ERF 2020

26TH Annual Conference

Spillovers in Labor Productivity and Global Value Chain Impacts: Evidence from Turkey

Mohamedou Nasser Dine

ECONOMIC RESEARCH FORUM

منتدى البحوث الاقتصادية

Spillovers in Labor Productivity and Global Value Chain Impacts: Evidence from Turkey

Mohamedou Nasser Dine

Osaka University

Abstract

Based on the world input-output database 2016 (WIOD), this study examines the impact of the global value chain (GVC), via the backward and forward linkages, on labor productivity. Using a spatial econometric approach, it pays a particular attention to the spillovers effects in productivity across industries through input-output relations. It is shown that a stochastic shock in productivity in one sector significantly transcends and boosts productivity in other sectors through input-output dependencies. Moreover, productivity significantly declines with backward linkages within own sectors. However, productivity increases with forward linkages both within own sectors and across sectors through input-output relations. A sectoral analysis of the GVC effects on productivity reveals that manufacturing backward linkages is negatively associated with productivity not only within own sectors but also across manufacturing sectors, whereas productivity in service sectors rises with forward linkages within and across service sectors. This study shows that ignoring the spillovers effects across sectors causes the estimates to be biased.

JEL Classifications: F160, F140, F660

Keywords: Backward linkages, Forward linkages, Labor Productivity, Spillovers

1- Introduction

With the 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 a global value chain (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 goods and intermediates, where the intermediates goods and services cross borders several time along the supply chain, rending trade indicators, which lack in accounting for multi-counting of the value added across the supply chain, poor approximation of the trade statistics. New measures of trade in value added have been set forth to report the extent to which an economy is involved in the global value chain. Particularly, the share of foreign value added embodied in gross export as measure of linkages to the GVC from an importer standpoint and the share of value added embodied in third countries exports as an indicator of linkages from an exporter standpoint (Hummels et al, 2001, Koopman et al, 2014). The impact of GVC integration on economies is increasingly explored. Some key outcomes of such integration are employment generation, productivity and knowledge spillovers. Constantinescu et al (2019) studied the impact of the share of foreign value added embodied in export (Backward linkages) on productivity for a sample of 40 countries and 13 manufacturing industries and found that GVC integration boosts productivity. Baldwin et al (2014) convey that productivity gains associated with the GVC integration may accrue from different channels such as increasing competition, access to a variety of inputs, learning externalities and technologies spillovers. Using intercountry input-output tables, Kummritz (2017) empirically examined the magnitude impact of GVC integration indicators on labor productivity and found that labor productivity significantly rises with forward linkages and not significantly associated with backward linkages. However, the impact of GVCs participation might be disproportionate for different economies as a consequence of the substantial heterogeneity among countries. In fact, Ignateko, Raei and Mircheva (2019) convey that the gain associated with the GVC participation is hard to assess because of the large degree of heterogeneity between economies. Consequently, the impact of GVC participation may vary substantially across countries.

Another important feature of GVC participation is the dependencies between sectors in the use of intermediates. Balassa (1961) argue that linkages between sectors are key sources of productivity spillovers and that the magnitude of the spillovers are even further amplified by the transmission of technological improvements. The vast majority of the introduced studies examined the direct effect of GVC indicators on productivity without accounting for the spillovers effects between sectors, which may arise as a result of sectors interdependence. An exception is the study of Badinger and Egger (2008), which used 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, which they modelled using an autoregressive error model. They found a significant intra and inter-industry knowledge spillover effect on productivity as well as reminder spillovers. Nasser Dine (2019) used an SLX model to examine the impact of GVC integration variables on employment generation in Turkey while accounting for the spillovers effects in these variables. He shows that trade related variables do not affect the job creation within own sectors only but also across sectors.

In this study, we focus on Turkey's GVC participation impact on labor productivity using the world input-output tables and Socio-Economic Account released in 2016 (Timmer et al 2016). Specifically, this study examines the effects of backward and forward linkages on labor productivity at the sector level. There is a growing literature on the impact of trade openness on productivity in Turkey. In fact, Filiztekin (2004) shows that trade liberalization is significantly associated with productivity in manufacturing sectors. In particular, increasing import and export penetrations enhance productivity at the sector level. Ozler and Yilmaz (2009) maintain that reduction in trade barriers is significantly associated with productivity improvement in manufacturing sectors. However, and to the best to my knowledge, there are no studies that examine the impact of GVC participation on labor productivity at the sector level and using the WIOD 2016 in Turkey. Furthermore, this study empirically examines Balassa's (1961) hypothesis using input-output relations. We argue that a stochastic shock in labor productivity in one sector is likely to transmit to other sectors through the input-output relations and that changes in GVC indicators in one sector do not affect that sector's own productivity only (Direct effects) but also potentially all other sectors through input-output linkages as well (Indirect effects). The interdependence between sectors is modelled using a row-standardized input-output weight matrix.

Our findings confirm the stated hypothesis that changes in productivity progress beyond own sectors effects and significantly transcend to sectors via input-output linkages with magnitude impacts depending on the degree of connectivity. Moreover, changes in GVCs backward and forward linkages affect productivity both within and across sectors. Manufacturing backward linkages seem to be negatively associated with productivity suggesting that the imported intermediates act as substitute for domestically produced goods leading the share of value added to declines and so does the productivity. The impact of backward linkages in manufacturing sectors seems to transcend to the sectors linked through the input-output weight matrix. We find that service sectors' productivity rises with forward linkages both within and across sectors lending support to the learning by exporting assumption (De Loecker, 2012).

2- Data

2-1 WIOD and SEA data

This study relies on the 2016 released WIOD and Socio-Economic Accounts (Timmer et al. 2016). The WIOD covers 43 countries and a model for the rest of the world for the period 2000~2014 for 56 sectors. Furthermore, information on employment, stock of capital among other variables are available on the Socio-Economic Accounts (SEA). We construct our main GVCs variables: Backward and Forward linkages[1]. We calculate labor productivity as the share of value added by employees and restrict our analysis on Turkey's sectors. A summary statistic of the main variables and their description is reported in table 1.

Table 1. Summary Statistics of the Variables

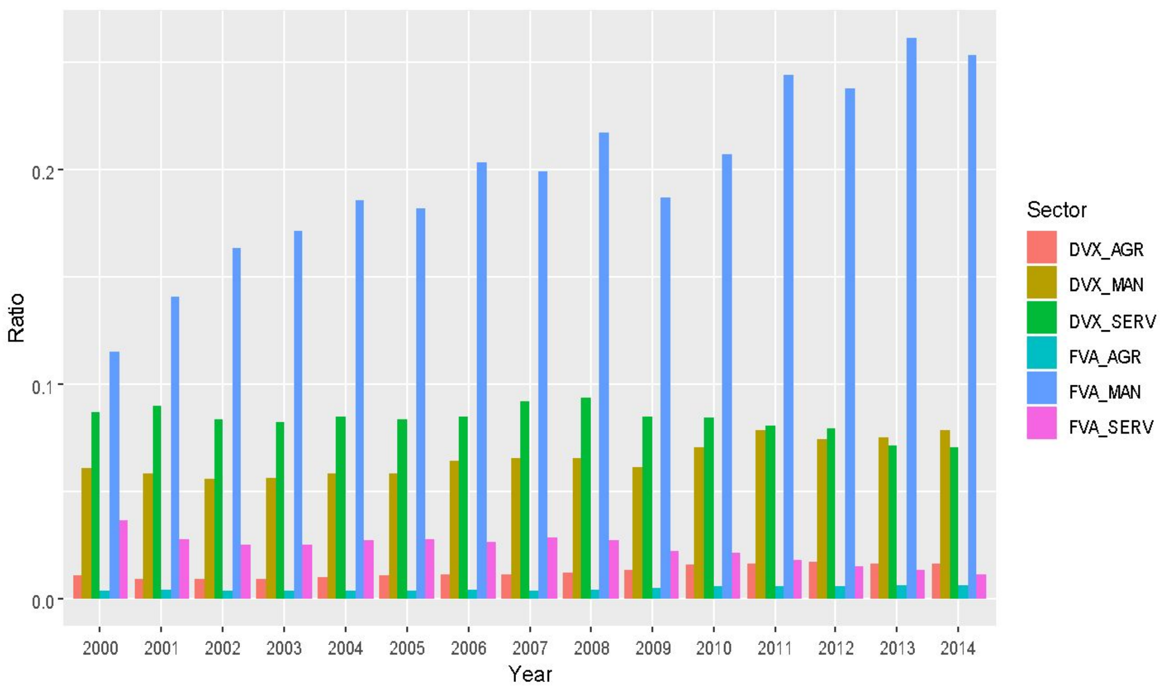
VARIABLES	Description	MEAN	SD
	All sectors		
Labor productivity	Ratio Value added per employee (in millions of US$)	44.43	45.55
FVA in EXP	Ratio of Foreign value added Exports	0.124	0.120
DVX in EXP	Ratio of Indirect Domestic value added and Exports	0.16	0.241
Capital Stock	Capital stock by Sector (in millions of US$)	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	23,580	39,797

[1] See appendix for more details about the calculation

	Sector		
Wages	Labor Compensation by Sector (in millions of US$)	2,740	4,082

Figure 1 illustrates changes in the industry-average foreign (backward linkages) and indirect domestic value added export (forward linkages) as shares of gross export over the studied period. On the one hand, backward linkages indicator in manufacturing sectors marks the highest share of gross export and posts faster growth compared to the services and agriculture sectors, with the latter lagging behind. On the other hand, services sectors represent the highest share of the indirect domestic value added export as a share of gross export, manufacturing follows second and agriculture sectors constitute the lowest share of gross export.

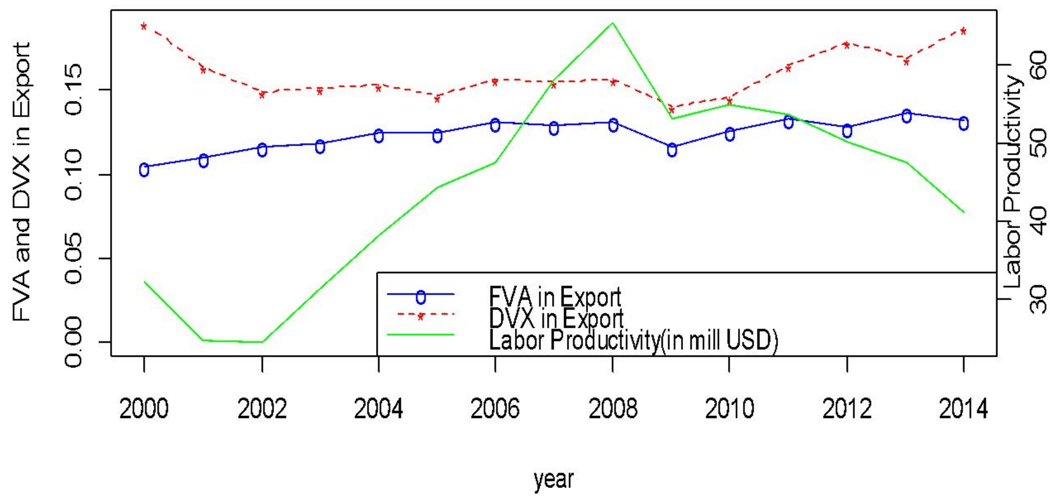
Figure 1. Sectors FVA and DVX Export as share of Gross Export from 2000~2014



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

Figure 2, depicts the averaged time trends of the labor productivity, backward linkages (FVA export) and forward linkages (DVX export) variables over the period 2000~2014. The productivity had been declining to reach its bottom in 2001 as a result of the Turkey 2001's economic crisis, before it significantly rebounds in 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 since. Following the fall in the value added, the forward linkages continued to decline during 2000~2002, and stabilized from then till 2008 where it slightly declined before beginning an ascendant trend. The industry-averaged backward linkages have been mildly increasing and slightly declined as a consequence of the 2008 financial crisis before it continued to increase.

Figure 2. FVA, DVX in Export and Labor Productivity

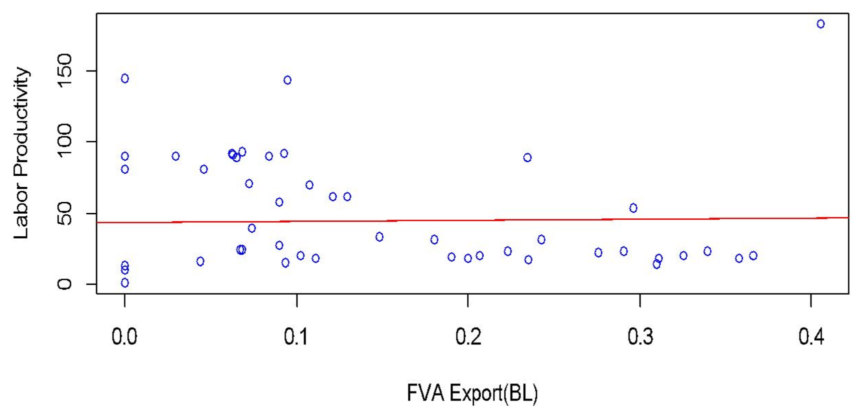


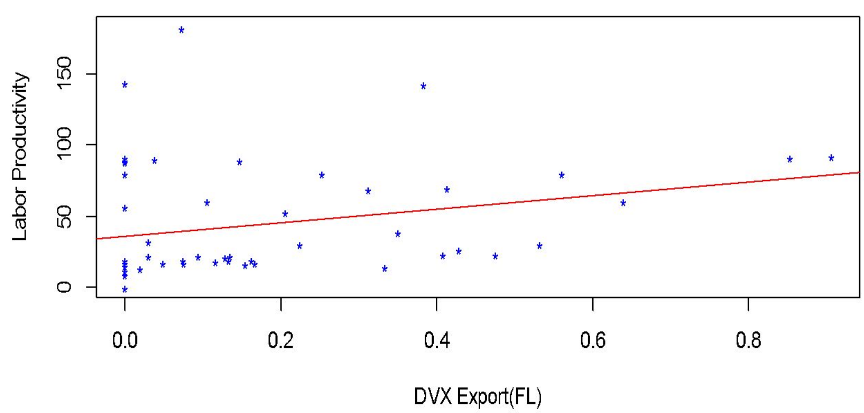
Source: Author's own calculation based on the WIOD and SEA 2016.

Figure 3 illustrates a scatterplot of the 2000~2012-time average of the labor productivity, backward (FVA) and forward (DVX) linkages. There seems to be no virtual evidence supporting association between labor productivity and the foreign value added in export (backward linkages) variables with insignificant fitted regression slope. On the other hand, the association between labor productivity and indirect value added export (forward linkages) seems positive with a significant fitted regression slope.

While indicative, the associations depicted in figure 3 are hardly suggestive of significant relationship between the variables as latent observable and unobservable determinants may be driving the apparent relationship. Consequently, a proper econometric framework should be set forth to properly analyze the relationships. In fact, sectors have heterogeneous characteristics such as technologies and labor inputs. Therefore, it is central to account for these disparities in order to properly assess the magnitude effects of the incorporated variables on productivity. Moreover, time-variant shocks that simultaneously impact all sectors at the same extent need to be sorted out. In the next section, we set out an empirical framework to examine the impact of the GVCs participation indicators on labor productivity.

Figure 3. Scatterplots of FVA, DVX Export and Labor Productivity





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

2-2 Input-output weight matrix

In this study, we model sectors' interdependence 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 average use of intermediates is calculated inter-industries and a weight matrix, which column's entries c_{ij} stand for the average purchase of intermediates by sector *j* sourced from sector *i*. This yields a 56 x 56 matrix, which we row-standardize to get rid of units' measurement disturbances and for adequate implementation in 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

3- Methodology and Empirical Models

3-1 Methodology

The methodology this study follows to calculate GVCs participation indicators (Backward and forward linkages) is as introduced by Hummels et al (2001). Backward linkages[2] indicator is calculated as the share of foreign value added in export to export, that is, the import of intermediates used in a country's export as a share of gross export. Forward linkages indicator is calculated as the share of export of intermediates used in the export to third countries to gross export. The World Input-Output Database, (Timmer et al 2016), provides information on export and import of goods with respect to their end of use (intermediates and final goods) and origin-destination (import and export). This enables tracing back the source of the value added content in exports and imports. The detailed calculation of the GVCs variables are presented in the Appendix.

3-2 Empirical Models

The econometric approach follows Constantinescu et al (2019) and rests on a production specification as a function of the capital stock K and labor L inputs as following:

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

Where A_{it} stands for impact of technology shifter of sector i and in time t, which is assumed to be driven by various trade related determinants. We assume that these effects originate from an import and export channels, which we approximate using the backward and forward linkages, respectively[3]. K_{it} capital and L_{it} labor input in sector *i* at time *t*.

[2] Also known as the vertical specialization.

[3] Constantinescu et al (2019) discarded the forward linkages variables for the model specification. One justification is the high multicollinearity between GVCs' variables. In our study, the multicollinearity between forward and backward linkages is weak and does not alter the estimations.

Dividing the production function by the labor input, assuming a Cobb-Douglass specification and taking the logarithm of the variables yields the following model specification.

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

We control for sectors' heterogeneity and time variant components by adding sector and time fixed effects parameters. Finally, adding a stochastic error term, the model can be written as following:

$$log(P_{it}) = a + \mu_1 log(BL_{it}) + \mu_2 log(FL_{it}) + \alpha log(K_{it}) + \varphi_i + \tau_t + \varepsilon_{it} \quad (1)$$

We augment the model with the wage variable and argue that higher levels of wages tend to motivate better productivity. In fact, the microeconomic theory clearly links wages and productivity. A plausible assumption is that higher productivity may lead to higher levels of wages. However, in developing countries, monopsony power tends to dominate, that is, employers pay workers less than their marginal productivity (Van Biesebroeck, 2015). Therefore, changes in labor productivity are unlikely to affect the level of wages.

We expect that the dependent variable reacts to changes in the explanatory variables with delay. Consequently, 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.

$$log(P_{it}) = a + \mu_1 log(BL_{it-1}) + \mu_2 log(FL_{it-1}) + \alpha log(K_{it-1}) + \beta log(W_{it-1}) + \varphi_i + \tau_t + \varepsilon_{it}$$
(2)

The parameters estimate of this specification can be 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.

One central contribution of the present study is the control for the spillovers effects that may arise from changes in the dependent variable across sectors. To see this, consider sector ***a*** and sector ***b***, where sector ***a*** significantly relies on the intermediates sourced from sector ***b*** for the production of goods (and vice versa). Assume that there is a stochastic shock that boosted the productivity levels in sector ***b***. That is more output (intermediates and final goods) are produced. This shock in the productivity is likely to transmit to sector ***a*** via the input-output channel triggering a rise in its productivity as well, via higher intermediates use and/or knowledge spillovers. Hence, this study attempts to provide some evidence that knowledge spillovers effects' assumption as a result of the access to various inputs used in a sector's production of goods (Amiti and Konings. 2007), is not a consequence of the international supply chain only but also the within a country's sectors interdependence.

It is unlikely that variables included equation 2 are readily able to capture these types of latent influences. That is, the spillover effects can arise as a result of omitted variables that are not included in the econometric specification (LeSage & Pace, 2009). One way of modelling the spillover effects is including the dependent variable weighted with the input-output weight matrix that accounts for the interdependence between sectors as in the following specification.

$$log(P_{it}) = a + \rho \sum_{j=1}^{N} wijln(P_{it}) + \mu_1 log(BL_{it-1}) + \mu_2 log(FL_{it-1}) + \alpha log(K_{it-1}) + \beta log(W_{it-1}) + \varphi_i + \tau_t + \varepsilon_{it} \quad (3)$$

Or in matrix form:

$$lo(P) = a + \rho W log(P) + \mu_1 log(BL) + \mu_2 log(FL) + \alpha log(K) + \beta log(W) + \varphi + \tau + \epsilon \quad (4)$$

In this specification, changes in explanatory variables in one sector do not influence productivity in that sector only (direct effects) but potentially all other sectors as well (indirect effects). Furthermore, a shock in productivity in one sector transmits to connected sectors through the input-output weight matrix relations and with magnitude average effect captured by the dependence parameter ρ. Moreover, with the specification of equation 4, we also address problems related to endogeneity arising from omitted variables that are correlated with dependent variable across sectors such as the level of GVC integration via backward, forward linkages and other determinants. Consequently, the variables' coefficients do not stand for marginal effects, because the partial derivative of the dependent variable with respect at a given explanatory variable is not equal to its marginal effect (its coefficient). This can be seen if we write the model as a data generating process:

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

Hence, change in one explanatory variable does not affect the labor productivity within sector only but also productivity in other sectors. Therefore, the interpretation of the partial derivative is separated into direct effects within own sectors and indirect effects on other sectors, which distribution can be simulated by drawing from a multi-normal distribution of the point estimates of the variables (LeSage and Pace, 2009). A significant dependence parameter ρ indicates global spillovers effects where changes in productivity in one sector set in motion a series of adjustments affecting all sectors with feedback effects. we test whether the spillovers 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 following:

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

$$\epsilon = \lambda W \epsilon + \varepsilon \quad and \quad \varepsilon \tilde{} N(0, \sigma^2 I) \quad (6)$$

The later specification is known as the SEM (Spatial Error Model) model and the coefficients are straightforwardly interpreted as marginal effects, because the dependence parameter in the errors term does not come to play when the partial derivative is computed.

Hence, it is central to determine the nature of the spillover effects arising from the sectors' interdependence, which we examine using several statistical tests such Wald and Likelihood tests.

4- Results

Table 4 reports the estimation results of the aforementioned models. We start with estimating the non-spatial models and then we provide evidence and the motivation behind accounting for the Spillovers effects. In column 1, the pooled OLS indicates that the backward linkages indicator is negatively associated with labor productivity with elasticity of -0.29. This suggests that higher import of intermediates, used in the goods' exports, diminishes the labor productivity indicator. Labor productivity rises with the indicator of forward linkages, that is, the export of inputs used in another country's export to third countries. 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 high export orientations tend to be more productive (De Loecker, 2013). As expected, we find that the productivity increases with both the capital stock and wages variables. However, the pooled OLS estimation suffers from a substantial overestimation bias as it lacks in controlling for sectors heterogeneity and time specific effects. In fact, using Honda Lagrange Multiplier, the study reports significant statistics supporting the control for sectors and time fixed effects in the estimation. In column 2, we report the estimation results of the two-way fixed effects model. After controlling for the year and sectors' fixed effects, the backward linkages indicator's elasticity becomes insignificant. Labor productivity remains significantly and positively associated with forward linkages' indicator with effect size of 0.056. Labor productivity variable increases with both capital stock and wages. While the model with the two-way fixed effects presents a significant improvement compared to the pooled OLS as it accounts for sectors' heterogeneity and time fixed effects, its estimates may be biased in case the units exhibit strong interdependence through input-output connections. That is, ignoring this interdependence may lead to erroneous inferences. We verify such hypotheses by assessing potential interdependence between sectors in the disturbances of the fixed effects models using Moran's *I*.

As discussed above, the study models the interdependence between sectors using an input-output weight matrix. 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 3.

Table 3. 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

[4] The null hypothesis is that there is no spatial correlation and the Moran's *I* asymptotically follows a normal distribution.

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

Table 3 indicates that several Moran's *I* statistics are significant implying that the two-ways fixed effects still suffer interdependence in the error term, which nature must be sorted out. In fact, Lagrange Multiplier tests lend support to a significant interdependence arising from the inclusion of the dependent variable or the error term. Therefore, it is of key importance to correctly specifying the models. We estimate a SAR model accounting for the weighted dependent variable with weight matrix and the SEM model accounting for the weighted error term with weight matrix. We find that spillovers coefficients (Rho/Lambda) in both SAR and SEM models are positive and significant. As we previously mentioned, the SAR model indicates a global spillovers effects where change in one explanatory variable affects not only productivity 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 having non null entries in the weight matrix *via* the disturbances. Consequently, it is necessary to determine the nature of the spillovers effects before engaging in interpreting the estimation.

Elhorst (2010), conveys that in case of strong dependence, goodness of fit criterions 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 (table 4), the SAR model fits the data generating process best. That is, the spillovers effects are of global nature, and changes in explanatory variables are likely to not only affect the own sectors, but also potentially all sectors via the input-output weight matrix. As previously discussed, the direct and indirect effects do not stand for marginal effects in the case of SAR models. Therefore, an estimation of the direct and indirect effects needs to be set forth. One central contribution of the (LeSage & Pace 2009) is the construction of the distribution of the direct and indirect effects drawn from a multivariate normal distribution of the point estimates in table 4.

Table 4. Estimation of spatial and non-spatial models

	(1)	(2)	(3)	(4)
	Dependent Variable: Employment (Log of productivity by employee)			
	Models without Spillovers		Models with Spillovers	
Variables	OLS	Two-ways FE	SAR	SEM
FVA	-0.29***	-0.087	-0.08*	-0.12**

	(0.031)	(0.053)	(0.047)	(0.05)
DVX	0. 10***	0.056**	0.062***	0.072***
	(0.030)	(0.026)	(0.023)	(0.022)
K	0.62***	0.47***	0.41***	0.44***
	(0.018)	(0.022)	(0.021)	(0.021)
W	0.026*	0.16***	0.06**	0.12***
	(0.014)	(0.026)	(0.026)	(0.030)
Rho/Lambda			0.35***	0.77***
			(0.039)	(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 dependence	43.65***	6.6**		
LL			517.5	498.24
AIC			-885	-846.49
BIC			-535.16	-496.66

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

The simulated direct, indirect and total effects are reported in table 5. First, one can sense the bias that arises from excluding the cross sectors spillovers effects in the labor productivity. The backward linkages indicator becomes significant suggesting that productivity significantly decreases within the sector as a result of higher GVC participation by the channel of import of intermediates used in goods' export. Specifically, 10% increases in the level of backward linkages decreases labor productivity by 0.8%. This implies that the imported intermediates, used in the country's exports, act as substitute for domestically produced goods, which leads the productivity to decline. Interestingly, labor productivity does not only increase with forward linkages within own sectors but also across sectors lending support to substantial spillover effects. In particular, a 10% increase in forward linkages indicator increases not only labor productivity by 0.62% in own sectors but also labor productivity across sectors by 0.3% with a total impact on labor productivity of 0.95%. As a result, it is clear that failing in considering interdependence between sectors leads to a downward bias in the impact that GVCs participation's indicators have on productivity. While stock capital seems unassociated with labor productivity, the level of wages significantly boosts labor productivity both within and across sectors. This implies that higher wages in own sectors stimulates and boosts productivity and that these effects transcend to other sectors linked via the weight matrix.

Overall, these findings suggest that GVCs participation plays a substantial role in productivity's changes not only within own sectors but also across sectors through the inputs-outputs linkages. However, and since GVCs participation's impact varies considerably among different sectors as a result of heterogeneous technologies and labor skills, it is central to assess its impact on productivity for different sectors.

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

In fact, the distribution of the value added is U-shaped (Baldwin, 2012) and changes according to the sector position in the supply chain. As a matter of fact, there is evidence that a significant value added accrue pre and post-manufacturing service and that the distribution of value added in manufacturing changes from high tech to small-scale sectors (Banga, 2018). As a result, it would be legitimate to examine the impact of GVCs participation's impact on productivity for different sectors. In this study, we focus mainly on service and manufacturing sectors because of data limitations. Therefore, we divided the data into two subsamples: service and manufacturing, then, we run the estimation using our preferred model[5]. The estimation results of this procedure accompanied with the fixed effects are reported in table 6. The results in column 1 and 2 point to the importance of accounting for the spillovers effects arising from the interdependence in the manufacturing sectors. In columns 2 and 3 of table 6, the autoregressive parameter is significant and positive at the magnitude of 0.51 indicating a significant input-output interdependence in labor productivity across manufacturing sectors. In fact, changes in labor productivity in one sector transmit through the autoregressive parameters to all other sectors via the input-output relations. Furthermore, the results reveal a negative association between the backward linkages and labor productivity in manufacturing industries. Specifically, a 10% increase in the backward linkages is associated with 3.6% decline in labor productivity within own sectors and 3.5% across sectors, with a total decline in productivity of 7.1%

[5] We construct a sub-weight matrix for each category of sectors.

both within and across manufacturing sectors. The negative association between backward linkages and productivity in previous results seems to be driven mainly by manufacturing backward linkages' effects, that is, import of manufacturing intermediates used in the country's export acts a substitute of domestic goods, which culminates in declining value added and consequently the productivity. On the other hand, 10% increase in manufacturing forward linkages yields 0.65% decline in productivity at the 10% significance level.

We find that labor productivity rises with the stock capital both within and across manufacturing sectors with a total increase of 6.4% as a result of 10% increase in the stock of capital per employee.

Table 6. Sectors GVC participation impact of Productivity

Dependent variable: log of Labor productivity						
	(1)	(2)	(3)	(4)	(5)	(6)
	Manufacturing			Services		
Variables	Fixed Effects	SAR		Fixed Effects	SAR	
		Direct Effects	Indirect Effects		Direct Effects	Indirect Effects
FVA	-0.32***	-0.36***	-0.355***	0.002	0.020	0.004
	(0.078)	(0.071)	(0.12)	(0.074)	(0.068)	(0.017)
DVX	-0.082*	-0.065*	-0.064	0.11***	0.10***	0.026***
	(0.043)	(0.038)	(0.043)	(0.032)	(0.029)	(0.010)
LgK	0.36***	0.32***	0.32***	0.61***	0.58***	0.14***
	(0.039)	(0.035)	(0.090)	(0.029)	(0.029)	(0.038)
LgW	0.23***	-0.032	-0.031	0.082*	0.033	0.008
	(0.065)	(0.066)	(0.074)	(0.029)	(0.028)	(0.0067)
Rho		0.51***			0.20***	
		(0.063)			(0.045)	
LL		251.83			311.17	
AIC		-427.66			-518.35	
BIC		-291.48			-303.3	

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

In columns 5 and 6, the autoregressive parameter is positive and significant with a magnitude of 0.2, suggesting a substantial input-output interdependence in the labor productivity across service sectors. That is, changes in labor productivity in one sector significantly affect productivity in sectors with magnitude decaying with the degree of connectivity. As discussed before, evidence shows that a substantial portion of value added accrues in the service sectors linkages to the value added and productivity (Baldwin, 2012). In the case of Turkey service's GVCs participation, the forward linkages are a key channel through which productivity is boosted in service sectors. In fact, labor productivity significantly increases with the forward linkages indicator both within and across service sectors. Specifically, a 10% increase in the forward linkages ratio is associated with 1% increases with labor productivity within own sectors and 0.26% across sectors with a total increase in the productivity of 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 happen through learning by exporting and technology dissemination (De Loecker, 2012). However, the results provide evidence that the learning by exporting process is not confined within its own sectors but transcends to include other sectors through input-output interdependence, that is, spillover effects. Finally, labor productivity significantly rises with capital stock both within and across service sectors.

5- Concluding remarks

This study provides evidence that GVCs participation, through backward and forward linkages, is significantly associated with productivity at the sector level. Using spatial econometric approach to model input-output dependence in productivity between sectors, the study provides evidence of significant spillovers effects in productivity across sectors. The study also finds evidence that GVCs participation not only affects productivity within own sectors (direct effects) but also across sectors through input-output dependence (indirect effects). Particularly, the results suggest that productivity in manufacturing and service sectors is susceptible of a significant spillover effect across sectors and that change in productivity in one sector positively transmits to other economy's sectors through the input-output relations. This is in line with Balassa's (1961) assumption that linkages between sectors are key sources of productivity spillovers. Finally, a Monte Carlo simulation suggests that GVC participation via backward linkages is negatively associated with productivity both within and across manufacturing industries lending support to the substitution hypothesis of the imported intermediates, and that GVC participation, via forward linkages, boosts productivity within and across service's sectors. Importantly, this study sheds some light on the channels through which GVC affects productivity. It also empirically tests Balassa's (1961) hypothesis, that linkages between industries are a main source of productivity spillovers. Understanding these channels and mechanisms through which the spillovers take place across industries is central for tailoring efficient policies. An important area of future research is to model the input-output relations both across sectors and countries using the WIOD 2016.

References

Amiti, M., & Konings, J. (2007, 12). Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia. *American Economic Review, 97*(5), 1611-1638.

Badinger, H., Egger, P., Badinger, H., & Egger, P. (2008). Intra- and Inter-Industry Productivity Spillovers in OECD Manufacturing: A Spatial Econometric Perspective. *CESifo Group Munich Working Paper Series*.

BALASSA, B. (1961, 2 1). TOWARDS A THEORY OF ECONOMIC INTEGRATION. *Kyklos, 14*(1), 1-17.

Baldwin, R. (1995). The Effects of Trade and Foreign Direct Investment on Employment and Relative Wages. *National Bureau of Economic Research*.

Baldwin, R., & Venables, A. (2013, 7). Spiders and snakes: Offshoring and agglomeration in the global economy. *Journal of International Economics, 90*(2), 245-254.

Calculating Trade in Value Added. (n.d.). Retrieved from https://www.imf.org/en/Publications/WP/Issues/2017/07/31/Calculating-Trade-in-Value-Added-45114

Caselli, F., & Wilson, D. (2004). Importing technology $. *Journal of Monetary Economics, 51*, 1-32.

Constantinescu, C., Mattoo, A., & Ruta, M. (2019). Does vertical specialisation increase productivity? *World Economy, 42(8)*, 2385-2402. Blackwell Publishing Ltd.

de Backer, K., & Yamano, N. (2012, 11 28). International Comparative Evidence on Global Value Chains. *SSRN Electronic Journal*.

Elhorst, J. (2010, 3). Relever le niveau de l'économétrie spatial appliquée. *Spatial Economic Analysis, 5*(1), 9-28.

Filiztekin, A. (2004). *OPENNESS AND PRODUCTIVITY GROWTH IN TURKISH MANUFACTURING.*

Global Value Chains: What are the Benefits and Why Do Countries Participate? (n.d.). Retrieved from https://www.imf.org/en/Publications/WP/Issues/2019/01/18/Global-Value-Chains-What-are-the-Benefits-and-Why-Do-Countries-Participate-46505

Gollop, Fraumeni, B., & Jorgenson, D. (1987). *Productivity and U.S. Economic Growth.* Harvard University Press.

Grossman, G., & Rossi-Hansberg, E. (2008, 12). Trading tasks: A simple theory of offshoring. *American Economic Review, 98*(5), 1978-1997.

Gündoğdu, C., & Saracoğlu, D. (2016). Participation of Turkey in Global Value Chains: An Analysis Based on World Input Output Database. *ERC Working Papers*.

Hummels, D., Ishii, J., & Yi, K.-M. (2001). The nature and growth of vertical specialization in world trade. *Journal of International Economics, 54*(1), 75-96.

Johnson, R., & Noguera, G. (2012, 3). Accounting for intermediates: Production sharing and trade in value added. *Journal of International Economics, 86*(2), 224-236.

Koopman, R., Powers, W., Wang, Z., Wei, S.-J., Koopman, R., Powers, W., . . . Wei, S.-J. (2010). Give Credit Where Credit Is Due: Tracing Value Added in Global Production Chains. *National Bureau of Economic Research Working Paper NO. 16426*.

Koopman, R., Wang, Z., & Wei, S. (2014, 2). Tracing value-added and double counting in gross exports. *American Economic Review, 104*(2), 459-494.

Kummritz, V. (2016). *Graduate Institute of International and Development Studies Center for Trade and Economic Integration Working Paper Series Do Global Value Chains Cause Industrial Development? Do Global Value Chains Cause Industrial Development? *.*

Los, B., Timmer, M., & de Vries, G. (2015, 1 1). How global are global value chains? A new approach to measure international fragmentation. *Journal of Regional Science, 55*(1), 66-92.

Nasser Dine, MN. (2019). Impact of Global Value Chains' Participation on Employment in Turkey and Spillovers Effects. *Journal of Economic Integration, 34(2),* 308-326.

Ozler, S., & Yilmaz, K. (2009, 7). Productivity response to reduction in trade barriers: evidence from Turkish manufacturing plants. *Review of World Economics, 145*(2), 339-360.

Taglioni, D., & Winkler, D. (2016). *Making Global Value Chains Work for Development.* The World Bank.

Timmer, M., Dietzenbacher, E., Los, B., Stehrer, R., & de Vries, G. (2015, 8 1). An Illustrated User Guide to the World Input-Output Database: The Case of Global Automotive Production. *Review of International Economics, 23*(3), 575-605.

Timmer, M., Los, B., Stehrer, R., & de Vries, G. (2013, 10). Fragmentation, incomes and jobs: An analysis of european competitiveness. *Economic Policy, 28*(76), 613-661.

Timmer, M., Los, B., Stehrer, R., & de Vries, G. (2016). An Anatomy of the Global Trade Slowdown based on the WIOD 2016 Release. *GGDC Research Memorandum*.

Appendix

Suppose there are S sectors and N countries and let X be the (SNxSN) intermediates input-output matrix, which row $(x_{i,.}(s))$ represents a country i sector s output of intermediate used as input either domestically or abroad and column $(x_{.,i}(t))$ represents the country i sector t use of intermediates sourced either domestically or from abroad.

In order to calculate the FVA and DVX indicators, we follow Leontief input-output model (Leontief 1936), broadly used in the literature of GVC analysis. We calculate the Leontief inverse matrix, which its pre and post multiplication by proper matrices can allow tracing the source of all intermediates and intermediates' intermediates involved in a country's exports. The calculation is as following:

Let $y_i(s)$ be the value of the output of the industy s of the country i. We can write the output $y_i(s)$ as the sum of all intermediates and final demands used both domestically and abroad.

$$y_i(s) = \sum_j \sum_t x_{ij}(s,\ t) + \sum_j f_{ij}(s) \qquad (1)$$

Let the (SNxSN) matrix A which elements are $a_{ij} = \frac{x_{ij}(s,t)}{y_j(t)}$ and the vector f of dimension (SNx1) which elements are $f_i(s) = \sum_j f_{ij}(s)$. Then equation (1) can be written in a matrix form as following:

$$y = Ay + f$$

$$\Leftrightarrow \qquad y = (I - A)^{-1} f \qquad (2)$$

Where $(I - A)^{-1}$ is the Leontief inverse (Leontief 1936), which elements $(a_{st})_{s,t}$ represent the quantity of the output in industry s needed to produce one additional unit of output in the industry t. To see this, consider the final demand produced by say country-industry k, f_k. It requires the use of Af_k intermediates, which in turn, requires $A^2 f_k$ and so on. This process yields a geometric series that converges to $(I - A)^{-1}$ which accounts for all intermediates involved in the production of the final demand f_k.

The pre and post multiplication of the Leontief inverse by proper matrices allows investigation of different factors involved in the production and exports' processes. Let $p_i(s)$ be the value added per gross output produced in the industry *s* of the country *i*. let $\hat{p}$ be the (SNxSN) diagonal matrix which elements are $p_i(s)$. Let $e_i(s)$ be the gross export of a sector *s* of a country *i*.

$$e_i(s) = \sum_{j \# i} \sum_t x(s,t)_{ij} + \sum_{j \# i} f_{ij}(s)$$

Let *E* an (SNxSN) diagonal matrix which elements are $(e_i(s))_i$ if the industry *s* is in the country *i* and 0 if not.

Finally let the (SNxSN) matrix *T*

$$T = \hat{p}(I - A)^{-1} E \qquad (3)$$

Equipped with the matrix *T*, the FVA for a given country *i* can be obtained by summing all corresponding columns and subtracting the diagonal block of *T*. Likewise the DVX for a given country *j* can be obtained by summing up all corresponding rows and subtracting the diagonal block of *T*[6].

[6] For detailed calculation see Aqib et al (2017)