The Impacts of Production Lengths on Sectoral Performance: The Case of EU and US Industries

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Abstract:

This paper aims to understand how the extent of integration affects sectoral total factor productivity and value added growth for the periods 1996-2011 and 2005-2015 for 14 European countries and the United States. Our estimation results show that while forward production length raises the total factor productivity and value added of manufacturing sectors only for the earlier period, it promotes both sectoral performance measures for the service sectors in both periods. For both manufacturing and service sectors and both periods, we obtain a compelling evidence of negative effects of backward length of non-GVCs on total factor productivity and value added growth. We also find that backward length of GVC activities increases value added growth. For service sectors, when forward length of non-GVCs activities rises, sectoral performance variables are positively affected, which reveals the complementarity role of services sector in domestic production. Strong evidence for the negative impact of buying from domestic market or importing final products from international market and the positive impact of importing intermediates, participating in GVCs, on sectoral performance indicate that the success of industries is highly dependent on their efficient integration in the global production process.

Keywords: Production Lengths, Upstreamness, Sectoral TFP Growth, Sectoral Value-Added Growth

JEL Codes: F14, F43, F68, O24

1. Introduction

In the last thirty years, rapidly enhancing technology and decreasing transportation costs tightly connect modern economies via value added and production chains. The position of industries in these production chains carries crucial information regarding forward and backward linkages of industries across the global network. Participating into both of these linkages provides many opportunites for sectors such as optimal resource allocation, finer division of labor, higher specialization, economies of scale, technology spillovers, and higher productivity. Even though this high interconnection makes countries more defenseless to foreign shocks like in continuing Covid-19 pandemic, contacting with producers and suppliers from distinct geographies spreads risks involved in trade activities. Furthermore, the advanced transformation system feeded by high level of technology and investments can make global production more secure and sustainable.

Concept of counting production stages is proposed by Dietzenbacher and Romero (2007). This is defined as a average propagation length (APL) which indicates the complexity of production process. Fally (2012) suggests a different distance to final demand variable, which measures the how many stages are passed before reaching to final demand. The index is also known as the upstreamness index measuring the countries' position in total production chains. Note that industries are located more upstream in value chains if they sell relatively more intermediate goods or services. Moreover, Antras and Chor (2013) propose the downstreamness index to measure the average number of production stages.

Recently, Wang et al. (2016) further decompose value added into pure domestic, traditional, and GVCs parts (even in simple and complex portions). Thus, we are able to measure the depth of production and GVCs activities further. Note that their new length measure based on forward linkages is mathematically close to the upstreamness index proposed by Fally (2012), their new length measure based on backward linkages is qualitatively similar to the downstreamness index proposed by Antras and Chor (2013). However, the earlier two studies could not differentiate the production process and consider about the full production process, rather than GVCs. While the indices developed by Wang et al. (2016) mainly depend on initial value added or primary inputs of sector, the calculations in Fally (2012) and Antras and Chor (2013) depend on gross output. Probably because of these differences, Wang et al. (2016) find a longer production chain and a higher global value chain participation during the 1995-2011 period.

Although these new indices are utilized by many researchers, these studies are mostly descriptive studies. For example, Ye and Voigt (2014) figure out that the upstreamness of Chinese products in GVCs has been increasing compared to the other BRICS countries. Chor et al. (2014) report that Chinese export is more downstream than its imports over the period 1992-2011. Suganuma (2016) claims that global upstreamness has risen in the mid-2000s using the WIOD database, which is mainly driven by the manufacturing industries. Hagemejer and Ghodsi (2017) argue that intermediate shares of both imports and exports have been on the rise in New Member States in the European Union such as the Czech Republic, Hungary, Poland, Slovakia and Slovenia since 1995. In fact, the upstreamness trend in these countries is similar to the EU-15 level towards the year 2011. Finally, Hagemejer (2018) points out that importing intermediate goods and being far away from final consumers are associated with faster productivity growth of New Member States for the period between 1995 and 2009.

Hence, the main goal of this paper is to investigate the impacts of production lengths of industries by focusing on developed countries. Specifically, we first look at the effects of both backward and forward lengths of sectors in production chains on the sectoral performance of countries. We then investigate whether the impacts of backward and forward lengths of both non-GVCs and GVCs activities on sectoral performance vary. One of the contributions of our paper is not only to use length measures provided by Fally (2012) and Antras and Chor (2012) but also to employ a variety of both backward and forward lengths proposed by Wang et al. (2016). The existing empirical literature just focuses on upstreamness (Ito and Vezina, 2016; Hagemejer, 2018; Del Prete et al., 2018). In contrast, importing activities are the other and crucial side of the trade activities. Therefore, we also employ backward length in our empirical analysis. Our second contribution is that GVCs and non-GVCs categorizations of lengths are first employed in the empirical analysis. To the best of our knowledge, although production length is employed in many studies, there is no empirical studies investigating the role of GVC lengths on sectoral performance.

Our estimation results show that while forward production length increases the total factor productivity and value added in the manufacturing sectors only in the first period, it raises both of the performance measures for service sectors in both periods. Since manufacturing sectors are relatively more affected from the 2008 Global Financial Crisis (see, Milio et al., 2014), the relationship between forward production length and sectoral performance variables is not sustained. This relationship continues to exist for service sectors in the second period probably because service sectors depend relatively more on domestic markets. For both manufacturing

and services sectors and both periods, there is a strong evidence for the negative effect of backward length of non-GVCs on total factor productivity and value added growth, mainly resulting from imported final products and domestic intermediates near to final products. For services sectors, when forward lengths of non-GVCs activites rise, sectoral performance variables are positively affected. This unveils the complementarity role of service sector in domestic production activities. To clarify the contemporary discipline of the world economy, services have the supporting roles for international manufacturing activities in increasing efficiency in supplying, production, and marketing.

This study is organized as follows. The next describes the datasets and variables used in this study. The third section explains the methodology and estismation strategy. The fourth section presents the empirical results. The final section provides concluding remarks and policy recommendations.

2. Data

This study employs two main databases. The variables regarding sectoral total factor productivity, value added, capital stock, and number of employees are taken from the first dataset, the EU KLEMS (2017)[1]. By closely following the Wang's value added and final demand decomposition structure, a large variety of sectoral gross and value-added trade variables are computed by utilizing the Inter Country Input Output Tables (OECD, 2016 and 2018)[2]. Note that since 2016 and 2018 TiVA editions are not fully compatible with each other[3], we choose to have two separate sets of estimates. The time span of the first and second datasets are between the years 1996-2011 and 2005-2015, respectively.[4] Variables in the national currencies from the EU KLEMS database are converted into US dollars via employing exchange rates from Eurostat (Eurostat, 2019). Although the coverage of both databases regarding country and sectors are larger than our operational sample, we choose to exclude some countries and industries in order to construct exact industrial match as much as possible.

[1] Jäger, 2018. We also employ WIOD sample (Timmer et al., 2015) for a robustness check of our results. We get the approximately the same results with that we found in here. Because of space limitation, the results are not shown here, but they are available upon request.
[2] WTO/OECD (2016); OECD (2019a).
[3] TiVA 2016 is based on SNA 1993 whereas TiVA 2018 is based on SNA 2008 statistics (OECD, 2019a).
[4] The matching strategy of industry codes are shown in Appendix Table A1.

We have thus 14 and 17 sectors of 14 European countries[5] and the United States for the first and second datasets, respectively.

For the industry level distance to final consumption and length of GVCs, we utilize the OECD ICIO Tables (OECD, 2019b). According to Wang et al. (2016)[6] decomposition methodology, the forward linkages (PLv) are composed of domestic inputs to produce domestic final products; production of final products as a part of traditional trade; domestic intermediate products for production of foreign products; and domestic intermediate products for production of other countries' exported products. Similarly, the backward linkages (PLy) are composed of domestic inputs to produce domestic final products; foreign final inputs as a part of traditional trade; foreign intermediate products for production of domestic products; and foreign intermediate products for production of exported products. In our analysis, we take the weighted averages of the first two and the last two measures and name them as a non-GVC part and a GVCs part, respectively.

Table 1 summarizes the descriptive statistics of variables employed in our estimates.[7] According to the eye inspection of forward linkages and sectoral performance variables for the years 1996, 2005, and 2015[8], the highest production and GVCs lengths are observed in finance and information technology sectors, which means that these sectors produce high value added and are located into upstream part of production and GVCs. Moreover, the higher values of sectoral performance variables are notable in finance and information technology sectors. For backward lengths, the highest production and GVCs lengths are observed in food and textile sectors, which means that these sectors mostly depend on the imported intermediates. Even if we do not observe any strict patterns between them, the high value of sectoral performance variables are notable in finance and information technology sectors, which are upstream sectors.

[5] Austria, Germany, Denmark, Spain, Finland, France, United Kingdom, Italy, Luxembourg, Netherlands, Slovak Republic, Slovenia, Sweden, Czech Republic. Actually, KLEMS contains 28 countries however some of them do not have capital information at all such as Belgium, Bulgaria, Cyprus, Croatia, Ireland, Latvia, Portugal, and Romania. Furthermore, since TFP is already calculated in KLEMS dataset, we prefer to employ this variable instead of our calculations. This also lose all observations of some countries such as Estonia, Greece, Hungary, Lithuania, Malta, and Poland.

[6] Value added measures include taxes of sectors as different from the Wang's calculations.

[7] In Table 1, "V" represents the share of forward related volumes in output and "Y" represents the share of backward related volumes in output.

[8] We weight the country-sector level lengths with the share of their relevant country level trade volumes in total volumes to reach the measures at sectoral levels.

Table 1: Summary Statistics

	The First Dataset						The Second Dataset					
Variables	**Manufacturing**		**Service**		**Total**		**Manufacturing**		**Service**		**Total**	
	# of Obs.	Mean	# of Obs.	Mean	# of Obs.	Mean	# of Obs.	Mean	# of Obs.	Mean	# of Obs.	Mean
TFP growth	1,313	0.02	2,704	0.00	4,797	0.01	1,164	0.01	2,260	0.00	4,084	0.00
Value added growth	2,953	0.04	6,073	0.04	10,770	0.03	2,271	0.01	4,287	0.02	7,786	0.01
Capital stock p.w. (constant USD)	1,553	143378	3,856	1785518	6,552	1191495	1,186	183033	2,727	1558146	4,725	1069347
PLv	2,958	1.93	4,437	1.79	9,367	1.97	1,595	1.93	4,147	1.87	6,699	1.91
PLv_nonGVC	2,937	1.42	4,413	1.51	9,321	1.59	1,594	1.42	4,147	1.57	6,698	1.56
PLv_GVC	2,958	3.42	4,395	4.44	9,325	4.10	1,595	3.44	4,147	4.30	6,699	4.11
PLy	2,958	2.52	4,437	1.80	9,367	2.11	1,595	2.38	4,147	1.86	6,699	2.04
PLy_nonGVC	2,923	1.85	4,340	1.48	9,168	1.65	1,587	1.76	4,100	1.52	6,625	1.61
PLy_GVC	2,958	3.84	4,437	3.97	9,367	3.89	1,595	3.80	4,147	3.92	6,699	3.88
V_D/Output	2,937	0.14	4,437	0.48	9,346	0.34	1,594	0.17	4,147	0.44	6,698	0.36
V_RT/Output	2,958	0.10	4,437	0.07	9,367	0.08	1,595	0.12	4,147	0.07	6,699	0.08
V_GVC/Output	2,958	0.09	4,437	0.07	9,367	0.08	1,595	0.09	4,147	0.07	6,699	0.07
Y_D/Output	2,923	0.20	4,437	0.49	9,269	0.36	1,587	0.22	4,145	0.45	6,689	0.38
Y_RT/Output	2,958	0.17	4,437	0.06	9,367	0.09	1,595	0.17	4,147	0.06	6,699	0.08
Y_GVC/Output	2,958	0.18	4,437	0.08	9,327	0.11	1,594	0.17	4,147	0.08	6,698	0.11

3. Methodology

To evaluate the impacts of production length on sectoral performances, we construct the following empirical model:

$$DV_{c,i,t} = \beta_0 + \beta_1 DV_{c,i,t-1} + \beta_2 K_{c,i,t} + \beta_3 L_{c,i,t} + \beta_4 X_{c,i,t} + \beta_5 T_t + \varepsilon_{c,i,t} \qquad (1)$$

where T_t stands for time dummies and c and i stands for countries and sectors, respectively. $DV_{c,i,t}$ stands for the two main sectoral performance variables: total factor productivity and value added growth. $K_{c,i,t}$ is capital per worker. $L_{c,i,t}$ represents forward (backward) production length. $X_{c,i,t}$ represents backward (forward) length or relevant backward (forward) volumes.[9] The backward volume is mainly composed of three parts and expressed as shares of sectoral outputs: (i) Domestic value added from all domestic sectors used in domestic final products (Y_D/Output), (ii) domestic value added from all domestic sources used in exported final products (Y_RT/Output), and (iii) domestic (re-imported) and foreign value added in intermediate imports from all sectors which are both domestically used and exported (Y_GVC/Output). Similarly, the forward volume is also mainly composed of three parts and expressed as shares of sectoral outputs: (i) Domestic value added of sector used in domestic markets (V_D), (ii) domestic value added of sector used in exported final products (V_RT), and (iii) domestic value added of sector used in exported intermediate products including production sharing between two or more countries (V_GVC). Because all these backward and forward volume variables are expressed as shares of outputs, we consider these variables as factor variables and include only the last two variables in our models and make our interpretations with respect to the first (omitted) variable, which is the share of domestically supplied products and domestically used products in the total sectoral output. Moreover, we also extend our model by dividing the production lengths into two categories as non-GVC and GVC.[10]

[9] When we look at the effects of forward production linkages, we control backward volumes because the forward linkage index is already weighted average of forward volume variables. In fact, by doing so, we are able to control both backward and forward linkages in the production process.

[10] In these models, we mainly follow the calculations explained in Wang et al. (2016) regarding the construction of each length measure. For robustness checks, we also employ Fally (2012) and Antras and Chor (2013) methodologies to calculate production lengths and analyze their effects on sectoral performance. We find identical results, but as explained above, we cannot differentiate these total indices into GVC or non-GVC parts though. Therefore, we apply the methodology of Wang et al. (2016) to calculate production and GVC lengths employed in the estimates. The results with Fally (2012) and Antras and Chor (2013) calculations are available upon request.

For the both samples, we utilize the System Generalized Methods of Moments (SGMM) industries to investigate the association between lengths of GVCs and sectoral performance of manufacturing and services.[11] The methodology utilizes first difference so that time-invariant heterogeneity across sectors can be eliminated (Arellano and Bover, 1991). SGMM is superior than OLS and FE in terms of endogeneity issue because the methodology uses lagged variables of dependent variables as instrumental variables.[12]

4. Empirical Results

This paper applies the system GMM estimation technique to understand the association between the lengths of production and sectoral performance variables of manufacturing and service industries. Tables 2 and 3 present the results for the manufacturing sample. Tables 4 and 5 display the results for the service sample.

Manufacturing - Total Factor Productivity Growth:

Panel I of Table 2 presents the estimations for the impact of production lengths on TFP growth for the manufacturing sectors for both datasets. At the first two columns of Table 2, forward and backward lengths are employed individually and both have positive impacts on TFP growth. In the third column, we then include both length measures in the analysis. In this case, forward length continues to be significant. To check the robustness of our results, we also employ backward volumes instead of the length measure at the last two columns. The forward length is still significantly positive in these specifications. The same sensitivity analysis is also applied for backward length, which can be seen from the fourth and fifth columns. The statistically significant and positively estimated coefficients on forward length for the first period implies that TFP growth rises in sectors that are further away from final demand. For the first period, backward length has also the positive but weak relationship with TFP growth. In the second period, all production length measures lose their significances. One notable point

[11] In the empirical literature, studies generally employ the LSDV estimation methodology. We also do our analysis with this technique. In this analysis, we add not only time dummies but also country and sectoral dummies into our models. Comparing LSDV and SGMM estimations, we find very similar results and get the similar conclusions with our results. Because of the space limitations, the results are not presented in here, but they are available upon request.

[12] In this technique, the number of instruments should be less than or equal to the number of cross units. The exogeneity and power of the instruments are tested by Hansen test where high p values are required. In addition, autocorrelation is tested by Arellano-Bond tests. All specifications in all estimations are passed from both Hansen and AR(2) tests.

about the second period is slowdown of global trade activities after the 2008 Global Financial Crisis. World Development Report (2020) asserts that GVCs activites have slowed down after this crisis and even fell the years between 2011 and 2014.

To reiterate, one of the concerns is to compare the effects of non-GVC and GVC lengths, but total production length measures do not allow us to investigate it. Thus, Panel II of Table 2 presents the relationships between non-GVC/GVC lengths and TFP growth. We find the significantly negative effect of backward non-GVC lengths on TFP growth in both data periods. This may result from the high volume of imported final products and low complexity of domestic intermediates (very close to final products). In the second period, significantly and positively estimated coefficients on the length of imported intermediates suggest that a complex and longer backward value chain would be one of the determinants of high TFP growth. This emphasizes the necessity and importance of imported intermediates in the production processes even if there is a financial turmoil around the world (see Bernard (2007) and Antras et al. (2017) for the further discussion on the importance and complementarities of imported intermediate products).

Manufacturing – Value Added Growth:

Panel I of Table 3 shows the estimation results for value added growth and production lengths of manufacturing sectors for both datasets. In the first period, both forward and backward lengths raise value added growth. These impacts do not sustain their significances in the second period as in the analysis of TFP growth. Panel II of Table 3 looks at the effects of non-GVC and GVC lengths on the value added growth. Similar to Table 2, backward lengths of non-GVC are negatively and significantly related to value added growth, which means that importing final goods/services decreases sectoral value added growth. In contrast, there is an evidence of a positive effect of complexity or length of imported intermediates on the value added growth. These effects also persist in the second period. Therefore, we can assert that manufacturing sectors efficiently integrate international markets and take some precautions in order not to disrupt the possible trade gains.

Table 2: Total Factor Productivity Growth and Production/GVCs Lengths, Manufacturing

Manufacturing	The First Dataset							The Second Dataset						
Panel I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv	0.096**		0.164*			0.100*	0.091*	0.141		0.122			0.084	0.074
	(0.040)		(0.085)			(0.058)	(0.049)	(0.164)		(0.109)			(0.090)	(0.096)
PLy		0.101*	0.039	0.154	0.084*				0.123	0.076	0.108	0.006		
		(0.055)	(0.053)	(0.108)	(0.044)				(0.100)	(0.123)	(0.086)	(0.092)		
Lagged TFP growth	-0.103**	-0.009	-0.048	-0.291	-0.074	-0.096	-0.114	-0.178	-0.236	-0.270*	-0.238**	-0.364***	-0.213**	-0.284**
	(0.041)	(0.114)	(0.116)	(0.222)	(0.104)	(0.079)	(0.086)	(0.131)	(0.144)	(0.140)	(0.109)	(0.105)	(0.095)	(0.112)
Capital	0.004	0.002	0.007	0.107	0.016	0.013	0.007	-0.002	-0.033	-0.061	-0.041	-0.014	0.026	0.010
	(0.030)	(0.022)	(0.030)	(0.089)	(0.027)	(0.025)	(0.023)	(0.105)	(0.038)	(0.045)	(0.025)	(0.052)	(0.057)	(0.072)
V_GVC/Output				2.447*	0.666*						0.411	0.741		
				(1.393)	(0.358)						(0.353)	(1.217)		
V_RT/Output					0.132							0.221		
					(0.279)							(0.609)		
Y_GVC/Output						0.480**	0.173						0.528**	0.565*
						(0.190)	(0.234)						(0.261)	(0.313)
Y_RT/Output							0.325							-0.064
							(0.249)							(0.358)
# of Obs.	971	971	971	971	971	971	971	683	683	683	683	683	683	683
# of country-sector	79	79	79	79	79	79	79	66	66	66	66	66	66	66
# of instruments	62	59	74	74	85	77	89	60	60	70	70	71	70	71
AR(2)	0.779	0.864	0.992	0.246	0.850	0.789	0.711	0.783	0.995	0.816	0.989	0.542	0.701	0.842
Hansen (p)	0.437	0.227	0.265	0.282	0.602	0.450	0.761	0.214	0.333	0.369	0.532	0.585	0.765	0.597
Panel II	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv_GVC	0.061		0.067			0.048	0.015	0.073		-0.006			0.040	0.117
	(0.041)		(0.103)			(0.040)	(0.039)	(0.100)		(0.108)			(0.078)	(0.096)
PLv_nonGVC	-0.211**		-0.183			-0.047	-0.029	-0.072		-0.056			0.124	0.135
	(0.101)		(0.165)			(0.085)	(0.072)	(0.123)		(0.136)			(0.225)	(0.208)
PLy_GVC		0.055	0.133	0.108	0.091				0.304	0.567*	0.600*	0.458*		
		(0.141)	(0.106)	(0.133)	(0.137)				(0.202)	(0.315)	(0.308)	(0.265)		
PLy_nonGVC		-0.303***	-0.266**	-0.222**	-0.215				-0.246*	-0.347*	-0.664***	-0.315**		
		(0.105)	(0.103)	(0.109)	(0.171)				(0.127)	(0.191)	(0.246)	(0.138)		
# of Obs.	971	970	970	970	970	971	971	683	683	683	683	683	683	683
# of country-sector	79	79	79	79	79	79	79	66	66	66	66	66	66	66
# of instruments	78	81	81	85	87	85	87	70	70	73	72	73	71	73
AR(2)	0.757	0.963	0.876	0.982	0.804	0.896	0.818	0.901	0.959	0.466	0.443	0.363	0.864	0.556
Hansen (p)	0.251	0.497	0.286	0.680	0.615	0.488	0.531	0.311	0.758	0.607	0.677	0.732	0.570	0.608

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies are included in all specifications. In the second dataset, we also include the second lag of dependent variable. The Hansen test is a test of overidentification restrictions. Under the null hypothesis, the test statistic is distributed as a chi-squared in the number of overidentifying restrictions, p-values are presented. System GMM results are two-step estimates. The two-step standard errors are computed in accordance to the Windmeijer (2005) finite-sample correction. All estimates in Panel II employ the same control variables used in Panel I.

Table 3: Value Added Growth and Production/GVCs Lengths, Manufacturing

Manufacturing	The First Dataset							The Second Dataset						
PANEL I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv	0.125***		0.133*			0.186***	0.235**	0.076		0.139			0.052	0.059
	(0.044)		(0.076)			(0.051)	(0.099)	(0.079)		(0.093)			(0.129)	(0.093)
PLy		0.204***	0.126**	0.218***	0.289**				0.119	-0.005	0.081	0.033		
		(0.066)	(0.062)	(0.079)	(0.120)				(0.144)	(0.135)	(0.102)	(0.109)		
Lagged VA growth	0.061	0.044	-0.017	-0.050	-0.071*	-0.082*	-0.183	-0.161	-0.276***	-0.154	-0.152	-0.234**	-0.094	-0.155
	(0.038)	(0.038)	(0.040)	(0.038)	(0.042)	(0.045)	(0.129)	(0.138)	(0.103)	(0.122)	(0.115)	(0.101)	(0.154)	(0.110)
Capital	-0.044**	-0.001	0.016	0.032	0.094	-0.049	-0.065	-0.023	-0.092	-0.023	-0.047	-0.039	-0.113	-0.027
	(0.017)	(0.021)	(0.044)	(0.079)	(0.097)	(0.038)	(0.057)	(0.068)	(0.064)	(0.039)	(0.031)	(0.032)	(0.097)	(0.051)
V_GVC/Output				1.663*	1.939*						1.266*	1.086*		
				(0.964)	(1.030)						(0.669)	(0.628)		
V_RT/Output					1.169							0.380		
					(1.033)							(0.547)		
Y_GVC/Output						1.083***	0.730**						-0.078	0.720
						(0.314)	(0.347)						(0.737)	(0.633)
Y_RT/Output							-0.144							-0.163
							(0.439)							(0.421)
# of Obs.	1,197	1,197	1,197	1,197	1,197	1,197	1,197	762	762	762	762	762	762	762
# of country-sector	85	85	85	85	85	85	85	71	71	71	71	71	71	71
# of instruments	101	101	78	78	85	78	89	60	60	70	70	71	63	73
AR(2)	0.703	0.842	0.861	0.676	0.806	0.522	0.270	0.510	0.195	0.322	0.326	0.249	0.487	0.334
Hansen (p)	0.767	0.764	0.207	0.324	0.272	0.137	0.283	0.467	0.262	0.382	0.389	0.300	0.204	0.489
PANEL II	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv_GVC	0.076		0.008			0.005	0.040	0.446**		0.091			0.289*	0.349*
	(0.073)		(0.083)			(0.107)	(0.081)	(0.178)		(0.196)			(0.172)	(0.206)
PLv_nonGVC	-0.124		-0.155			0.111	0.120	-0.413**		-0.139			-0.271	-0.100
	(0.121)		(0.183)			(0.167)	(0.154)	(0.178)		(0.152)			(0.197)	(0.243)
PLy_GVC		0.180*	0.131	0.309**	0.248***				0.350	0.266	0.548*	0.585**		
		(0.093)	(0.096)	(0.140)	(0.087)				(0.250)	(0.231)	(0.275)	(0.232)		
PLy_nonGVC		-0.213**	-0.179*	-0.300**	-0.281*				-0.491***	-0.555***	-0.903***	-0.971***		
		(0.103)	(0.106)	(0.145)	(0.144)				(0.175)	(0.195)	(0.268)	(0.346)		
# of Obs.	1,197	1,195	1,195	1,195	1,195	1,197	1,197	762	762	762	762	762	762	762
# of country-sector	85	85	85	85	85	85	85	71	71	71	71	71	71	71
# of instruments	78	81	87	85	93	85	87	70	74	79	74	79	71	75
AR(2)	0.795	0.923	0.844	0.978	0.916	0.677	0.698	0.176	0.666	0.560	0.700	0.792	0.301	0.319
Hansen (p)	0.243	0.160	0.423	0.267	0.395	0.223	0.306	0.642	0.362	0.521	0.411	0.638	0.365	0.596

Notes: See Notes to Table 2.

Services - Total Factor Productivity Growth:

Panel I of Table 4 displays the association between TFP growth and production lengths for services sectors. In both periods, backward production length is negatively and significantly related to TFP. The forward production length is positively and significantly related to TFP. Our results are consistent with the literature because Muradov (2017) claims that production chains start with high value added service activities such as research and design rather than low value added manufacturing activities. Note that R&D embedded service industries such as information technology, financial intermediation, and wholesale and retail trade can be seen as high value added sectors in our datasets (see Table 1 for high value added of service sectors compared to manufacturing).

Panel II of Table 4 reports the results of further analysis with respect to composition of production lengths. The findings reveal the source of negative effect of backward length found at the upper panel. While backward GVCs length has no impact on TFP growth, backward non-GVC reduces TFP growth in both periods. Even though the backward GVCs (non-GVC) lengths in service sectors is even slightly higher than that of manufacturing sector, the share of imported intermediates (domestic purchases) in service sector is half (approximately twice) of that of manufacturing sector. In fact, since service sectors depend highly on domestic inputs (see Table 1, manufacturing sectors depend relatively more on imported intermediates), the weighted backward length in Panel I appears to have negative effects. The backward length of intermediates from domestic markets is approximately 1.5, very close to one, which means that products obtained from domestic markets are generally final products. Hence, we observe an occasion in which purchasing more final products can be the reason for a lower TFP growth. Another notable matter is related to forward linkages. GVC length is negatively and significantly associated with TFP growth. When we consider already high values of forward length of GVCs, adding one border in this chain even further removes products away from the final consumer.[13] In contrast, forward non-GVC length promotes TFP growth, unveiling the complementarity role of services in domestic production. Therefore, selling in domestic market

[13] In fact, the volume of intermediate export is found to be positive, suggesting that exporting activity is productivity enhancing. However, if these exports are heavily composed of complex intermediate products, it can decrease productivity. All these imply that service sectors can benefit from selling their products as intermediates to the external market. However, the length of this transaction should be short in order to benefit more.

enhances productivities of service industries In this sense, we can argue that service sectors are more likely to support domestic sectors through their complementary roles.

Services – Value Added Growth:

Panel I of Table 5 reports the associations between value added growth and production lengths. While forward production length is positively and significantly related to value added growth in both periods, backward production length is negatively and significantly related to value added growth only in the first period. Panel II reveals the source of adverse effect of backward length. While backward GVC length raises value added growth, backward non-GVC length reduces value added growth in both periods. Given the importance of the length of GVCs, it requires countries to be more synchronized in their production processes and trade policies to increase the benefits they receive from GVCs. In addition, an increase in usage of service products as intermediates in a domestic market, that is an increase in forward length of non-GVCs activities, raises value added growth. At this point, investments in information and communication technologies not only raise the productivity and value added of overall service sectors, but also contribute to better connectivity and coordination of domestic sectors in the cross-border sourcing process.

Table 4: Total Factor Productivity Growth and Production/GVCs Lengths, Services

Service	The First Dataset							The Second Dataset						
PANEL I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv	0.015***		0.042***			0.019**	0.020*	0.030**		0.038***			0.024***	0.022**
	(0.004)		(0.011)			(0.009)	(0.010)	(0.012)		(0.011)			(0.007)	(0.010)
PLy		-0.027	-0.101***	-0.077***	-0.060**				-0.038*	-0.058**	-0.045*	-0.037*		
		(0.018)	(0.025)	(0.022)	(0.030)				(0.021)	(0.024)	(0.023)	(0.020)		
Lagged TFP growth	0.107**	0.062	0.068*	0.077*	0.139	0.067	0.073	-0.006	0.043	-0.002	0.017	0.008	0.039	-0.004
	(0.046)	(0.051)	(0.040)	(0.044)	(0.129)	(0.047)	(0.137)	(0.075)	(0.071)	(0.074)	(0.073)	(0.076)	(0.077)	(0.079)
Capital	-0.002	-0.008	-0.007	-0.009*	-0.012*	-0.006	-0.004	0.003	-0.004	0.001	-0.002	-0.006	0.005	0.001
	(0.002)	(0.006)	(0.004)	(0.005)	(0.007)	(0.004)	(0.005)	(0.007)	(0.005)	(0.006)	(0.005)	(0.006)	(0.004)	(0.006)
V_GVC/Output				0.287***	0.348***						0.202*	0.203*		
				(0.095)	(0.121)						(0.115)	(0.108)		
V_RT/Output					-0.174							-0.054		
					(0.170)							(0.101)		
Y_GVC/Output						0.076	0.015						0.029	0.021
						(0.111)	(0.182)						(0.095)	(0.138)
Y_RT/Output							-0.077							0.025
							(0.122)							(0.097)
# of Obs.	1,492	1,492	1,492	1,492	1,492	1,492	1,492	1,868	1,868	1,868	1,868	1,868	1,868	1,868
# of country-sector	133	133	133	133	133	133	133	189	189	189	189	189	189	189
# of instruments	142	142	130	130	141	130	141	183	183	201	201	204	191	192
AR(2)	0.875	0.929	0.976	0.946	0.746	0.912	0.971	0.918	0.896	0.922	0.996	0.949	0.878	0.918
Hansen (p)	0.709	0.843	0.501	0.584	0.667	0.355	0.586	0.297	0.358	0.618	0.618	0.631	0.468	0.370
PANEL II	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv_GVC	-0.020*		-0.026**			-0.030**	-0.026**	-0.030**		-0.009			-0.021**	-0.023*
	(0.011)		(0.011)			(0.012)	(0.013)	(0.012)		(0.015)			(0.011)	(0.013)
PLv_nonGVC	0.035*		0.028*			0.037*	0.033*	0.023**		0.078***			0.025**	0.030**
	(0.020)		(0.015)			(0.022)	(0.019)	(0.011)		(0.029)			(0.013)	(0.014)
PLy_GVC		0.005	0.014	0.057*	0.044				0.000	0.030	0.027	0.034		
		(0.025)	(0.030)	(0.029)	(0.026)				(0.016)	(0.023)	(0.032)	(0.023)		
PLy_nonGVC		-0.096***	-0.053	-0.027	-0.025				-0.041	-0.143**	-0.047	-0.087*		
		(0.035)	(0.035)	(0.032)	(0.033)				(0.038)	(0.064)	(0.048)	(0.050)		
# of Obs.	1,492	1,484	1,484	1,484	1,484	1,492	1,492	1,868	1,857	1,857	1,857	1,857	1,868	1,868
# of country-sector	133	133	133	133	133	133	133	189	188	188	188	188	189	189
# of instruments	130	130	155	131	155	151	155	191	201	189	192	189	192	177
AR(2)	0.809	0.920	0.841	0.895	0.654	0.851	0.507	0.932	0.928	0.777	0.966	0.834	0.880	0.815
Hansen (p)	0.376	0.526	0.878	0.480	0.925	0.866	0.914	0.431	0.669	0.284	0.362	0.319	0.336	0.227

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies are included in all specifications. The Hansen test is a test of overidentification restrictions. Under the null hypothesis, the test statistic is distributed as a chi-squared in the number of overidentifying restrictions, p-values are presented. System GMM results are two-step estimates. The two-step standard errors are computed in accordance to the Windmeijer (2005) finite-sample correction. All estimates in Panel II employ the same control variables used in Panel I.

Table 5: Value Added Growth and Production/GVCs Lengths, Services

Service	The First Dataset							The Second Dataset						
PANEL I	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv	0.020***		0.033***			0.031***	0.009*	0.036***		0.043***			0.026***	0.019**
	(0.005)		(0.010)			(0.009)	(0.005)	(0.008)		(0.011)			(0.007)	(0.007)
PLy		-0.015	-0.044**	-0.041**	-0.060***				0.019	-0.030	-0.015	-0.014		
		(0.014)	(0.021)	(0.019)	(0.018)				(0.016)	(0.021)	(0.016)	(0.014)		
Lagged VA growth	0.230***	0.179***	0.176***	0.179***	0.188***	0.186***	0.379***	0.100***	0.098***	0.087**	0.120***	0.120***	0.110***	0.107***
	(0.034)	(0.034)	(0.039)	(0.039)	(0.051)	(0.041)	(0.051)	(0.034)	(0.034)	(0.036)	(0.034)	(0.034)	(0.034)	(0.034)
Capital	-0.006***	-0.011***	-0.010***	-0.015***	-0.008**	-0.006*	-0.001	0.002	-0.003	-0.000	-0.002	-0.001	-0.001	0.001
	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
V_GVC/Output				0.181**	0.261***						0.202***	0.149**		
				(0.077)	(0.073)						(0.063)	(0.060)		
V_RT/Output					-0.022							0.069		
					(0.052)							(0.054)		
Y_GVC/Output						0.110	-0.020						0.012	-0.189**
						(0.110)	(0.067)						(0.070)	(0.092)
Y_RT/Output							-0.002							0.149***
							(0.038)							(0.055)
# of Obs.	2,357	2,357	2,357	2,357	2,357	2,357	2,357	2,541	2,541	2,541	2,541	2,541	2,541	2,541
# of country-sector	174	174	174	174	174	174	174	239	239	239	239	239	239	239
# of instruments	180	182	185	185	187	185	187	232	232	233	233	245	233	245
AR(2)	0.381	0.203	0.206	0.215	0.266	0.242	0.882	0.503	0.466	0.444	0.603	0.598	0.550	0.533
Hansen (p)	0.287	0.434	0.407	0.451	0.451	0.355	0.495	0.224	0.224	0.244	0.202	0.372	0.256	0.412
PANEL II	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
PLv_GVC	-0.005		-0.003			0.014	0.010	-0.035***		-0.048***			-0.036***	-0.021**
	(0.015)		(0.016)			(0.015)	(0.017)	(0.011)		(0.015)			(0.010)	(0.009)
PLv_nonGVC	0.032*		0.033			0.039*	0.048*	0.030***		0.066***			0.029**	0.014
	(0.017)		(0.021)			(0.021)	(0.024)	(0.011)		(0.019)			(0.013)	(0.012)
PLy_GVC		0.016	0.036	0.038***	0.036*				0.002	0.074***	0.050***	0.049***		
		(0.019)	(0.022)	(0.014)	(0.021)				(0.015)	(0.025)	(0.018)	(0.016)		
PLy_nonGVC		-0.022	-0.084**	-0.034**	-0.081**				0.036	-0.093**	-0.056**	-0.039		
		(0.023)	(0.038)	(0.015)	(0.032)				(0.027)	(0.044)	(0.028)	(0.025)		
# of Obs.	2,355	2,342	2,342	2,342	2,342	2,355	2,355	2,541	2,530	2,530	2,530	2,530	2,541	2,541
# of country-sector	174	174	174	174	174	174	174	239	238	238	238	238	239	239
# of instruments	185	185	188	187	188	159	188	233	233	241	245	241	230	225
AR(2)	0.281	0.157	0.445	0.895	0.412	0.411	0.390	0.439	0.518	0.347	0.626	0.617	0.380	0.530
Hansen (p)	0.425	0.443	0.445	0.421	0.398	0.172	0.467	0.231	0.251	0.313	0.376	0.352	0.226	0.174

Notes: See Notes to Table 4.

6. Conclusion

This paper thus aims to assess how sectoral lengths of production activities affect TFP and value added growth for the periods 1996-2011 and 2005-2015 for 14 European countries and the US. For the manufacturing sectors, forward production length increases the total factor productivity and value added of manufacturing sectors only in the first period. In both periods, we find a strong evidence for the adverse effect of backward length of non-GVC activities on total factor productivity and value added growth probably because these products are mostly final products and do not promote productivity as in the case of imported intermediates. The positive effect of backward length of GVC activities seems to be significant in all periods except in the first period of TFP growth analysis.

For the services, in both periods, forward production length increases the total factor productivity and value added. Backward length of non-GVCs activities decreases both sectoral TFP and value added growth similar to the findings for the manufacturing analysis. The positive effect of backward GVCs length is significant only in value added growth analysis. If forward length of non-GVCs activites increases, sectoral performance variables are positively affected. This reveals the complementarity role of service sector in domestic production.

Our estimation results imply that the positive effect of forward length is substantial for both sectors. Since manufacturing sectors are relatively more affected from the 2008 global crisis and global downturn, the relationship between forward production length and sectoral performance variables is not sustained at the post-crisis era. This relationship continues to exist for service sectors in this period probably because service sectors depend relatively more on domestic markets. Furthermore, participating in GVCs activities through importing is the crucial determinant of sectoral performance of both manufacturing and service sectors. Overall, our results have important policy recommendations regarding the sectoral performance manufacturing and services in developed countries. Policies regarding efficient integration in global production process should be taken into consideration because sectoral performances highly depend on the imported intermediates. This is highly crucial especially for downstream manufacturing sectors. Contagious effects of possible external policies can be alleviated via more international coordinations which are only possible with very advanced information, communication, and transportation systems.

Acknowledgements: The first author acknowledges support from the Turkish Academy of Sciences.

Conflicts of Interest: The authors declare that there is no conflict of interest regarding the publication of this article.

References

Antras, P., Chor, D., Fally, T., & Hillberry, R. (2012). Measuring the upstreamness of production and trade flows. *American Economic Review*, 102(3), 412-416.

Antras, P., Fort, T. C., & Tintelnot, F. (2017). The margins of global sourcing: Theory and evidence from us firms. *American Economic Review*, 107(9), 2514-64.

Bernard, K. (2007). Private Damages Actions: A US Perspective on Importing US Damages Actions to the EU. *Antitrust Chronicle*, 11.

Chor, D., Manova, K., & Yu, Z. (2014). *The global production line position of Chinese firms.* Paper presented at the Industrial Upgrading and Urbanization Conference, Stockholm.

Del Prete, D., Giovannetti, G., & Marvasi, E. (2018). Global value chains: New evidence for North Africa. *International economics*, 153, 42-54.

Dietzenbacher, E., & Romero, I. (2007). Production chains in an interregional framework: Identification by means of average propagation lengths. *International Regional Science Review*, *30*(4), 362-383.

Eurostat (2019). Exchange and Interest Rates. Available at https://ec.europa.eu/eurostat/web/exchange-and-interest-rates/data/database (accessed 11.02.2019)

Fally, T. (2012). On the Fragmentation of Production in the US. *University of Colorado-Boulder*.

Hagemejer, J. (2018). Trade and Growth in the New Member States: The Role of Global Value Chains. *Emerging Markets Finance and Trade*, *54*(11), 2630-2649.

Hagemejer, J., & Ghodsi, M. (2017). Up or Down the Value Chain? A Comparative Analysis of the GVC Position of the Economies of the New EU Member States. *Central European Economic Journal*, *1*(48), 19-36.

Ito, T., & Vézina, P.-L. (2016). Production fragmentation, upstreamness, and value added: Evidence from Factory Asia 1990–2005. *Journal of the Japanese and International Economies*, *42*, 1-9.

Jäger, K. (2016). EU KLEMS Growth and Productivity Accounts 2017 Release, Statistical Module1. *Description of methodology and country notes for Spain*.

Jona-Lasinio, C., & Meliciani, V. (2019). Global Value Chains and Productivity Growth in Advanced Economies: Does Intangible Capital Matter? *International Productivity Monitor*(36), 53-78.

Milio, S., Durazzi, N., Garnizova, E., Janowski, P., Olechnicka, A., & Wojtowicz, D. (2014). Impact of the economic crisis on social, economic and territorial cohesion of the European Union.

Muradov, K. (2017, June). Determinants of country positioning in global value chains. In 25th International Input–Output Conference, *Atlantic City*, NJ (pp. 19-23).

OECD (2016), Global Value Chains and Trade in Value- Added: An Initial Assessment of the Impact on Jobs and Productivity, *OECD Trade Policy Papers*, No. 190, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jlvc7sb5s8w-en (accessed on 06.11.2018)

OECD (2019a). Trade in value added. OECD-WTO: Statistics on Trade in Value Added (database), https://doi.org/10.1787/data-00648-en (accessed on 15.02.2019)

OECD (2019b). "OECD Inter-Country Input-Output Tables",

https://www.oecd.org/sti/ind/inter-country-input-output-tables.htm (accessed on 13.05.2019).

OECD (2019c), "STAN Industry ISIC Rev. 4", STAN: OECD Structural Analysis Statistics (database), http://www.oecd.org/sti/ind/stanstructuralanalysisdatabase.htm (accessed on 15.02.2019)

R Core Team (2019). R: A Language and Environment for Statistical Computing, *R Foundation for Statistical Computing*, Vienna, Austria, available at https://www.R-project.org/.

Suganuma, K. (2016). *Upstreamness in the Global Value Chain: Manufacturing and Services.* Paper presented at the Meeting of the Japanese Economic Association at Nagoya University on June.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015). An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production. *Review of International Economics*, 23: 575–605.

UIBE (2017), UIBE Global Value Chain Indexes System – Concept Note, retrived from https://v2.fangcloud.com/share/a26979974d538c7e5aeb24b55a?folder_id=63000172546&lang=en

UIBE (2017), Data files structure of the UIBE GVC index system, retrived from https://v2.fangcloud.com/share/a26979974d538c7e5aeb24b55a?folder_id=63000172546&lang=en

UIBE GVC Index Team, "Data files structure of the UIBE GVC index system" http://139.129.209.66:8000/d/daedafb854/

Wang, Z., Wei, S.-J., Yu, X., & Zhu, K. (2016). Characterizing global value chains.

Wang, Z., Wei, S.-J., Yu, X., & Zhu, K. (2017). *Characterizing global value chains: Production length and upstreamness*.

World Development Report, (2020). *Trading for Development: In the Age of Global Value Chains.* International Bank for Reconstruction and Development/The World Bank

WTO/OECD (2016), Trade in value added (Edition 2016), OECD-WTO: Statistics on Trade in Value Added (database), https://doi.org/10.1787/2644abe4-en (accessed on 15.02.2019)

Ye, M., & Voigt, S. (2014). The Global Value Chains in BRICS Countries. *Fudan Journal of the Humanities and Social Sciences, 7*(3), 411-420.

Appendix

Table A1. Industry Concordance Table

TiVA 2016	TiVA 2018	EU KLEMS	ICIO 2016	ICIO 2018	EU KLEMS DESCRIPTIONS	Main Category
C15T16	D10T12	10-12	C15T16FOD	D10T12	Food Products, Beverages and Tobacco	Manufacturing
C17T19	D13T15	13-15	C17T19TEX	D13T15	Textiles, Wearing Apparel, Leather and Related Products	Manufacturing
-	D16T18	16-18	-	-	Wood and Paper Products; Printing and Reproduction of Recorded Media	Manufacturing
C24	D20T21	20-21	C24CHM	D20T21	Chemicals and Chemical Products	Manufacturing
C27T28	D24T25	24-25	-	-	Basic Metals and Fabricated Metal Products, Except Machinery and Equipment	Manufacturing
C30T33	D26T27	26-27	C30T33XCEQ	-	Electrical and Optical Equipment	Manufacturing
C29	D28	28	C29MEQ	D28	Machinery and Equipment N.E.C.	Manufacturing
C34T35	D29T30	29-30	-	-	Transport Equipment	Manufacturing
C36T37	D31T33	31-33	C36T37OTM	D31T33	Other Manufacturing; Repair and Installation of Machinery and Equipment	Manufacturing
C50T52	D45T47	G	C50T52WRT	D45T47	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Services
C60T63	D49T53	H	-	D49T53	Transportation and Storage	Services
C55	D55T56	I	C55HTR	D55T56	Accommodation and Food Service Activities	Services
-	D58T60	58-60	-	D58T60	Publishing, Audiovisual and Broadcasting Activities	Services
-	D61	61	-	D61	Telecommunications	Services
C72	D62T63	62-63	C72ITS	D62T63	IT and Other Information Services	Services
C65T67	D64T66	K	C65T67FIN	D64T66	Financial and Insurance Activities	Services
C70	D68	L	C70REA	D68	Real Estate Activities	Services
-	D69T82	M-N	-	D69T82	Professional, Scientific, Technical, Administrative and Support Service Activities	Services
C75	D84	O	C75GOV	D84	Public Administration and Defence; Compulsory Social Security	Services

C80	D85	P	C80EDU	D85	Education	Services
C85	D86T88	Q	C85HTH	D86T88	Health and Social Work	Services
-	D90T96	R-S	-	D90T96	Arts, Entertainment, Recreation and Other Service Activities	Services

Notes: To match industries across datasets, we use documents such as "industry breakdown for the 2016 TiVA Indicators" (WTO/OECD, 2016), "list of industries for TiVA 2018" (OECD, 2019a), "the notes for the differences between TiVA 2016 and TiVA 2018" (OECD, 2019a), ReadMe files of OECD ICIO versions (OECD, 2019b), "EU KLEMS industry list" (Jäger, 2018) and "Eurostat SNA NACE Rev.2 (ISIC Rev.4) A*64 to A*10 hierarchy" (OECD, 2019c).