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Drivers of productivity change in global value chains: Reallocation vs. innovation ☆

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ABSTRACT

We investigate the role of technological improvement and market share reallocation in determining global changes in sectoral labor productivity. Contrary to previous work that neglects dependencies between suppliers in global value chains, we account for input linkages that impact both channels of productivity improvement. Using sector-level data from the World Input–Output Database, we show that reallocation between countries has a larger effect on productivity change than innovation within countries.

1. Introduction

Changes in productivity are a major source of growth and development. Prior studies argued that the weighted average productivity of an industry can change through two main channels (Metcalfe, 1994). While the first mechanism operates at the intensive margin and stresses the role of technological improvement within producers (Mohnen and Hall, 2013), the second operates at the extensive margin and captures the reallocation of market shares between them (Alfaro and Chen, 2018). Under the hypothesis that competition increases the shares of more productive actors, the second channel explains why average productivity can improve even in the absence of innovation.

Recent literature suggests that input linkages in global value chains (GVCs) affect both aforementioned channels of productivity change. On the one hand, technological improvement does not only increase the productivity of the innovator but also the productive performance of its downstream customers, implying that productivity gains accumulate along the production chain (McNerney et al., 2022). On the other hand, Cantner et al. (2019) argue that competitive selection leads to higher market shares of producers with the most productive suppliers in their value chain, but not necessarily with the highest individual productivity. Employing multinational input–output tables, this paper asks whether reallocation between countries has a larger effect on productivity change than innovation within countries in a given industry.

2. Productivity Measure and Decomposition

The main idea of the present investigation is to measure productivity on the level of value chains instead of individual countries in a given sector. Then we aggregate this measure across countries and assess the contribution of innovation and reallocation on global productivity improvement. Our analysis focuses on global labor productivity in a given industry instead of total factor productivity (TFP) across industries in a country for several reasons. First, the choice of labor productivity eases comparability to prior work because several important studies on productivity growth decomposition considered labor productivity instead of TFP (e.g., Bernard and Jones, 1996; Dietzenbacher et al.,

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2000; McMillan et al., 2014). Second, the computation of value chain productivity and country weights simplifies considerably for labor productivity. Third, TFP might be biased in the presence of technologically heterogeneous producers and input complementarities (Dosi and Grazzi, 2006). Since the consideration of disaggregated data is crucial for the measurement of competition, we conduct the decomposition separately for each industry.

Building on the work by Timmer and Ye (2017), we employ input–output accounting to compute labor productivity as the ratio of the sum of value added across all layers of the production chain to the sum of both direct and indirect labor required for producing final output. Hence, our measure reflects that country-sectors source a substantial amount of indirect labor through the use of their suppliers' inputs.[1] Moreover, it excludes the portion of labor producing intermediate output for other country-sectors. Direct and indirect labor demand is obtained from

$$\mathbf{L} = \hat{\mathbf{l}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}, \tag{1}$$

where $\hat{\mathbf{l}}$ is a diagonal matrix with labor coefficients, measuring the direct labor demand of a particular country-sector per unit of gross output. $(\mathbf{I} - \mathbf{A})^{-1}$ is the Leontief inverse with the identity matrix $\mathbf{I}$. $\mathbf{A} = (a_{i,j}(s,r))$ is a matrix of technical coefficients, defined as output shipped from sector s in country i to sector r in country j, divided by the output of the receiving country-sector. $\mathbf{f}$ represents a diagonal matrix with final demand. We then compute the sum of direct and indirect labor necessary to produce final output from the column sum of $\mathbf{L} = (l_{i,j}(s,r))$. Using the accounting identity, which implies that the sum of value added along all layers of the value chain coincides with the output sold to end consumers, we measure the former as final demand. Thus, our value-chain labor productivity measure for sector s in country i is:[2]

$$\pi_i(s) = \frac{f_i(s)}{\sum_j \sum_r l_{j,i}(r,s)}. \tag{2}$$

To compare the role of technological improvement and market share reallocation for productivity improvement in sector s, we consider the global labor productivity Π of sector s

$$\Pi(s) = \sum_i w_i(s)\pi_i(s), \tag{3}$$

which weights productivities $\pi_i(s)$ by the labor shares $w_i(s)$ of the respective countries in that sector:

$$w_i(s) = \frac{\sum_j \sum_r l_{i,j}(s,r)}{\sum_i \sum_j \sum_r l_{i,j}(s,r)}. \tag{4}$$

In line with Griliches and Regev (1995), we then decompose the change in $\Pi(s)$ according to

$$\Delta\Pi(s) = \sum_i \bar{w}_i(s)\Delta\pi_i(s) + \sum_i \Delta w_i(s)\bar{\pi}_i(s) \tag{5}$$

into technological improvement (within effect) in the first term, and the reallocation of market shares (between effect) in the second term on the right-hand side of Eq. (5), where Δ is the difference operator, and a bar over a variable stands for its average over two consecutive periods. Our quantitative comparison of the two effects is eased by summing the effects over years and reporting their percentage shares in global sectoral labor productivity improvement. A positive and dominant absolute within effect would imply that $\Delta\Pi(s)$ improved mainly because individual layers of value chains have increased their productivity through technological change. In contrast, a positive and dominant absolute between effect would suggest that the majority of improvement originates in growing market shares of countries with a higher value chain productivity in that sector.

3. Evidence from World Input–Output Tables

Our empirical application rests on the 2013 release of the World Input–Output Database (WIOD; Timmer et al., 2015), which provides data on employment, value added, and production linkages for 35 ISIC Rev. 3 industries in 40 countries for the period 1995–2009. All data have been converted into US Dollars and adjusted for inflation using sectoral price indexes with base year 1995.

Considering the median across all industries and taking value chain linkages into account, we find that 60% of productivity improvement are due to reallocation, and only 40% originate in innovation (Fig. 1).[3] The decomposition results by economic activity in Table 1 further show that the between effect consistently dominates the within effect in agriculture, mining, manufacturing, and services, whereas the opposite holds for construction.[4] One way to interpret this result is that construction is a non-tradable sector, whereas output in agriculture, mining, manufacturing, and a part of the service sector is tradable (see OECD, 2018, p. 61). Therefore, we would expect that sectors exposed to international competition through trade are subject to a larger reallocation effect.

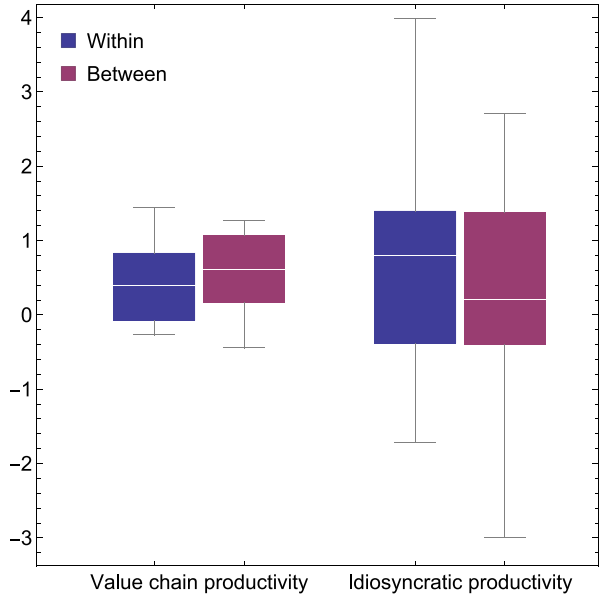

Fig. 1. Decomposition of aggregate productivity change. Box plots for the within and between effects across all industries are shown. White markers indicate median values.

[1] An implicit assumption underlying our approach and data is that all output, within a given country-industry, is produced with the same input mix, while in reality the latter might depend on the downstream use of output (de Gortari, 2019). Since the present study focuses on the global reallocation of sectoral market shares through competition, we believe that our results are not materially affected by this assumption.

[2] To simplify the notation, we omit time indices here and in the following exposition.

[3] Note that the absolute within and between effects in Eq. (5) are not always positive, implying that the total productivity change may be smaller than one of its constituent elements. This explains why percentage shares of within and between effects can exceed unity in absolute value.

[4] Despite moderate technological improvement in mining and agriculture, productivity in these industries decreased due to a negative and dominant between effect, which can be explained by the decline of these industries in several high-income countries in Europe and North America and their growing importance in low-middle and high-middle income economies such as India, Indonesia and Brazil over the sample period.

Table 1
Productivity decomposition by economic activity.

Economic activity	Within	Between
Panel A: Value-chain productivity		
Agriculture	−0.05	1.05
Manufacturing	0.43	0.57
Construction	1.00	0.00
Mining and quarrying, utilities	0.01	0.99
Services	0.38	0.62
Panel B: Idiosyncratic productivity		
Agriculture	−0.09	1.09
Manufacturing	0.69	0.31
Construction	1.65	−0.65
Mining and quarrying, utilities	4.00	−3.00
Services	0.47	0.53

Note: Reported values represent the median within and between effect across the industries in a given category.

To assess the contribution of global input–output linkages to the sectoral labor productivity decomposition, we compare our value-chain productivity measure to the idiosyncratic productivity of countries in each sector, which neglects the existence of input linkages. The results in Fig. 1 and Table 1 testify to a considerably weaker role of reallocation for the idiosyncratic productivity measure, with a median between effect across all industries of merely 21%. This stresses the relevance of input linkages in studies of productivity change and implies that the role of reallocation is downward biased when these linkages are ignored.

4. Conclusion

Although production networks have been a vital research topic in macroeconomics and international trade in recent years (Bernard and Moxnes, 2018), a quantitative assessment of the different channels of productivity change in the setting of a production network has been missing in previous studies. Against this background, we measure labor productivity in GVCs and compare the importance of technological improvement and market share reallocation in productivity improvement. We find that reallocation effects are quantitatively more important than innovation once input linkages are accounted for, especially in tradable industries. Our results have implications for the literature on growth and development, but also for competition analysis since network effects may counteract disadvantages in productive performance at the level of individual producers. Furthermore, our analysis relates to the literature on the factor content of trade (Davis and Weinstein, 2001) where it shows how country-specific labor endowments are implicitly being reallocated through intermediate input linkages across the world. A direction for future work would be to extend the analysis to total factor productivity. We will address this question in future research.

Data availability

Data will be made available on request.

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