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The smile curve at the firm level: Where value is added along supply chains

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HIGHLIGHTS

- Firms at the early and late stages of a supply chain feature higher value added shares than *midstream* firms, hence shaping a 'smile curve'.
- To this point, the evidence in support of the 'smile curve' has been anecdotal, whereas we test it on about 2 million firms from the European Union.
- The study of the firm-level value added can help in microfounding the benefits from specialization on segments of the supply chain, as it eventually aggregates as GDP.

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ABSTRACT

In this paper, we investigate at the firm-level where value is added along supply chains on a sample of about 2 million firms in the European Union. In line with the hypothesis of a '*smile curve*', we detect a non-linear U-shaped relationship between the value added content of a firm and its distance from final consumption. Tasks at the early and late stages of the supply chains generate higher value added, possibly due to a higher knowledge-intensity, after controlling for firm heterogeneity. Importantly, our work shows that it is possible to exploit firm-level databases for an empirical microfoundation of value generation, which is useful for understanding the possibly unequal benefits of participating in global value chains.

1. Introduction

The organization of firms experienced dramatic changes, after technological advances and reductions in trade costs triggered an unbundling of production tasks across national borders (Baldwin et al., 2014). As Krugman et al. (1995) already stated, modern economic integration implies that 'goods are produced in a number of stages in a number of locations, adding a little bit of value at each stage', i.e., generating Global Value Chains (GVCs).

This paper addresses the question of where the value is added along GVCs for the first time using a firm-level dataset. We find empirical support for the existence of a *smile curve* exploiting a sample of about 2.3 million firms in the European Union in 2015. That is, value generation is more concentrated at the early and late stages of an ideal sequence of a production process. These are the segments where pre- and post-production services are located, such as R&D, design, marketing and after-sales services. In fact, only including the full span of industries, i.e. primary, manufacturing, and services, it is possible to uncover the smile curve. This notion was first introduced in the 90s by Stan Shih, the CEO of Acer, 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 (Shih, 1996; Alcacer and Oxley, 2014).[1]

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[1] On a more general basis, Baldwin and Evenett (2015) speculate that there could have been '*tilts*' in the last decades, such that production of intermediates and their assembly entail less and less value over time, due for example to automation. Unfortunately, we do not have data for the 80s to check this hypothesis.

We find that a parametric U-shape curve on supply chains is systematic after controlling for firm heterogeneity and country characteristics, both when we classify tasks by business functions, as in the framework developed by Sturgeon (2008), and when we adopt the novel *downstreamness* metrics proposed by Antràs and Chor (2013), where a distance from final consumption is proxied using input–output usage.

Interestingly, we also find empirical support for a phenomenon of domestic retention of value added. High-value activities are preferably kept in origin countries and performed either by independent buyers/suppliers or by domestic affiliates integrated by Multinational Enterprises (MNEs).

By now, the mechanisms through which value generation unevenly distributes on the supply chain are still unexplored. However, we argue that ours is an example of how analyses on firm-level value added can help in microfounding benefits from industrial specialization, development, and economic growth, as it eventually aggregates as GDP.

2. Data and preliminary evidence

We collect unconsolidated data for firms active in the European Union in 2015 from ORBIS, a cross-country database maintained by Bureau van Dijk that sources financial accounts from national business registries, annual reports, newswires, and web pages. Financial accounts are reported in the database if the firm meets the criteria to be filed in national registries. The database mimics official size distributions for most EU countries (Kalemli-Ozcan et al., 2015).

Our main variable of interest is the firm-level value added, calculated as a difference between turnover and purchases of intermediate inputs from other companies. Hence, we estimate the firm's value added content in production as the ratio between its value added and the output (turnover or sales). We further keep information on a firm's 4-digit NAICS core industry, which we use to spot its position on the supply chain, and additional financial accounts for controls on capital intensity, firm age and size, price–cost margin, foreign status. See Appendix Data for details.

To locate firms along the supply chain,[2] we merge firm-level industrial activities with *downstreamness* metrics sourced from Antràs and Chor (2013), according to which the relative location of a 4-digit NAICS industry is given by its relative usage in intermediate vs final production, as retrieved from input–output tables. Such position metrics are normalized on a range [0,1], where 0 ideally represents the start of a production line and 1 represents final goods/services destined to final consumers.

Finally, we assume that a company is vertically integrated if there is a parent with a direct or consolidated majority of equity stakes[3] (>50%). Among vertically integrated firms, we separate foreign subsidiaries when the country of the parent company is different from the hosting country.

In Tables 1 and 2, we report sample coverage by geography, industry and status. We end up with a sample of 2,296,848 companies, of these about 18% operate in manufacturing and 60% are located in EU15.[4] In our sample, 44% of EU companies never integrated under any parent company, whereas about 6% are foreign-owned.

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	–	83,064
Total	1,283,013	1,013,835	2,296,848

In Fig. 1, we detect first visual evidence of the *smile curve* after we classify firms by *business functions*.[5] Albeit preliminary, this finding is in line with business case studies, as for example in Mudambi (2008), and discussed qualitatively in OECD (2013).

In Fig. 1, the median company is represented in each boxplot as a red line. Firms in pre-production services have the highest median value added in production, around 0.60, followed by post-production services at around 0.53. That is, for each euro of sold production, a median business service creates 60 cents or 53 cents, respectively. Instead, companies engaged in the production of intermediate inputs show the lowest median value at 0.35. Despite a clear U-shape in median values, companies' value added ratios are highly dispersed within business functions, i.e., it is quite possible to find R&D or marketing activities that generate less value than the production of intermediates. In general, the distribution of value added content by producers of intermediate goods is the most compressed, whereas the distribution of post-production services is the most dispersed.

Note: value added content expresses as share of value added on sales. Lines represent respectively, lower adjacent values, 25th percentiles, medians, 75th percentiles and upper adjacent values.

3. Empirical results

In Fig. 1, we find a within-class heterogeneity that may be explained by country and firm-level characteristics. Moreover, our broader classification by business functions oversimplifies the way supply chains fragment in tasks in the modern organization of production. Therefore we challenge here the existence of the *smile curve* after: (i) introducing a detailed position metrics by Antràs and Chor (2013); (ii) testing various econometric models including country and firm-level controls.

We estimate the equation:

$$\left(\frac{\text{value added}}{\text{output}}\right)_{ijc} = \Phi\left(X_i, Z_j, \lambda_c\right) \tag{1}$$

where the dependent variable is the value added content of a firm i active in industry j and located in country c. Alternatively, we adopt a simple OLS or a fractional probit response model, which is a generalized-linear model (GLM) technique suitable for

[2] For a similar matching exercise see Del Prete and Rungi (2017). In their paper, Antràs and Chor (2013) present two alternative metrics for *downstreamenss*. 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*).

[3] In this we follow international standards, for example in OECD (2005) and UNCTAD (2009). See Rungi et al. (2017) for details on treatment of ownership structures.

[4] In Appendix Table A1 we report country details. Depending on specific rules by national regulatory bodies, smaller firms may be exempted by presentation of financial accounts.

[5] We consider pre-production services following NAICS codes: Architectural, Engineering and related services (5413); Scientific Research and Development Services (5417); Management of Companies and Enterprises (55); Computer Systems Design and related services (5415). We consider post-production services following NAICS codes: Retail Trade (44 and 45); Advertising, Public Relation and related services (5418); Other Professional, Scientific and Technical Services (5419). A separate distinction for BEC categories is possible after using conversion tables with NAICS rev. 2012 and Harmonized System (HS) provided by UN Statistics Division.