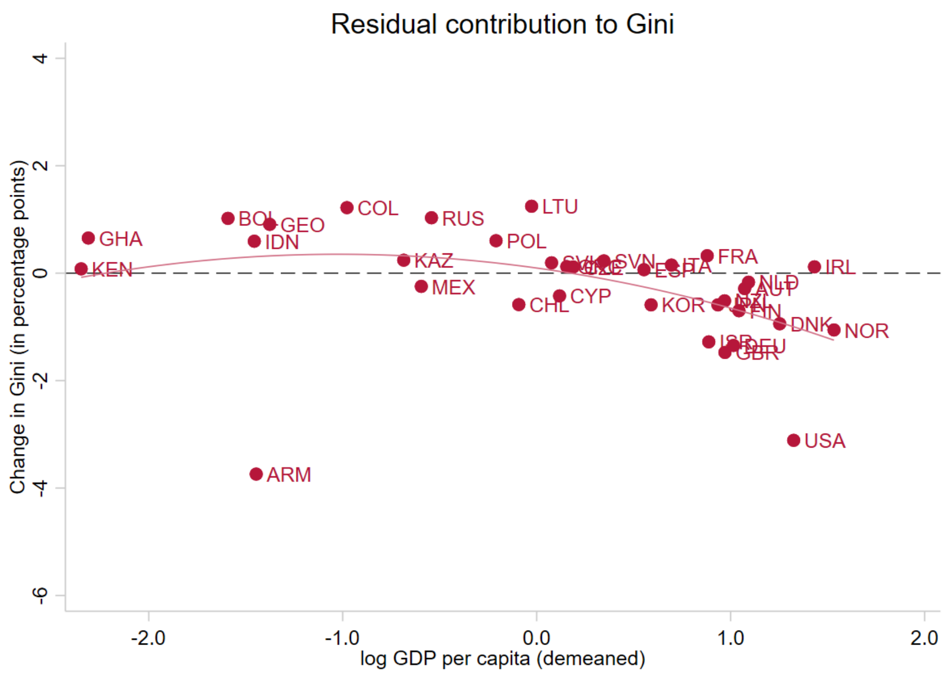
c)



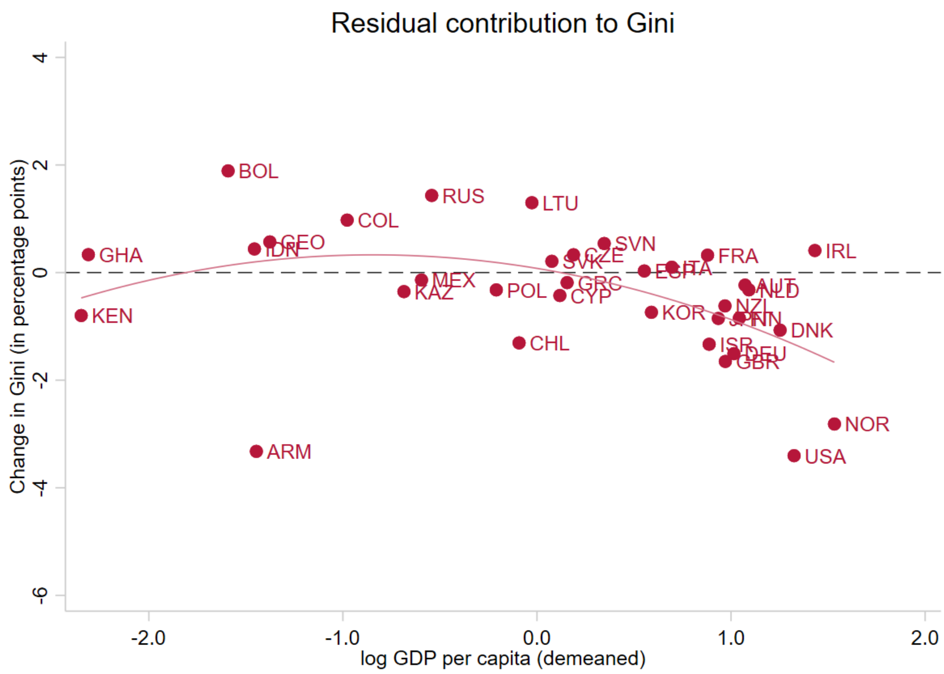
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Figure B4 The contribution of GVC participation to wage inequality, residual term

OLS estimation



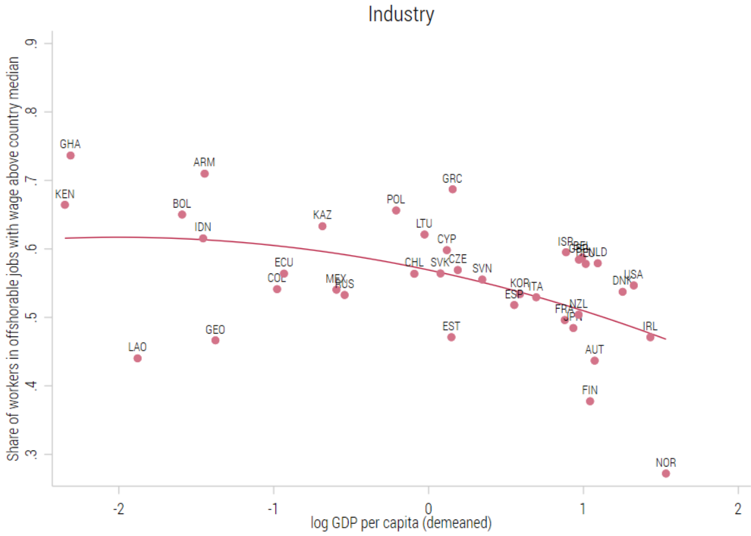
IV estimation



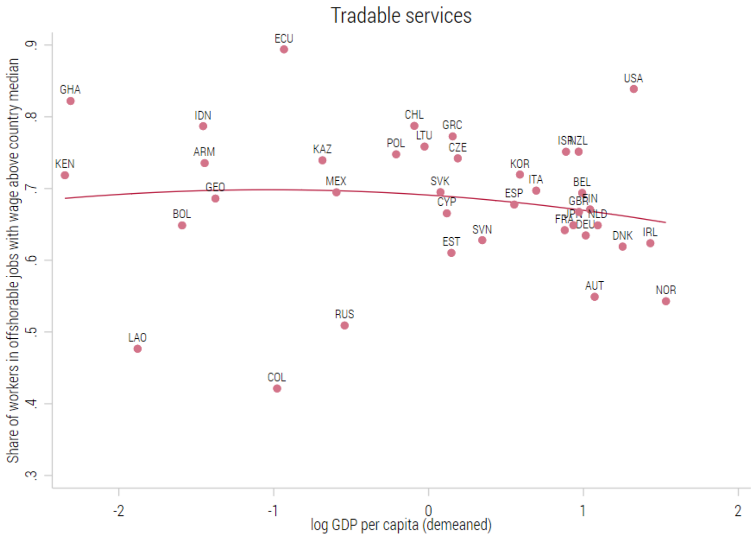
Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.

Figure B5. Share of workers performing offshorable occupations with wages above the country's median

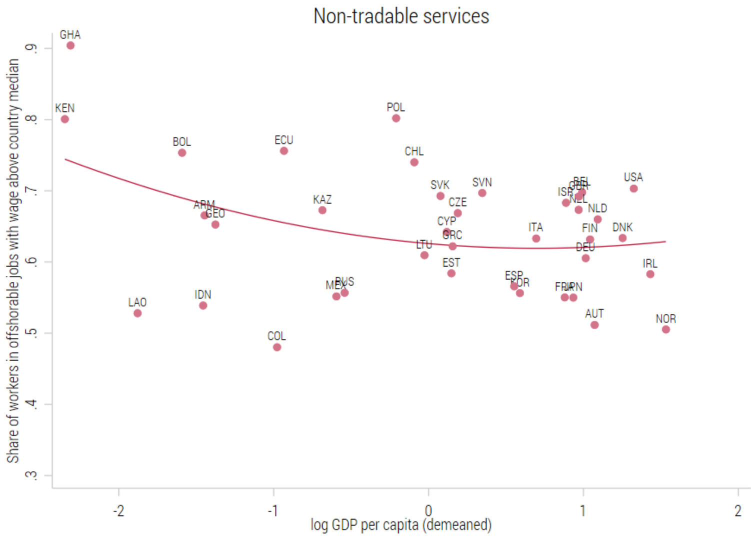
a)



b)



c)



Source: Authors' calculations based on PIAAC, STEP, World Bank, and EORA data.