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The 'Smile Curve': where Value is Added along Supply Chains

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Abstract

In this paper we analyze where value is added along supply chains on a sample of more than 2 million of firms in the European Union. We detect a non-linear U-shaped relationship between the value added generated by firms and their position on a productive sequence, for which tasks at the top and at the bottom show higher value added. Our findings are in line with previous hypotheses on the existence of a so-called '*smile curve*', resumed by both business and economic studies and discussed at length in international fora. Our results are robust to different empirical strategies for flexible functional forms. As far as we know, ours is the first firm-level successful attempt to test for value generation along supply chains. Further, we find empirical support for a phenomenon of domestic retention of value added by MNEs, which may prefer keeping at home the tasks at higher potential to safeguard present and future competitive advantages. By country, intermediate stages of production are at higher value when performed by foreign affiliates, whereas domestic producers retain higher value at the very top and at the very bottom of the supply chain, organized either as independent suppliers or as domestic affiliates. Although an economic theory is still missing for explaining how and why value generation is non-linear along a typical technological sequence, here we argue that a microfoundation with firm-level data is useful for understanding the growth potential of countries' specialization patterns along different segments of supply chains.

Keywords: global value chains, global supply chains, downstreamness, smile curve, downstreamness, value added, heterogeneous firms, multinational enterprises.

JEL codes: F23, F15, F14, L23, L25, L22.

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1 Introduction

The organization of firms has experienced dramatic changes over the last decades, after technological advances and reductions in trade costs triggered an unbundling of production tasks across national borders (Baldwin and Lopez Gonzalez, 2015), therefore generating Global Value Chains (GVCs) which encompass the full range of activities that are required to bring a good or service to the final consumer (Cattaneo et al., 2010). As Krugman et al. (1995) already stated, in times of worldwide economic integration, 'goods are produced in a number of stages in a number of locations, adding a little bit of value at each stage'. Against this background, a flourishing literature identifies the determinants of the organization choices of the firms involved in supply chains (Antràs and Helpman, 2008; Acemoglu et al., 2009; Antràs and Chor, 2013; Corcos et al., 2013; Del Prete and Rungi, 2015; Alfaro et al., 2015; Amador and Di Mauro, 2015), in terms of vertical integration and geographic location when production stages are included or not in the perimeter of corporate boundaries. The aim of this strand of research is to assess the organization choices of supply chains, when the latter are defined as technological sequences running from the idea of a product to the final sale to consumers, going through intermediate productive stages that may involve more than one input supplier in more than one country. If the input is included in the perimeter of corporate boundaries, we have intra-firm trade. If the input is sourced from an independent supplier, companies engage in arm's length trade. Stronger emphasis is instead given in other studies to the actual generation of value and potential, both globally (Coe et al., 2008; Mudambi, 2008) and at a regional level (Pavlínek and Ženka, 2011; Crescenzi et al., 2014), as deriving from the organization of firms in supply chains.

A different and contemporary strand of research started the study of GVCs from a another point of view, when trying to reconcile gross trade data with national accounts (see among others Timmer et al. (2015)). They start acknowledging the existence of a multiple accounting problem for gross trade data, when fragmentation of production occurs, and intermediate goods and services cross national borders more than once. Hence, they propose some decomposition methodologies (Johnson and Noguera, 2012; Koopman et al., 2014; Los et al., 2016) to disentangle the 'true' generation of value that can be attributed to a single country-industry. Following the generation of value over time, it is then possible to understand the changing patterns of country specialization and assess contribution to economic growth (OECD, 2013; Costinot et al., 2013; Baldwin and Lopez Gonzalez, 2015; Taglioni and Winkler, 2016; Del Prete et al., 2017). Yet, scholars from the latter strand of research are not interested in a technological ordering of production stages, nor in the optimal design of corporate boundaries that it would entail. Once adopting a looser definition of GVCs, they just try to trace the generation of value added by all labor and capital inputs that are directly and/or indirectly needed for the production of final manufacturing goods.

In this contribution, we want to bridge the previous approaches proposing a microfoundation that uses firm-level data on value added generation, information on the organization modes of GVCs, and the relative position of each firm along the supply chain. Indeed, firm-level financial accounts more than often report information on value added, which has been relatively neglected until now as an indicator for firm-level performance and contribution to growth. Eventually, the sum of value added of all firms in a country makes up the GDP of that country. Value generated at the firm-level is the original source from which a distribution of incomes to factors of production is possible under the form of wages and salaries for workers, returns for capital, and finally taxation for public services. Once corrected by size dividing by output, we do obtain the value added content for the activities of the firm expressed in percentage as also suggested by Baldwin and Evenett (2015) and Baldwin et al. (2014).

For a bridge across previous strands of research, we can indeed rely on the framework proposed by Baldwin and Evenett (2015), who assume that the position of a task with respect to final consumption may entail a different implicit generation of value.[1] Therefore, following anecdotal case and/or descriptives derived from Input-Output tables (Baldwin et al., 2014), value seems to be more concentrated at the top and at the bottom ends of the chain, where pre- and post-production services are located,

[1] The study of assembly lines is however nothing new to business and management literature, whether they fall within or across national borders (e.g. Bartlett and Ghoshal (2000)).

on an ideal curve running from concept, R&D and/or design through manufacturing and assembling to marketing and after-sales services (Alcacer and Oxley, 2014). From the latter comes the name of *'smile curve'* for a U-shape of value added plotted on the productive sequence. The notion was first developed in the 90s by the CEO of the Chinese Taipei-based hardware and electronics corporation Acer, Stan Shih, who acknowledged that Acer's focus on assembling PCs, i.e. in the middle of the chain, was keeping the company in the least profitable segment of the market (Shih, 1996). On a more general basis, Baldwin and Evenett (2015) speculate that there could have been *'tilts'* in the last decades of worldwide economic integration, such that production of intermediate components and their assembly may entail less and less value over time, whereas pre-production and post-production tasks may have increased their value generation for the final sale of a product.

Unfortunately, we are not able to go back in time, when the unbundling by tasks across borders started, and compare the shape of value generation. Nonetheless, we find that the presence of a 'smiley' U-shape curve is systematic in our data for all firms located in the European Union in 2015, both when we classify tasks by business functions, as in the original framework by Sturgeon (2008), and when adopting the 'downstreamness' metrics proposed by Antràs and Chor (2013), on the basis of input-output usage. In both cases a distance from the final consumption is eventually proxied, although with greater detail at the 6-digit industry-level in the latter case. Exploiting parametric and semiparametric approaches for plotting the generation of value added at the firm-level on downstreamness metrics, we find that the value is higher for tasks at the very top and at the very end of the supply chains, even after controlling for firm heterogeneity and country characteristics, which however do affect the magnitude of value generation.

In fact, as expected, we also find that more productive firms and a lower level of competition are associated to a higher value added content at the firm-level. The results are similar also country by country, with some exceptions in Eastern Europe.

Even more interestingly, we find empirical support for a phenomenon of domestic retention of value added when we control for the way companies organize on the supply chains. Activities at higher value on the ends of the supply chain are preferably kept in the origin country and performed by either independent buyers/suppliers not integrated in any MNEs, or by integrated domestic affiliates. Foreign affiliates in the middle of the supply chain produce at higher value when compared to domestic affiliates in the same stages of production. This phenomenon is particularly evident in the case of New Member States (NMS) that entered the European Union after 2004. In this case the value along the chain by foreign affiliates is no more a *'smiley'* but a flat linear relationship, decreasing from upstreamness to downstreamness stages.

By and large, the mechanisms through which value generation unevenly distributes on the supply chain are still relatively unexplored. However, we argue, a microfoundation with firm-level analyses is useful also to assess how countries' specialization patterns on specific segments of the value chain can affect distribution of incomes, development and eventually economic growth.

2 Data construction and preliminary evidence

We collect firm-level data for companies operating in the European Union from ORBIS, a cross-country database maintained by Bureau van Dijk, which originally sources financial accounts from various national registries.

For each firm included in our database, we are able to detect its value added content in production, measured as a ratio between firm-specific added value and output (sales/turnover). Companies in our sample also report the core industrial activity at the 4-digit level NAICS and NACE classifications, which we use as an indicator for relative positions on the supply chain.

At first, we just reclassify manufacturing activities, separating between primary, intermediate and final goods, and service activities, separating between pre-production and post-production services. In this we follow a more classical approach borrowed from anecdotal evidence and discussed originally by Mudambi (2008) for a stylized versions of the *'smile curve'*.

Thereafter, we merge firm-level industrial activities with *'downstreamness'* metrics of supply chains sourced from Antràs and Chor (2013)[2], according to which the relative location of an industry in production processes is given by its usage in intermediate vs final production. In absence of original information on actual shipments, downstreamness metrics turn to input-output tables in order to obtain positions of each industry on an ideal technological sequence. They are normalized on a range $[0, 1]$, where 0 ideally represents the start of a production line and downstream stages proximate to 1 represent goods/services destined to final consumers. For sake of robustness, we exploit here both alternative metrics provided by Antràs and Chor (2013) for 'downstreamness'. The first is built more simply as a ratio of the aggregate direct use of an input to the aggregate total use of that industry ($DuseTuse$), and the second is weighted for the average position of that industry in the supply chain, counting back at which input distance an industrial output is used ($DownMeasure$).

Further, we derive the organization mode of each firm on the supply chain as follows. We assume that a company is vertically integrated in a supply chain when a parent company controls directly or indirectly the majority of its equity (>50%). On the contrary, we assume that a company is not vertically integrated but it is part of (at least) a supply contract when no corporate entity has full control of its stakes[3], but it buys (sells) intermediate goods and services, which are sold (bought) by other firms. A general classification between intermediate and final goods is possible after we convert NAICS industries in BEC (Broad Economic Categories) using correspondence tables from UN statistics offices. As every producer of final goods from our data is also a buyer of intermediate goods, because it reports purchases of materials and services, we may always consider them as located at the end of a supply chain. Similarly, producers of intermediate goods can be naturally considered as suppliers of other companies, although we don't have information on which companies are final recipients of shipments.

Eventually, when focusing on vertically integrated affiliates, we can distinguish between domestic or foreign-owned according to the country of origin of the parent company. In absence of actual shipments among companies, we can reasonably assume that if a company produces or acquires intermediate inputs, and it is not controlled by a parent, it can only originate arm's length shipments, whether destined and/or coming from companies located at home or abroad. That is, we can exclude that non-affiliated companies can engage in intra-firm trade. On the other hand, we cannot exclude that integrated companies actually producing or acquiring intermediate goods can be eventually engaged both in intra-firm trade and arm's length trade after signing supply contracts with companies outside their own corporate boundaries.

In Tables 1 (see Table 6 in Table Appendix for country details) and 2, we report descriptive statistics of our firm-level coverage by geography, industry and status. We end up with a sample of 2,296,848 companies with information on value added content in year 2015. Of these, about 18% are firms operating in manufacturing industries and 60% are located in EU15.[4]

In Table 2 we further report that 44% of European companies in our sample are never integrated under any parent company. Among affiliated/integrated companies, about 6% are foreign-owned because a parent company is located abroad.

[2]Metrics for distance from the final consumer, based on input-output tables, were first proposed by Antràs et al. (2012), and inspired by the effort previously made by Fan and Lang (2000), where however no technological sequence was derived for the relative position of industries along the supply chain.

[3]The direct or indirect corporate control of affiliates by parent companies follows international standards set for example in OECD (2005) and UNCTAD (2011, 2009). For more details on previous usage of these data see also Rungi et al. (2016), Altomonte and Rungi (2013) and Cravino and Levchenko (2016).

[4]Depending on specific rules by national regulatory bodies, some countries may still show an uneven coverage on financial accounts, mainly because they are required to submit complete balance sheets only after reaching a certain size threshold, which can be different by country. It seems to be the case of Austria or Germany, for example, with a lower number of companies reporting information on value added, whereas smaller countries like Portugal or Slovakia have a higher coverage (Table 6). Concerns about possible sample selection by country and/or by size will be addressed in following empirical analyses.

Table 1: Geographic coverage

	Manufacturing	Services	Total
EU15	266,983	1,118,750	1,385,733
NMS	131,092	780,023	911,115
Total	398,075	1,898,773	2,296,848

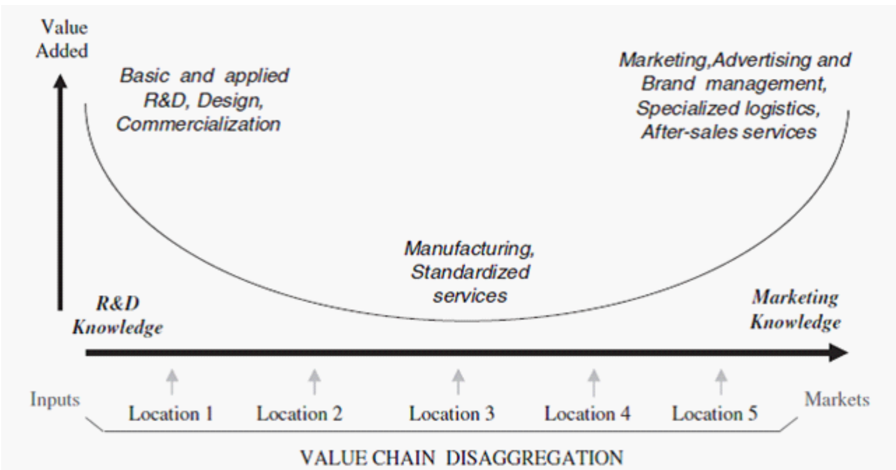
Table 2: Integration and foreign status

	Integrated	Non-integrated	Total
Domestic	1,199,949	1,013,835	2,213,784
Foreign	83,064	0	83,064
Total	1,283,013	1,013,835	2,296,848

2.1 Visual test of a 'smiling curve' by business functions

The smile curve can be presented in a graph with a Y-axis for value-added and an X-axis for supply chain (Figure 1). Along the curve, activities can be broadly grouped into five categories: the upstream pre-production services, the downstream post-production services and the middle with primary, intermediate and final goods manufacturing activities. Activities at the upstream end generally comprise R&D services, architectural and engineering services. Activities at the downstream end typically comprise marketing, advertising, distribution and retail. Finally activities in the middle comprise manufacturing, standardized service delivery and other repetitious processes in which commercialized prototypes are implemented on a mass scale.

Figure 1: Value Chain (Mudambi, 2008)



In line with the pattern reported in Figure 1, as exemplified by Mudambi (2008) and discussed from a qualitative point of view in OECD (2013), in Figure 2 we find first visual evidence for the existence of a *'smile curve'* after ordering industrial activities at the firm-level over those five business functions.[5]

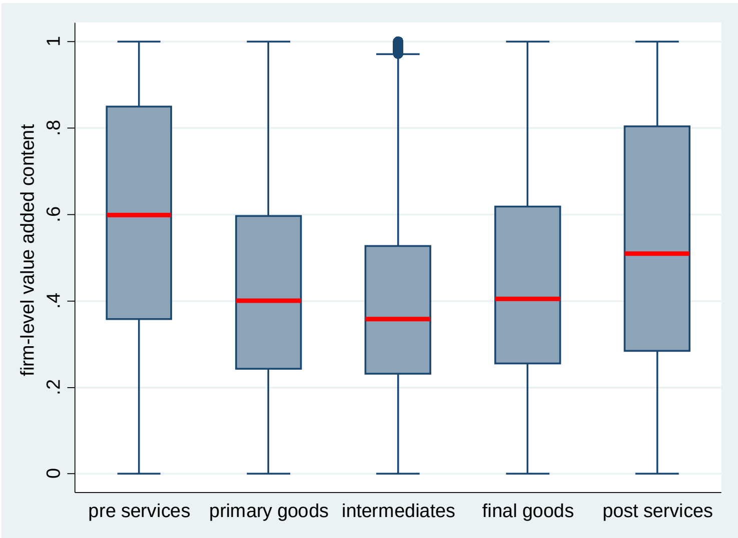
[5] The classification of manufacturing industries in primary goods, intermediate goods and final goods is done accordingly to correspondence tables provided by UN statistics offices.

However, no specific classification exists for pre-production services and post-production services. We propose here our

The median company in each business function is reported with a red line in each box of Figure 2. Pre-production services is the function where the median company has the highest value added content in production. On the other extreme, post-production services have a median value added content worth 53% of production value. Companies engaged in the production of intermediate inputs show the lower median value added of 37%.

Despite a clear concavity in value generation, companies present a high dispersion in value added content within business functions. It means that it is quite possible to find R&D or distribution activities that generate less value than production of intermediate goods when we look at single companies, in the interquartile distributions of single boxplots in Figure 2. Median values and dispersions are indeed higher in pre and post-production services. More compressed is the distribution of value added content by producers of intermediate goods, whose interquartile range falls between 23% and 53%, whereas the most dispersed is the distribution of post-production services companies that fall in a range between 29% and 81%. In Table 3 we further report an estimate of premia by least squares, after considering the intermediate production as a control group, in which we do confirm the ordering of Figure 2. Companies engaged in pre- and post-production services report on average a value added content that is respectively 18.9% and 13.4% than production of intermediates. Primary and final goods have a weakly significant premium on intermediates of about 3.1% and 4.8%.

Figure 2: First visual test of a 'smiling curve' by business functions



own, when a service is unambiguously used before or after the manufacturing of a product. R&D services, architectural and engineering services are example of pre-production services. Marketing, advertising, distribution and retail can be uniquely attributed to post-production. However, some of them can be actually demanded in different moments of the production process, as for example in the case of logistics or warehouse storage when exploited by intermediate producers.

Table 3: Value added content premia vs production of intermediates

Business function	Premia in value added content
pre services	0.189***
	(0.020)
primary goods	0.031*
	(0.018)
final goods	0.048*
	(0.026)
post services	0.134***
	(0.024)

Note: OLS estimates with intermediates as control group. Number of companies: 613,935. *,**,*** stand respectively for p<0.100, p<0.050 and p<0.001.

3 Empirical strategy

The heterogeneity we find within business functions in Figure 2 may be actually explained by specific country, industry and firm-level characteristics. Moreover, our classification by business functions may be just an oversimplification, as tasks like these are more easily identified when studying single corporate case studies, where higher detail is available for the exact contribution of each function on a firm-level supply chain.

This is the reason why from now on we challenge the existence of the *'smile curve'* in two ways. We first introduce an alternative and more detailed measure of position along the supply chain, given by the downstreamness metrics provided by Antràs and Chor (2013), then we introduce a multivariate strategy for possible firm-level drivers of value added.

A quadratic fit and robustness checks for the functional forms are tested respectively in Section 3.1 and 3.2. In Section 3.3 we differentiate by firm-level organization modes of GVC and European geography.

3.1 Quadratic fit

We start by estimating the following equation:

$$\left(\frac{value\_added}{output}\right)_{ijc} = \beta_0 + \beta_1 X_j + \beta_2 Z_i + \lambda_c + \varepsilon_{ijc} \tag{1}$$

where the dependent variable is the ith firm-specific value added content active in industry j and located in country c, which we calculate as the ratio of value added on production value as reported in financial accounts. The term X_j collects proxies for positions along the supply chain with a quadratic term, on the basis of the jth activity performed by the single firm. It will include alternatively downstreamness metrics (and squared terms). The term Z_i collects firm-level controls and λ_c is a set of country fixed effects for each of the EU members in which the firm may be located. Standard errors are clustered by 4-digit industries.

In Table 4, we report OLS estimates with downstreamness metrics by columns, respectively in the simple (*DuseTuse*) and weighted versions *(DownMeasure)*. We find that the value added content is more than proportionally higher for firms that are located at the top and at the bottom of the supply chain, i.e. a quadratic fit is detected for value added generation on downstreamness metrics, taking the shape of a U-curve with a minimum on production of intermediate goods. The finding is robust to the inclusion of firm-level controls and change in downstreamness metrics.

In Figure 3 we report the quadratic fit of the second and fourth column for firm-level value added content along supply chains. We conclude that the test for a 'smiling curve' is robust after: i) exploiting a more detailed proxy for distance from final consumption; ii) controlling in the empirical strategy for firm-level heterogeneity, levels of competition and country characteristics.

Eventually, the graphs in 3 are much smoother than the one we depict in Figure 2 by business functions. In fact, firm-level controls do catch a good share of heterogeneity in value added content at the firm-level.

As expected, more capital-intensive firms correlate with a lower value added content in production, whereas more productive, younger and smaller firms tend to generate more value. The latter is indeed the case of services firms that systematically generate higher value.

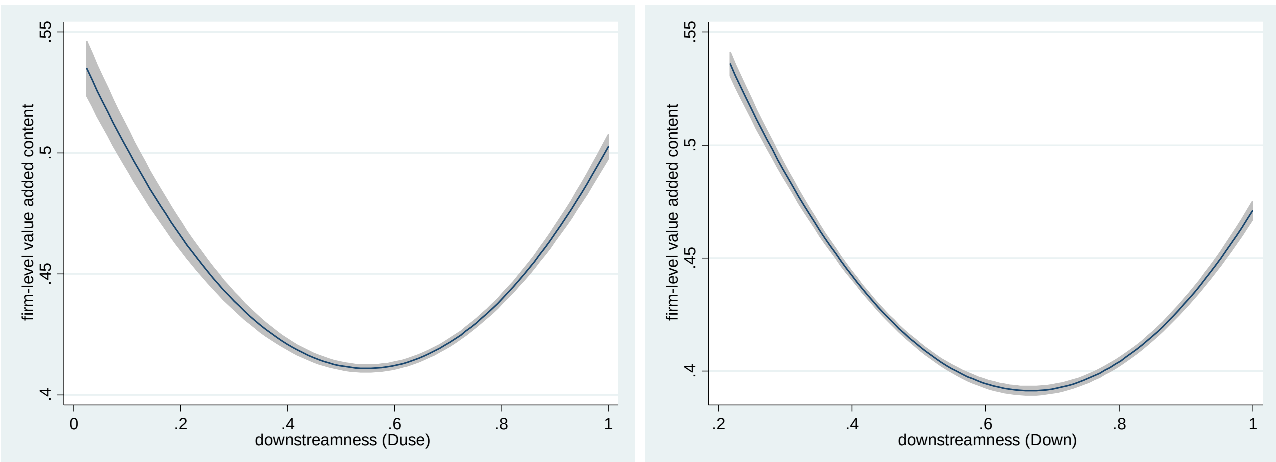
The inclusion of a control for price-cost margin is pivotal in checking for the presence of firm-specific rents embedded in the generation of value added. Indeed, it seems quite possible that part of it could be explained by a lack of competition in the specific market where the firm operates. The correlation of price-cost margins and value added content is weakly positive.

Interestingly, we find scope for a phenomenon of domestic retention of value added. We systematically find that higher value production stages are preferably located in the origin country of a MNE. This finding is robust also when we control for productivity of firms.

The latter finding is much clear when we observe the fitted values from Figure 5. Although foreign intermediate producers are on average producing at higher value, the activities at highest value on the extremes of the distribution are mostly located in the origin country, whether they are integrated under the management of a parent or they are independent company (i.e. non-integrated stages) participating to GVCs as buyer/suppliers. Further analyses are needed to understand the channels through which such a distribution and retention of value added is possible.

In Table Appendix, we also report the post-estimation fit of eq. 1 for each country included in our sample, where different 'smiling' shapes are found although with some exceptions due to uneven coverage of smaller countries.

Figure 3: Quadratic fit of firm-level value added content on downstreamness metrics



a) Post-estimation quadratic fit on eq. 1.

b) Post-estimation quadratic fit on eq. 1.

Table 4: Least squares results

Dependent variable: value added content	(1) OLS	(2) OLS	(3) OLS	(4) OLS
duse	-0.408*	-0.633**		
	(0.232)	(0.307)		
duse^2	0.401**	0.567**		
	(0.201)	(0.244)		
down			-1.071***	-0.933**
			(0.386)	(0.398)
down^2			0.830***	0.719**
			(0.304)	(0.316)
(log of) capital intensity		-0.026***		-0.026***
		(0.004)		(0.004)
(log of) size		-0.008**		-0.008**
		(0.004)		(0.004)
(log of) age		-0.014***		-0.014***
		(0.003)		(0.003)
(log of) productivity		0.083***		0.081***
		(0.005)		(0.005)
price-cost margin		0.004*		0.004*
		(0.002)		(0.002)
foreign affiliate		-0.069***		-0.070***
		(0.009)		(0.009)
integrated stage		-0.028***		-0.030***
		(0.003)		(0.003)
Constant	0.554***	0.053	0.735***	0.177
	(0.064)	(0.103)	(0.118)	(0.144)
Observations	2,026,364	1,393,798	2,026,364	1,393,798
R-squared	0.006	0.240	0.011	0.241
Country dummies	NO	YES	NO	YES
Errors clustered by 4-digit industry	YES	YES	YES	YES

Clustered standard errors by industry. *,**,*** stand respectively for $p<0.100$, $p<0.050$ and $p<0.010$.

3.2 Robustness for alternative functional forms

In this section we check whether the *'smile curve'* is robust to alternative specifications that are more flexible for alternative functional forms.

We start testing a generalized linear model (GLM) in the form:

$$E\left[\left(\frac{value\_added}{output}\right)_{ijc} / X_j, Z_i, \lambda_c\right] = G\left(\beta_0 + \beta_1 X_j + \beta_2 Z_i + \lambda_c\right) \tag{2}$$

where alternatively the $G(\cdot)'$s are known functions that satisfy $0 < G(s) < 1$ for each s. As in previous tests, the value added content of a company is tested against X_j that collects downstreamness metrics and their powers, whereas the term Z_i collects firm-level controls and λ_c is a set of country fixed effects.

As Papke and Wooldridge (1996) demonstrated, when the dependent variable is a share the linear regression model may yield incorrect predictions, especially for values that are extreme on the distribution of regressors. It is our specific case, for a dependent variable expressed as a ratio and an empirical test where the contribution of extreme values of the distributions is much important.

We pick the fractional response regression model among the family of GLM models for its ability to plot on a bounded (fractional) dependent variable, in line with Papke and Wooldridge (1996). In Table 5 we report results separately assuming that the $G(\cdot)$ is a logistic or a probit, with both metrics of downstreamness. A quadratic fit for a 'smiling curve' along the supply sequence is statistically significant also when we control for the functional form on the left hand side of the eq. 2. Signs for firm-level controls are all in line with previous results from Table 4, although we may conclude that firm size is not significantly correlated anymore with value added content.

Table 5: Fractional response (GLM) model - Probit and Logit family functions

Dependent variable: value added content	(1) Fractional Logit	(2) Fractional Logit	(1) Fractional Probit	(2) Fractional Probit
duse	-2.563**		-1.676**	
	(1.187)		(.082)	
duse^2	2.355**		1.504**	
	(0.942)		(0.648)	
down		-3.634**		-2.489**
		(1.597)		(1.068)
down^2		2.837**		1.924**
		(1.264)		(0.846)
(log of) capital intensity	-0.130***	-0.122***	-0.072***	-0.071***
	(0.014)	(0.015)	(0.010)	(0.010)
(log of) size	-0.009	-0.012	-0.019*	-0.018*
	(0.016)	(0.015)	(0.011)	(0.010)
(log of) age	-0.049***	-0.050***	-0.039***	-0.039***
	(0.013)	(0.013)	(0.008)	(0.008)
(log of) productivity	0.316***	0.309***	0.234***	0.229***
	(0.028)	(0.027)	(0.016)	(0.015)
price-cost margin	0.869***	0.682***	0.014*	0.013*
	(0.143)	(0.139)	(0.07)	(0.007)
foreign	-0.308***	-0.298***	-0.196***	-0.198***
	(0.038)	(0.037)	(0.025)	(0.024)
integrated stage	-0.140***	-0.137***	-0.078***	-0.081***
	(0.012)	(0.012)	(0.008)	(0.007)
Constant	-2.181***	-1.690***	-1.568**	-1.228***
	(0.422)	(0.596)	(0.281)	(0.391)
Observations	1,393,798	1,393,798	1,393,798	1,393,798
Pseudo R-squared	0.062	0.061	0.056	0.061
Log pseudo likelihood	-891488.07	-892133.51	-896482.12	-896373.47
Country fe	YES	YES	YES	YES
Errors clustered by 4-digit industry	YES	YES	YES	YES

Clustered standard errors by industry. *,**,*** stand respectively for p<0.100, p<0.050 and p<0.010.

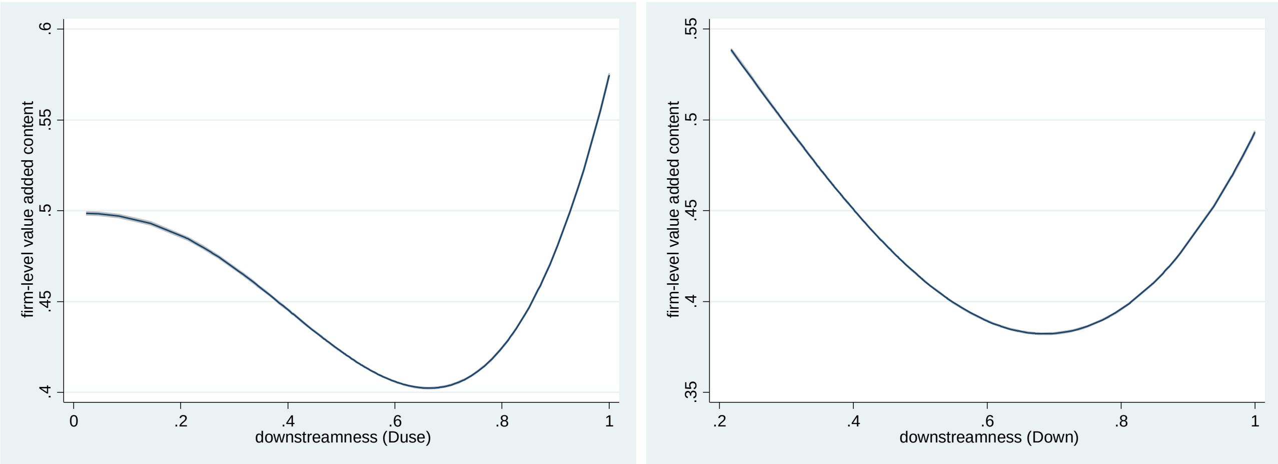
Finally, we check if a polynomial different from a quadratic fit can be found after adopting a so-called fractional polynomial regression model[6], which simply searches among different powers the polynomial that best fits the sample. After controlling for the same firm-level characteristics and country fixed effects as in eq. 2, we obtain the fractional polynomial fit reported in Figure 4. The shape of the second panel has still a curvature similar to Figure 3, although the first panel reports a small segment of convexity at first, which reduces the estimated value contribution of activities at the

[6] See Royston and Altman (1994) and Sauerbrei and Royston (1999) for further details on the procedure and motivation of its application.

top of the supply chain, making the figurative *'smile'* appear more as a *'snigger'*.

All in all, we can conclude that a quadratic fit is a good approximation of the 'smile curve' and we can consider the estimates in 4 and 5 as valid for the scopes of our analyses.

Figure 4: Post-estimation fit of firm-level value added content on downstreamness metrics after fractional polynomial regression



a) Post-estimation fit of a third-degree polynomial on eq. 2, after fractional polynomial response strategy, statistically significant at p<.001.

b) Post-estimation fit of a second-degree polynomial on eq. 2, after fractional polynomial response strategy, statistically significant at p<.001.

4 'Smile Curve' and organization modes: European Union, EU15 and NMS

In this section we distinguish three different organization modes from our firm-level data and compare their generation of value along the supply chain: i) independent buyers and/or suppliers are firms that acquire and/or sell intermediate materials or services without belonging to any corporate boundary, i.e. they don't have a parent company; ii) domestic integrated firms and iii) foreign integrated firms, depending if the origin country of the parent is the same or different from the one where they operate.

Since we don't have actual shipments of products and delivery of services, we may never know which are the partner firms, and where they are located. Yet we may assume that integrated affiliates deliver and/or receive part of their intermediate production/demand from within the corporate boundary. On the other hand, an independent buyer/seller of intermediate inputs can only trade at home or abroad with other independent companies, at arm's length. The headquarters of foreign companies can come from any country inside or outside the European Union.

Given baseline eq. 1, we derive the following post-estimation graphs, to test whether value generation is different along supply chains by organization mode. From our data, we do observe that a slightly negative difference exists in generation of value between domestically integrated affiliates and independent buyers/suppliers, which is in line with the coefficients shown in Tables 4 and 5. However, it is worth noting the case of the foreign integrated affiliates that show a dramatically different shape for value generation on supply chains.

Intermediate foreign producers in the EU that are part of MNEs have a systematic positive premium with respect to domestic producers, whether independent or vertically integrated by domestic affiliates. However, at the very top and at the very bottom of the supply chain we do have that domestic producers on average outperform foreign producers in value added generation. The finding is systematic for every econometric procedure we tested until now. For sake of simplicity we report only one of the two alternative metrics provided by Antràs and Chor (2013).

At this stage of the analyses, two plausible explanations are possible for this finding.

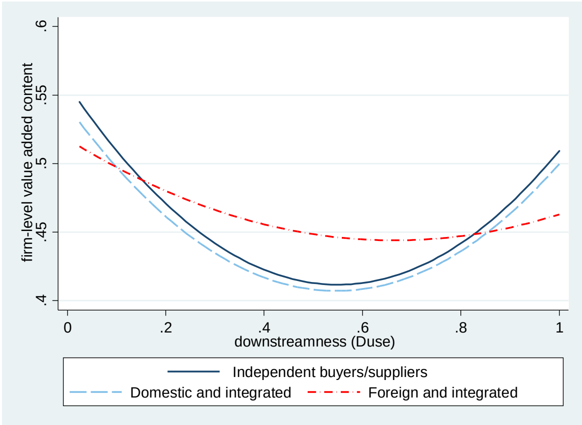
It makes sense that MNEs prefer retain in the origin country those production stages that make a difference for their present and future competitive advantages. Innovative ideas can come from the top of the chain, as in the case of R&D or manufacturing design. The logistics, the distribution network, marketing and advertising strategies are crucial for catching and maintaining customers and are probably more efficiently managed from the headquarters.

Yet it's also possible that foreign intermediate producers do source from local (non-integrated) suppliers for production stages that are at the top and/or at the bottom of the supply chain.

Unfortunately, in absence of intra-firm transactions we cannot understand which is the strategy within MNEs that prevails. In either case, on a country basis, the main source of value for the very initial and final production stages are domestic producers.

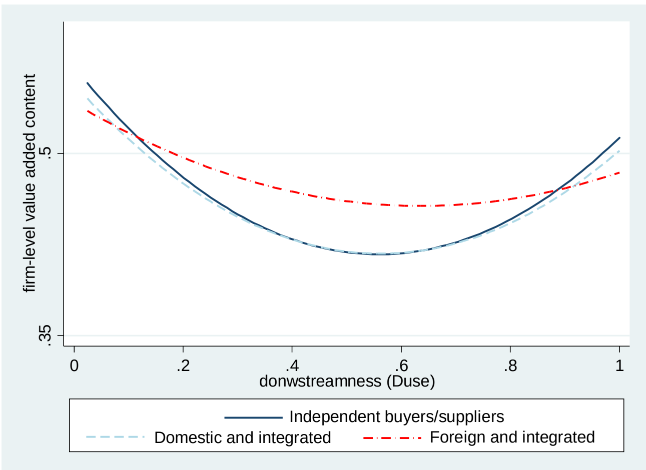
Interestingly, we obtain different shapes for the case of foreign integrated affiliates, when in Table 6 we separate firms located in NMS in the European Union since 2004 from the ones in old EU15 Members before that date. First of all, the curves of EU15 are shifted upwards. That is, we register on average a higher value content in EU15 for a representative firm at each production stage and for each organization mode. Also, the difference between independent companies and domestically integrated firms narrows and often becomes not statistically significant along the whole distribution. Eventually, we find that foreign companies in NMS have a flatter and almost linear generation of value added along the supply chain, decreasing in downstreamness. That is, foreign producers that are more proximate to final demand in NMS generate less value than upstream foreign producers. On the other hand, in NMS the difference between domestic buyers and producers at the very top and at the very bottom of the supply chain is much greater in magnitude, even if similar producers in EU15 generate on average more value in the same downstreamness position.

Figure 5: Participation mode, value generation and supply chains in the European Union

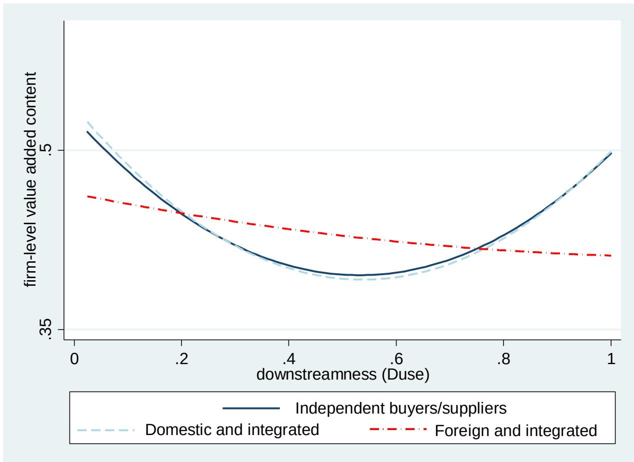


(3)

Figure 6: Participation mode, value generation and supply chain in EU15 and NMS



a) EU15 - postestimation quadratic fits as from eq. 1 of value generation on supply chain at 95% level of statistical significance.



b) NMS - postestimation quadratic fits as from eq. 1 of value generation on supply chain at 95% level of statistical significance.

(4)

5 Conclusions

In this paper we tested at the firm-level the generation of value along supply chains on a unique sample of more than 2 million companies active in the European Union in year 2015. We found robust empirical evidence for the existence of a so-called 'smiling curve', in line with what discussed in anecdotal business cases (Mudambi, 2008; Alcacer and Oxley, 2014), then usefully resumed by Baldwin et al. (2014) and discussed in international fora (OECD, 2013) for the important policy implications that it entails.

We do find that the generation of value-added is indeed concentrated at the top and at the bottom of a supply chain, even after controlling for several functional forms and for firm-level heterogeneity and country characteristics. With few exceptions, single EU countries show a similar pattern of value generation.

Further, we find empirical support for a phenomenon of domestic value added retention, since production stages on the extremes of the supply chain, where value is higher, are preferably kept in the origin country and performed by either independent buyers/suppliers or domestic affiliates. It makes sense that companies prefer to keep at home activities, like R&D laboratories, brand management and other headquarter services, in order to safeguard their present and future competitive advantages. However, there may be implications at a macro-level, since countries' specialization patterns on segments of the supply chain at higher (lower) value do imply also higher (lower) distribution of incomes by country and an uneven distribution of benefits from participation to supply chains.

Eventually, we argue, the channels for which such a concentration of value added occurs on the extremes of a supply chain are still largely unexplored. More work is needed from theory and empirics to understand the origin of the 'smiling curve' and its evolution over time.

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A Data Appendix

Value added content: computed at firm-level from Orbis database. It is the value added (sales - material costs) over operating revenue.

Downstreamness: computed by Antràs and Chor (2013) from the 2002 U.S. I–O Tables, after using the detailed Supplementary Use Table after conversion tables issued by the BEA 2002, to obtain average measures of the relative position of each industry in U.S. production processes. Antràs and Chor (2013) propose two measures of downstreamness. The first measure is the ratio of the aggregate direct use to the aggregate total use ($DUseTUse$) of a particular industry i's goods, where the direct use for a pair of industries is the value of goods from industry i directly used by firms in industry j to produce goods for final use, while the total use is the value of goods from industry i used either directly or indirectly in producing industry j's output for final use. A high value of $DUseTUse$ thus suggests that most of the contribution of input i tends to occur at relatively downstream production stages close to final demand. The second measure of downstreamness (*DownMeasure*) is a weighted index of the average position in the value chain at which an industry's output is used, with weights given by the ratio of the use of that industry's output in that position relative to the total output of that industry. These measures have been matched with the 4-digit NAICS rev.2007 parent and affiliate primary activities.

Capital intensity: computed from Orbis database. It is the ratio between fixed assets over number of employees in log.

Age: computed from Orbis database. It is the age of the firm in log.

Size: computed from Orbis database. It is the number of employees in log.

Productivity: computed from Orbis database. It is the value added over number of employees in log.

Price-cost margin: computed from the Orbis database. It represents the level of competition, defined as: [operating revenue - (cost of material + costs of employees)]/ operating revenue].

Foreign: computed from the Orbis database. It is a dummy variable equal to 1 if the firm i is a foreign owned affiliate and 0 otherwise.

Integrated stage: computed from the Orbis database. It is a dummy variable equal to 1 if the firm i is a affiliated/integrated under the management of a parent company and 0 otherwise.

B Table Appendix

Table 6: Geographic coverage by country

Country	Final goods (A)	Intermediate goods (B)	Services firms (C)	Total (A+B+C)
Austria	165	144	1,753	2,062
Belgium	1,365	1,114	13,440	15,919
Bulgaria	15,705	12,962	180,828	209,495
Cyprus	15	14	68	97
Czechia	5,833	3,919	48,389	58,141
Germany	740	642	6,225	7,607
Denmark	584	462	3,760	4,806
Estonia	3,089	2,235	35,160	40,484
Spain	29,636	21,156	347,939	398,731
Finland	5,620	3,817	43,320	52,757
France	26,270	19,870	117,721	163,861
United Kingdom	6,023	4,932	34,725	45,680
Greece	1,132	981	7,807	9,920
Croatia	5,107	3,702	53,558	62,367
Hungary	1,467	1,250	10,592	13,309
Ireland	134	122	1,849	2,105
Italy	53,215	40,895	333,987	428,097
Lithuania	457	403	3,524	4,384
Luxembourg	7	5	32	44
Latvia	3,373	2,380	60,260	66,013
Malta	18	14	20	52
Netherlands	167	143	1,468	1,778
Poland	3,719	2,897	1,549	8,165
Portugal	17,912	14,177	193,959	226,048
Romania	22,912	19,283	262,944	305,139
Sweden	7,649	5,099	13,570	26,318
Slovenia	7,357	4,680	42,275	54,312
Slovakia	5,556	4,121	79,480	89,157
Total	**225,227**	**171,419**	**1,900,202**	**2,296,848**

Figure 7: Quadratic fits by country of value added content on downstreamness (DuseTuse)

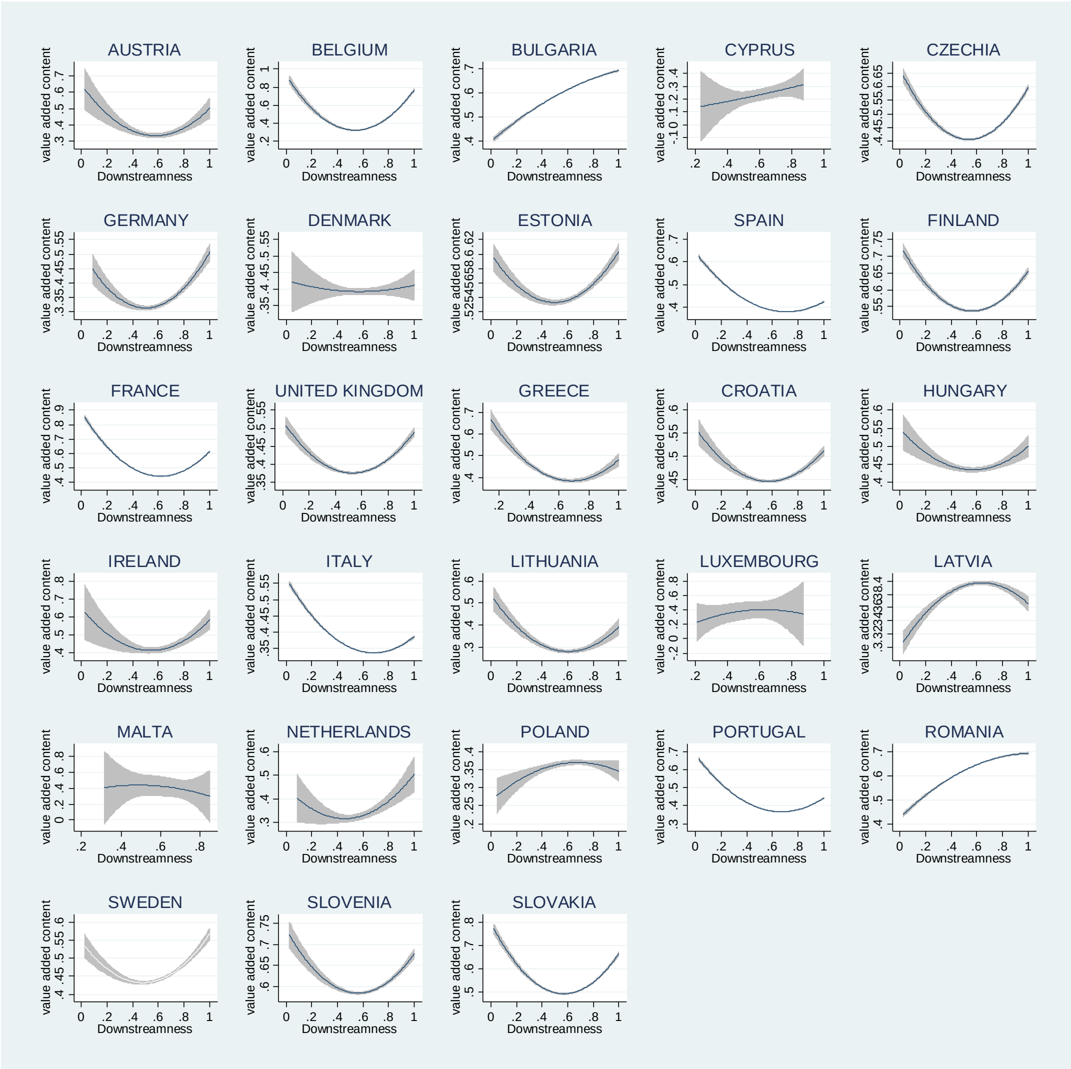

Figure 8: Quadratic fits by country of value added content on downstreamness (DownMeasure)