

# Structure and length of value chains

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Research in global value chains (GVCs) has generated significant interest because it unveiled indirect, unobserved linkages among economies. The focus was usually on international trade, decomposed and re-calculated in value added terms.

A relatively new stream of research examines the contribution of global value chains to total production and the length of the related production processes. This approach delves deeper into the anatomy of value chains and is expected to address a wider scope of scholarly and policy-relevant questions. Clearly, global value chain intertwines with domestic value chain, and exports and imports are only parts of, respectively, outputs and inputs. Accordingly, it is total production not only trade that needs to be decomposed. Total production length reflects the overall complexity of production chain, or how significantly it differs from direct delivery of products for final use (in this case, the length would equal 1). A breakdown of total production length indicates the intensity of the fragmentation of production within and across borders.

Laying the ground for this type of research, Wang et al. (2016)<sup>1</sup> develop a system of indicators to exhaustively characterize country and sector involvement in GVCs. They perform a decomposition of sector value added based on the “forward industrial linkage” and that of sector final output based on the “backward industrial linkage”. These provide inputs to their GVC participation indices. More importantly, Wang et al. (2016) contribute a technique of additive decomposition of the production length that allowed them to measure the average number of production stages along each individual component in value chains. The measures of production length inform the derivation of a new average production line position index that is designed to indicate whether a sector or a country is more upstream or downstream in GVCs.

The paper intended for a presentation at the Workshop on Regional / Multi-Regional Input-Output Analysis builds on the ideas of Wang et al. (2016). It re-invents a holistic system of analytical indicators of structure and length of value chains at country-sector level with various aggregation options. Technically, its contributions to the ongoing research may be summarized as follows.

First, this paper handles output rather than value added or final product flows for all measurements. This does not affect the results because it is shown that the measurement of production length is equivalent with respect to sector value added (or final demand for a sector products) and sector output. Meanwhile, this is superior for visualization purposes because a single economic variable (output) is decomposed in both directions, forwards to the destination and backwards to the origin of value chain.

Second, the indicators of structure and length of value chains result from two mathematical procedures: decomposition of output and count of the production stages within each component. The decomposition forwards to the destination builds on a factorization of the Leontief inverse into two inverse matrices of which one is responsible for purely domestic

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<sup>1</sup>Wang, Z., Wei, S.-j., Yu, X. and Zhu, K. (2016). Characterizing global value chains. Working Paper No. 578. Stanford Center for International Development.

production chain and another for the production chain beyond national borders that exists because of international trade in intermediates. The count of production stages then builds on the power series expansion of the two inverses and the well known principle of the average propagation length. Similarly, the decomposition backwards to the origin employs a factorization of the Ghosh inverse.

Third, the factorization of the Leontief (Ghosh) inverse matrices allow for an explicit count of production stages that may be classified into production stages in the country of origin (destination), domestic production stages in partner countries and cross-border production stages. The counting procedure is able to simultaneously distinguish intermediate production stages and final (primary) production stages. The analytical framework is complete because it accounts for final and primary production stages that are often neglected in similar studies.

Fourth, the paper re-designs the average production line position index of Wang et al. (2016) and proposes new GVC orientation indices. These are based on the length indicators that are normalized with respect to total output. This means that total output serves as a common denominator ensuring that all lengths are entirely comparable. For example, the modified GVC position index relates the average number of production stages that link output to final users to the average number of production stages that link the same output to primary producers through GVCs. Such normalization avoids overemphasizing the length of some unimportant cross-border value chains.

Finally, the paper proposes a stacked column chart with variable column width for the visualization of structure and length of value chains. The chart accommodates visualization of both forward and backward value chains and provides an intuitive graphical interpretation of the GVC participation, orientation and position indices.

For an empirical application of the proposed analytical framework, the paper utilizes the 2015 edition of the OECD Inter-Country Input-Output (ICIO) tables. Calculations covered the years 2000, 2005, 2008 and 2011. Overall, the results at the aggregate global, country and sector levels suggest that global value chain is much longer than domestic intermediate production chain, but its contribution to total output is much smaller. The importance of the global value chain tends to increase over time. The GVC orientation index reveals that in 2000-2008, the principal driver behind the increase in total production length was global value chain, but in 2008-2011, it was domestic intermediate production.

Country or sector position upstream in value chain means that production requires mostly primary inputs, and outputs are supplied to intermediate users. Position downstream means that production requires more intermediate inputs, and outputs are supplied to final rather than intermediate users. Relative positions in GVCs, as expected, are rather stable for sectors that largely define country positions in GVCs. The proposed analytical tools do not answer whether countries positioned upstream or downstream derive more benefits, but explain in detail country involvement in global value chains.

Indicators and visualizations proposed in the paper are thought to be accessible to non-technical audience and useful in explaining the contribution of global value chains to the economy. The author hopes that the results will help raising awareness of the analytical capabilities of the multi-regional (or inter-country) input-output tables.