Productivity, Global Value Chains and Cross-industry Spillovers in Turkey

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Abstract

This study examines the spillovers in productivity across industries and the impact of GVC participation, through backward and forward linkages, by estimating a spatial autoregressive model (SAR) using data drawn from the World Input-Output Dataset and Socio-Economic Accounts. We find that positive changes in productivity in one sector are significantly associated with higher productivity across sectors connected through input-output linkages. We find that productivity rises with forward linkages with a significant positive spillover across sectors through input-output connections, while backward linkages lead to declining productivity. A sectoral analysis shows that productivity benefits from forward linkages with positive spillover effects across service sectors but weakens with backward linkages within and across manufacturing sectors. This study empirically demonstrates that ignoring the spillovers effects in productivity leads to underestimating the impact of GVC participation on productivity.

Keywords: Labor Productivity, Spillover Effects, Backward Linkages, Forward linkages

JEL Classifications : F61, F16, J24

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I. Introduction

With advances in transportation and communication technologies, improvement of the infrastructure facilities, and falling trade barriers, the process of international economic integration has been rapidly growing and organized around the concept of global value chains (hereafter, referred to as GVC). Access to new modes of specialization has induced firms to slice down the production into tasks performed at different locations to optimize their factor costs (Feenstra and Hanson 1997; Grossman and Rossi Hansberg 2008). The fragmentation of the production process has stimulated a substantial growth in trade in final and intermediate goods, where the intermediate goods and services cross borders several times along the supply chains. This makes the traditional trade indicators poor approximation of the trade statistics because of the bias in the multi-counting of the value-added along the supply chains. New measures of trade-in value added have been introduced to gauge the integration of the economies into the GVC. Particularly, the share of foreign value-added embodied in gross export is used as a measure of linkages to the GVC from an importer standpoint, and the share of value-added embodied in third countries' exports is used as a measure of linkages from an exporter standpoint (Hummels et al, 2001, Koopman et al, 2014).

The impact of participation in the GVC on economies is increasingly explored with a particular emphasis on employment, productivity, and knowledge spillovers.

Constantinescu et al. (2019) study the impact of the share of foreign value-added embodied in export (Backward linkages) on productivity for a sample of 40 countries with 13 manufacturing industries and concluded that GVC integration boosts productivity. Baldwin et al. (2014) convey that productivity gains associated with GVC integration may accrue from different channels such as increases in competition, access to a variety of inputs, learning externalities, and technology spillovers. Using intercountry input-output tables, Kummritz (2017) empirically examines the impact of GVC integration on labor productivity and finds that labor productivity significantly rises with forward linkages but is not associated with backward linkages.

The impact of GVC participation on economies may be disproportionate considering the heterogeneity factor. Ignateko, Raei, and Mircheva (2019) maintain that the gain associated with GVC participation is hard to be measured because of the considerable heterogeneity between economies. Consequently, the impact of GVC participation is likely to vary across countries.

Moreover, industries are interconnected via the use of intermediates from different sectors in their production. Balassa (1961) argues that linkages between sectors are key sources of productivity spillovers and that the magnitude of the spillovers is even further amplified by the transmission of technological improvements. The direct effect of GVC

participation on productivity is well documented, yet, little has been done in examining the indirect effects (spillovers), which arise from sectors' input-output dependencies. Some exceptions are the studies of Badinger and Egger (2008) and Nasserline (2019, 2021). Badinger and Egger (2008) considered a spatial econometric approach to model the total factor productivity spillovers at the R&D industry level and a reminder spillover not related to knowledge spillovers, using an Autoregressive Error model. They found significant intra- and inter-industry knowledge spillover effects in productivity. Nasser Dine (2019) estimated a Spatial Lagged X (SLX) Model to examine the impact of GVC integration on employment in Turkey and the spillover effects. He conveyed significant direct and indirect effects (spillovers) of GVC participation on employment. Nasser Dine (2021) estimated a Difference Generalized Method of Moments (GMM) to examine the industry-level effects of backward linkages and domestic value-added exports on employment and productivity in Japan. He finds that the domestic value-added export is a key driver to employment formation and productivity while the effects of backward linkages are negatively associated with the dependent variables.

This study focuses on the impact of GVC participation on labor productivity in Turkey by using data drawn from the World Input-Output Dataset (WIOD) and Socio-Economic Account released (SEA). Here, the GVC participation is measured by the backward and forward linkages.

The impact of international trade on productivity has been examined in the literature. Filiztekin (2004) shows that trade liberalization and increasing import and export penetrations boost productivity at the sector level. Ozler and Yilmaz (2009) convey that a decline in trade barriers is significantly associated with productivity improvement in manufacturing sectors. This study is a step further in exploring and understanding how GVC participation impacts productivity at the sector level in Turkey. To the best of my knowledge, this paper is the first to examine the implication of GVC participation on labor productivity in Turkey while empirically examining Balassa's (1961) hypothesis using Input-output relations. That is, we argue that changes in labor productivity in one sector are likely to transmit to the other sectors through the input-output relations. Furthermore, we hypothesize that changes in GVC participation variables in one sector are likely to affect productivity not only in that sector but also the productivity in sectors connected to it via input-output linkages, which is modeled utilizing a row-standardized input-output weight matrix as we will see in details in next sections.

Our findings confirm Balassa's (1961) hypothesis, that is, changes in productivity in one sector significantly transcend to impact the productivity in other sectors through the input-output linkages with magnitude effects depending on the connectivity between sectors. We find that changes in GVC backward and forward linkages affect productivity not only within but also across sectors. We find that productivity weakens with backward

linkages in the manufacturing sector, suggesting that the imported intermediates act as a substitute to domestically produced goods leading the share of value-added to decline and thus the productivity. The impact of backward linkages on productivity in manufacturing sectors transcends to the sectors linked through the input-output. We find that the productivity in the service sectors rises together with forward linkages both within and across sectors, which supports learning by exporting hypothesis (De Loecker, 2012).

II. Data

II-A. WIOD and SEA data

This study uses data drawn from World Input-Output Dataset (WIOD) and the Socio-Economic Accounts (SEA), compiled by Timmer et al., 2015. The WIOD provides data in input-output and final goods flow detailed for covers 43 countries and stacked by 56 sectors from 2000 to 2014. The SEA contains information on employment, value-added, stock of capital, etc and over the same period from 2000 to 2014. The two datasets enable the calculation of backward and forward linkages.

Labor productivity is calculated as the share of values-added by employees. The backward and forward linkages are calculated for all countries in the WIOD and we restrict our sample to sectors in Turkey. A summary statistic of the main variables is reported in Table 1.

Table 1. Summary Statistics of the Variables

VARIABLES	Description	MEAN	SD
All sectors			
Labor productivity	Ratio Value added per employee (in millions of US\$)	44.43	45.55
FVA in EXP	Ratio of Foreign value added Exports	0.124	0.120
DVX in EXP	Ratio of Indirect Domestic value-added and Exports s	0.16	0.241
Capital Stock	Capital stock by Sector (in millions of US\$)	20,493	39,797
Wages	Labor Compensation (in millions of US\$)	2,339	4,082
Agriculture			
		MEAN	SD
Labor productivity	Value added (in millions of US\$)	83.56	30
FVA in EXP	Ratio of Foreign value added Exports by Sector	0.07	0.034
DVX in EXP	Ratio of Indirect Domestic value-added and Exports by sector	0.20	0.26
Capital Stock	Capital stock by Sector (in millions of US\$) by Sector	21,975	27,565
Wages	Labor Compensation by Sector (in millions of US\$)	2,288	2,692
Manufacturing			
		MEAN	SD
Labor productivity	Value-added (in millions of US\$) by Sector	30.45	41.07
FVA in EXP	Ratio of Foreign value added Exports by Sector	0.24	0.11
DVX in EXP	Ratio of Indirect Domestic value-added and Exports by sector	0.12	0.12
Capital Stock	Capital stock by Sector (in millions of US\$) by Sector	14,819	20,376
Wages	Labor Compensation by Sector (in millions of US\$)	1,651	2,169
Service			
		MEAN	SD
Labor productivity	Value-added (in millions of US\$) by Sector	47.73	13,787
FVA in EXP	Ratio of Foreign value added Exports by Sector	0.06	0.120
DVX in EXP	Ratio of Indirect Domestic value-added and Exports by sector	0.17	0.241
Capital Stock	Capital stock by Sector (in millions of US\$) by Sector	23,580	39,797
Wages	Labor Compensation by Sector (in millions of US\$)	2,740	4,082

Figure 1. FVA, DVX in Export and Labor Productivity

Source: Author's calculation based on the WIOD and SEA 2016.

Figure 1 depicts the averaged time trends for labor productivity, backward linkages (Foreign Value Added [FVA] export), and forward linkages (Indirect Value Added [DVX] export) variables throughout the period from 2000 to 2014. The productivity had been declining to reach its bottom in 2001 to 2002 as a result of the economic crisis in Turkey in 2001 before it significantly rebounds after 2002 and continues to ascend. The 2008 financial crisis put an end to the increasing trend in productivity which substantially declined in 2009 and continued to decline after that. Following the fall in the value-added, the forward linkages indicator continued to decline during 2000 and 2002 and stabilized since till 2008 where it slightly declined before increasing. The industry-averaged

backward linkages have somewhat increased and slightly declined because of the 2008 financial crisis before it continued to slowly increase.

Figure 2. Scatterplots of labor Productivity, FVA, and DVX Export

Source: Author's calculation based on the WIOD and SEA 2016.

Figure 2 shows the time-averages scatterplot for labor productivity, backward (FVA), and forward (DVX) linkages from 2000 to 2014 with the fitted lines. There seems to be no virtual evidence supporting an association between labor productivity and the foreign value-added (FVA) in export (backward linkages) with a seemingly flat-fitted slope. The association between labor productivity and indirect value-added (DVX) export (forward linkages) is positive with a positive and significant fitted slope.

Although the associations depicted in figure 2 are hardly suggestive of significant associations between the variables as these apparent relationships are likely to be driven by some unobservable factors and consequently a proper econometric model is therefore necessary for the analysis. For example, technologies and labor inputs vary between sectors, which makes it essential to consider these heterogeneities in assessing the effects of the GVC participation variables on productivity. Moreover, time-variant shocks that simultaneously impact all the sectors to the same extent need to be considered in the model. In the next section, we develop empirical models to examine the impact of the GVC participation indicators on labor productivity.

II-B. Input-output weight matrix

In this study, we model the interdependences between sectors using input-output relations. Specifically, we use the average use of intermediates over the studied period as a proxy for the extent to which each sector depends upon the other in terms of intermediates' supply used in its production of goods and services. Therefore, the time-averaged use of intermediates is calculated between industries in a form of a matrix wherein the column elements are formed of the average purchase of intermediates by sector j sourced from sector i . This process yields a 56×56 matrix that we row-standardize to get rid of units' measurement disturbances and to ensure adequate implementation in the spatial model's specifications. The resultant row-standardized weight matrix captures the interdependence between sectors through the input-output linkages. Table 2 summarizes the input-output weight matrix.

Table 2. Summary of Row-Normalized weight Matrix

Weight Matrix	Normalization	Dimension	% nonzero weights	Av No of Links	Symmetry
Input-Output Weight Matrix	Row-Standardized	56×56	64.63	36.19	No symmetrical

III. Methodology and Empirical Models

III-A. Methodology

This study follows Hummels et al (2001) to calculate backward and forward linkages. The backward linkages¹ are calculated as the share of foreign value-added in export to gross export, that is, the import of intermediates used in a country's export, normalized by the gross export. The forward linkages are calculated as the share of export of intermediates used in the export to third countries to gross export. The World Input-Output Database provides information on the export and import of goods according to the end of use and the origin to destination. This enables tracing back the source of the value-added content in exports and imports.

III-B. Empirical Models

The econometric approach follows Constantinescu et al. (2019) and rests on a production specification that manifests the value-added in the sector i in time t as a function of the inputs of capital stock K and labor L as follows:

$$V_{it} = A_{it}(\sigma_1, \sigma_2 \dots \sigma_n)F(K_{it}, L_{it}) \quad (1)$$

¹ Also known as vertical specialization.

Where A_{it} is the technology shifter of sector i in time t assumed here to be driven by trade-related variables $(\sigma_i)_i$. Specifically, we assume it is driven by the import and export channels that we capture through backward and forward linkages, respectively².

Dividing the production function by the labor input, assuming a Cobb-Douglas production function, and taking the logarithm yield the following model specification:

$$\log(P_{it}) = a + \mu_1 \log(BL_{it}) + \mu_2 \log(FL_{it}) + \alpha \log(K_{it}) \quad (2)$$

Where P_{it} is the labor productivity. We control for sectors' heterogeneity and time-variant components by adding sector and time fixed effects parameters and adding a stochastic error term as follows:

$$\log(P_{it}) = a + \mu_1 \log(BL_{it}) + \mu_2 \log(FL_{it}) + \alpha \log(K_{it}) + \varphi_i + \tau_t + \epsilon_{it} \quad (3)$$

We augment the model with the wage variable and argue that higher levels of wages tend to motivate higher productivity. The microeconomic theory links wages to labor productivity. The assumption that higher productivity may lead to higher levels of wages is likely a source of endogeneity. However, in developing countries, monopsony power tends to dominate, that is, employers pay workers less than their marginal productivity

² Constantinescu et al (2019) discard the forward linkages in the model specification. One justification is that there exists a high multicollinearity between GVC participation's variables. In this study, the multicollinearity between forward and backward linkages is weak and does not affect the estimates.

(Van Biesebroeck, 2015). Therefore, changes in labor productivity are unlikely to affect the level of wages³.

We expect that the dependent variable reacts to changes in the explanatory variables with delay. Thus, this study includes time-lagged explanatory variables on the right-hand side of the regression equation. This also diminishes the potential problem of simultaneity bias.

$$\log(P_{it}) = a + \mu_1 \log(BL_{it-1}) + \mu_2 \log(FL_{it-1}) + \alpha \log(K_{it-1}) + \beta \log(W_{it-1}) + \varphi_i + \tau_t + \epsilon_{it}$$

(4)

The estimated parameters for this specification can be straightforwardly interpreted as elasticities. That is, the coefficients are interpreted as percentage changes in the dependent variable caused by percentage changes in the corresponding explanatory variable.

A key contribution of this study is the control for the spillover effects that may arise in the labor productivity across sectors. To see this, consider sectors *a* and *b*, where sector *a* relies on the intermediates sourced from sector *b* to produce goods (and vice versa). Assume that there is a stochastic shock that boosts the productivity level in sector *b*. This shock in productivity is likely to transmit and cause growth in productivity in the sector

³ Our results remain consistent when we discard the wage variable.

a because of the increased access to intermediates and knowledge spillovers from the sector b . Hence, this study attempts to provide some evidence concerning the productivity spillover across sectors (Amiti and Konings. 2007). It is unlikely that variables included in equation 4 are readily able to capture these types of latent influences. That is, the spillover effects can arise as a result of the omitted variables that are not included in the econometric specification (LeSage & Pace, 2009). One way of modeling the spillover effects is by adding an input-output weighted dependent variable to the right-hand side of the regressions. This will enable studying the spillovers effects in labor productivity that stem from the input-output interdependence between sectors as in the following specification.

$$\begin{aligned} \log(P_{it}) = & a + \rho \sum_{j=1}^N w_{ij} \log(P_{it}) + \mu_1 \log(BL_{it-1}) + \mu_2 \log(FL_{it-1}) + \alpha \log(K_{it-1}) \\ & + \beta \log(W_{it-1}) + \varphi_i + \tau_t + \epsilon_{it} \quad (3) \end{aligned} \quad (5)$$

Or in matrix form:

$$\begin{aligned} \log(P) = & a + \rho W \log(P) + \mu_1 \log(BL) + \mu_2 \log(FL) + \alpha \log(K) + \beta \log(W) + \varphi + \tau \\ & + \epsilon \quad (4) \end{aligned} \quad (6)$$

In this specification, changes in explanatory variables in one sector do not influence productivity only in that sector, which is referred to as “*direct effects*” but potentially all the other sectors through the input-output relations, which are referred to as “*indirect*”

effects". Furthermore, changes in the productivity in one sector transmit to connected sectors through the input-output relations, with the magnitude average effect captured by a dependence parameter ρ . And, with the specification of Equation 6, we can also address problems related to endogeneity arising from the omitted variables that are correlated with the dependent variable across. Consequently, the coefficients of the independent variables do not stand for marginal effects, because the partial derivative of the dependent variable to a given explanatory variable is not equal to its coefficient. This can be seen if we write the model of Equation 4 as a data generating process:

$$\begin{aligned} \log(P) = (I - \rho W)^{-1} [a + \mu_1 \log(BL) + \mu_2 \log(FL) + \alpha \log(K) + \beta \log(W) + \varphi_i + \tau_t \\ + \epsilon] \end{aligned} \quad (7)$$

In Equation 7, the interpretation of the partial derivative is separated into "direct effects" within own sectors and "indirect effects" effects on productivity in other sectors, whose distributions can be simulated by drawing from a multi-normal distribution of the point estimates (LeSage and Pace, 2009). Moreover, a significant dependence parameter ρ is suggestive of "global spillover effects," where the changes in productivity in one sector set in motion a sequence of adjustments affecting productivity in the sectors with feedback effects. Here, we test whether the spillover effects are, rather, local in nature, that is, confined within sectors having similar characteristics by allowing an autoregressive process in the error term. The specification is as follows:

$$\log(P) = a + \mu_1 \log(BL) + \mu_2 \log(FL) + \alpha \log(K) + \beta \log(W) + \varphi_i + \tau_t + \epsilon$$

$$\epsilon = \lambda W \epsilon + \varepsilon \quad \text{and} \quad \varepsilon \sim N(0, \sigma^2 I) \quad (8)$$

The specification in equation 6 is known in the literature as the Spatial Error Model (hereafter, referred to as SEM) and the coefficients are straightforwardly interpreted as marginal effects because the dependence parameter in the error term (λ), does not come to play when the partial derivatives are computed. We also clarify whether the spillovers are global or local using Wald and Likelihood tests.

IV. Results and Discussion

Table 3 reports the estimation results of the models as introduced above. We first estimate OLS and fixed-effects models without accounting for the spillovers effects. In column 1, the estimation of the pooled ordinary least square (OLS) indicates that the backward linkages are negatively associated with labor productivity with the elasticity of -0.29 suggesting that productivity declines with the growing import of inputs used in the country's export. Labor productivity rises with forward linkages, that is, the export of inputs used in the export of another country's export to the third economies. This stands for an important channel through which trade affects productivity and is consistent with the concept of learning through exporting by which firms with higher export orientations tend to be more productive (De Loecker, 2013).

Table 3. Estimation of spatial and non-spatial models

<u>Dependent Variable: Employment (Log of productivity by employee)</u>				
	<u>Models without Spillovers</u>		<u>Models with Spillovers</u>	
	(1)	(2)	(3)	(4)
Variables	OLS	Two-ways FE	SAR	SEM
FVA	-0.29*** (0.031)	-0.087 (0.053)	-0.08* (0.047)	-0.12** (0.05)
DVX	0.10*** (0.030)	0.056** (0.026)	0.062*** (0.023)	0.072*** (0.022)
K	0.62*** (0.018)	0.47*** (0.022)	0.41*** (0.021)	0.44*** (0.021)
W	0.026* (0.014)	0.16*** (0.026)	0.06** (0.026)	0.12*** (0.030)
Rho/Lambda			<u>0.35***</u> (0.039)	<u>0.77***</u> (0.034)
R-squared	0.81	0.50	0.246	0.227
Time FE	No	YES	YES	YES
Sect FE	No	YES	YES	YES
LM test (Honda) (Two-ways effects)	64.99***			
LM test for Lag dependence	196.57***	10.15***		

LM test for error	43.65***	6.6**
dependence		
LL	517.5	498.24
AIC	-885	-846.49
BIC	-535.16	-496.66

Standard errors are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

As expected, the labor productivity increases together with the capital stock and wages. However, the pooled OLS estimation is likely to suffer from a substantial overestimation bias given that sector heterogeneity and time-specific effects are not controlled for. This is further supported by Honda's Lagrange Multiplier test. In column 2, we estimate the two-way fixed effects model where sector and year fixed effects are controlled for. The estimation results show that backward linkages are no longer associated with labor productivity. smaller in magnitude, the forward linkages remain positively associated with labor productivity, which as we explained in the OLS estimation, is consistent with the learning by exporting hypothesis.

The two-way fixed effects model presents a significant improvement compared to the pooled OLS estimation, in the sense that it accounts for sector heterogeneity and time fixed effects. However, its estimates may be biased in the case sectors are significantly interconnected leading the spillovers to arise. This interconnectedness can land in the

errors term or the dependent variable. In either case, the spillovers effects must be considered. Here, we verify this by testing the existence of interdependencies between sectors in the disturbances of the fixed effects model utilizing Moran's I , which report the interdependencies using the input-output weight matrix.

Table 4. Monte-Carlo simulation of Moran's I statistics

p-value	Statistic	Year	p-value	Statistic	Year
0.008991	0.099086	2001	0.023976	0.086131	2008
0.007992	0.142183	2002	0.421578	-0.00559	2009
0.976024	-0.112	2003	0.292707	0.007934	2010
0.92008	-0.08219	2004	0.140859	0.039491	2011
0.824176	-0.05465	2005	0.466533	-0.01334	2012
0.347652	0.005042	2006	0.625375	-0.03138	2013
0.01998	0.086741	2007	0.285714	0.011301	2014

. The Moran's I^4 statistics are generated for each year using a Monte Carlo randomization technique to construct the distributions. The results of this procedure are reported in table 4. Several Moran's I statistics are significant at a 10 percent significance level, implying that the two-ways fixed effects still suffer from a problem of interdependencies in the error term, which nature must be sorted out. The Lagrange multiplier test for errors

⁴ The null hypothesis is that there are no spatial correlations. The Moran's I statistic asymptotically follows a normal distribution.

dependence in table 3 supports Moran's I statistics. Moreover, the Lagrange multiplier also points to a significant dependency in the dependent variable. This highlights the necessity of the model identification and thus the nature of the spillover.

We estimate the Spatial Autoregressive Model (hereafter, referred to as SAR model) accounting for the labor productivity weighted with the input-output weight matrix and the Spatial Error Model (SEM) accounting for the weighted error term. We find that the spillover coefficient (ρ/λ) is positive and significant for both models. As we previously indicated, the SAR model identifies the global spillover effects wherein changes in one explanatory variable impacts productivity not only within that sector but also potentially all other sectors (LeSage & Pace 2009). On the other hand, the spillover effects in the SEM model are confined within sectors with non-null entries in the weight. Thus, it is necessary to determine the nature of the spillover effects before interpreting the results.

Elhorst (2010) conveys that, in the case of strong dependencies, the goodness of fit criteria can be adequate for model selection. That is, one can choose the model exhibiting the highest goodness of fit values. According to the likelihood, AIC, and BIC statistics in table 3, the SAR model fits the data generating process best. That is, the spillover effects are

global, and changes in explanatory variables are likely to affect productivity in and across sectors.

As previously discussed, the direct and indirect effects do not stand for marginal effects in the case of SAR models. Therefore, following LeSage & Pace 2009, we simulate the distribution of the direct and indirect effects drawn from a multivariate normal distribution of the point estimates reported in Table 3.

Table 5. Monte-Carlo Simulation of the Direct, Indirect, and Total Effects

Variables	Direct	Indirect	Total
FVA	-0.081*	-0.043	-0.12*
	(0.047)	(0.026)	(0.073)
DVX	0.062***	0.033***	0.095***
	(0.024)	(0.014)	(0.037)
K	0.41	0.22	0.63
	(0.021)	(0.036)	(0.040)
W	0.06***	0.032***	0.092***
	(0.026)	(0.013)	(0.038)

Standard errors are in parenthesis, *** p<0.01, ** p<0.05, * p<0.1

The simulated direct, indirect, and total effects are conveyed in Table 5. First, one can sense the bias that arises from excluding the cross sectors spillover effects in labor productivity. The coefficient of the backward linkages turns out to be significant,

suggesting that productivity weakens with the increased import of intermediates used in the export of goods. Specifically, a 10 percent increase in the backward linkages cuts labor productivity by 0.8 percent. This entails that the imported intermediates, used in the country's exports, act as substitutes for the domestically produced goods, which leads the productivity to deteriorate. Interestingly, labor productivity grows with forward linkages within and across sectors, reinforcing the spillover hypothesis. In particular, a 10 percent increase in forward linkages increases labor productivity by 0.62 percent but also across sectors by 0.3 percent. The total impact on labor productivity is therefore 0.95 percent. Hence, ignoring this interdependence between sectors causes a downward bias of the impact of GVC participation variables on productivity. While stock capital seems unassociated with labor productivity, better wages stimulate productivity, and this effect transcends to other sectors via the weight matrix.

Taken as a whole, these findings suggest that GVC participation plays a key role in explaining changes in labor productivity with significant spillovers effects through the input-output linkages are documented. Besides, changes in productivity in one sector transmit across sectors through the input-output linkages. Nevertheless, since the impact of participation in the GVC varies between sectors because of the heterogeneous technologies and labor skills, it is fundamental to assess the impact on productivity for different sectors.

The distribution of the value-added is U-shaped (Baldwin, 2012) and changes according to the position of the sector in the GVC. There is evidence that a significant value-added accrues pre- and post-manufacturing stages, and that the distribution of the value-added in the manufacturing varies from high to small-scale labor and capital-intensive (Banga, 2018). This motivates the analysis of the service and manufacturing sectors⁵. Consequently, the sample is split into two subsamples: the service and manufacturing sectors. The estimation is conducted for the subsamples using our selected model⁶.

<u>Table 6. Sectors GVC participation impact of Productivity</u>						
Dependent variable: log of Labor productivity						
	(1)	(2)	(3)	(4)	(5)	(6)
	Manufacturing			Services		
	Fixed			Fixed		
Variables	Effects	SAR		Effects	SAR	
		Direct	Indirect		Direct	Indirect
		Effects	Effects		Effects	Effects
FVA	-0.32*** (0.078)	-0.36*** (0.071)	-0.355*** (0.12)	0.002 (0.074)	0.020 (0.068)	0.004 (0.017)
DVX	-0.082* (0.043)	-0.065* (0.038)	-0.064 (0.043)	0.11*** (0.032)	0.10*** (0.029)	0.026*** (0.010)

⁵ Agriculture sectors were dropped from the analysis because of the limited number of observations.

⁶ We construct a sub-weight matrix for each category of sectors.

LgK	0.36*** (0.039)	0.32*** (0.035)	0.32*** (0.090)	0.61*** (0.029)	0.58*** (0.029)	0.14*** (0.038)
LgW	0.23*** (0.065)	-0.032 (0.066)	-0.031 (0.074)	0.082* (0.029)	0.033 (0.028)	0.008 (0.0067)
<u>Rho</u>	<u>0.51***</u> <u>(0.063)</u>			<u>0.20***</u> <u>(0.045)</u>		
<i>LL</i>	251.83			311.17		
<i>AIC</i>	-427.66			-518.35		
<i>BIC</i>	-291.48			-303.3		

Standard errors are in parenthesis. Monte-Carlo simulation of the direct and indirect effects is reported for the SAR models. *** p<0.01, ** p<0.05, * p<0.1

The estimation results of the fixed effects models are given in columns 1 and 4 of Table 6 whereas the estimation results of the SAR are in columns 2 and 3 for manufacturing and 4 and 6 for services. The autoregressive parameter (*Rho*) is significant and positive at the magnitude of 0.51, indicating a significant positive diffusion in productivity across manufacturing sectors through the input-output relations. Furthermore, the results reveal a negative association between the backward linkages and labor productivity in manufacturing industries. Specifically, a 10 percent increase in the backward linkages is associated with a 3.6 percent decline in labor productivity within its sectors and a 3.5 percent decline across sectors, with a total decline of 7.1 percent in productivity.

The negative association between backward linkages and productivity found in previous results of tables 3 and 5, seems to be driven for the most part by manufacturing backward linkages. Namely, the import of intermediates used in the export acts as a substitute for domestic goods in manufacturing industries, which diminishes the value-added and subsequently productivity. Likewise, a 10 percent increase in forward linkages in a manufacturing sector bears a 0.65 percent decline in productivity at the 10% significance level.

In Columns 5 and 6, the autoregressive parameter is positive and significant with a magnitude of 0.2, implying a positive transmission of the productivity across service sectors through input-output relations. Namely, changes in labor productivity in one sector significantly affect productivity in that sector with magnitude decaying with the intensity of the dependencies. Labor productivity significantly increases with the forward linkages with significant spillovers across service sectors. Specifically, a 10% growth in the forward linkages is associated with a 1% increase in labor productivity with spillovers that amount to 0.26% rendering the total growth in the productivity 1.26%. These findings are consistent with the existing literature suggesting that export-oriented firms tend to be more productive compared to firms less involved in export activities. This can materialize through learning by exporting and technology dissemination (De Loecker, 2012). Also, the results stipulate that the learning by exporting process is not confined rather it

propagates amongst sectors through input-output dependencies. Lastly, labor productivity significantly rises with capital stock with significant spillovers effects.

V. Concluding remarks

This study establishes that industry-level GVC participation, through backward and forward linkages, is significantly linked to productivity. Using a spatial econometric method, we show that industry-level labor productivity is susceptible to significant spillovers through the input-output dependencies. The study also finds evidence that the industry-level GVC participation, through backward and forward linkages, affects productivity with significant spillovers across sectors.

At the sectors-level, productivity is subject to significant spillovers in the manufacturing and service sectors, which is consistent with Balassa's (1961) assumption stipulating that linkages between sectors are key sources of productivity spillovers.

On the one hand, a Monte Carlo simulation suggests that GVC participation through backward linkages is negatively associated with productivity in manufacturing industry-level causing declines in productivity across sectors. This supports the substitution hypothesis of the imported intermediates. On the other hand, GVC participation, through forward linkages, fosters productivity within and across service sectors.

Importantly, this study reinforces Balassa's (1961) hypothesis indicating that linkages between industries are main sources of productivity spillovers. Understanding these channels and mechanisms through which the spillovers occur across industries is pivotal for elaborating efficient policies aiming at benefiting from GVC participation in promoting labor productivity. An important area of future research is to model the input-output relations both across sectors and countries using the WIOD 2016.

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* Ethics approval and consent to participate

Not Applicable

* Consent for publication

Not Applicable

* Availability of data and material

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Appendix

Agriculture	Crop and animal production, hunting and related service activities
	Forestry and logging
	Fishing and aquaculture
	Mining and quarrying
Manufacturing	Manufacture of food products, beverages and tobacco products
	Manufacture of textiles, wearing apparel and leather products
	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	Manufacture of paper and paper products
	Printing and reproduction of recorded media
	Manufacture of coke and refined petroleum products
	Manufacture of chemicals and chemical products
	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	Manufacture of rubber and plastic products

	Manufacture of other non-metallic mineral products
	Manufacture of basic metals
	Manufacture of fabricated metal products, except machinery and equipment
	Manufacture of computer, electronic and optical products
	Manufacture of electrical equipment
	Manufacture of machinery and equipment n.e.c.
	Manufacture of motor vehicles, trailers and semi-trailers
	Manufacture of other transport equipment
	Manufacture of furniture; other manufacturing
	Repair and installation of machinery and equipment
Services	Electricity, gas, steam and air conditioning supply
	Water collection, treatment and supply
	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services
	Construction
	Wholesale and retail trade and repair of motor vehicles and motorcycles

Wholesale trade, except of motor vehicles and motorcycles
Retail trade, except of motor vehicles and motorcycles
Land transport and transport via pipelines
Water transport
Air transport
Warehousing and support activities for transportation
Postal and courier activities
Accommodation and food service activities
Publishing activities
Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities
Telecommunications
Computer programming, consultancy and related activities; information service activities
Financial service activities, except insurance and pension funding
Insurance, reinsurance and pension funding, except compulsory social security
Activities auxiliary to financial services and insurance activities

Real estate activities
Legal and accounting activities; activities of head offices; management consultancy activities
Architectural and engineering activities; technical testing and analysis
Scientific research and development
Advertising and market research
Other professional, scientific and technical activities; veterinary activities
Administrative and support service activities
Public administration and defence; compulsory social security
Education
Human health and social work activities
Other service activities
Activities of households as employers; undifferentiated goods- and services- producing activities of households for own use
Activities of extraterritorial organizations and bodies