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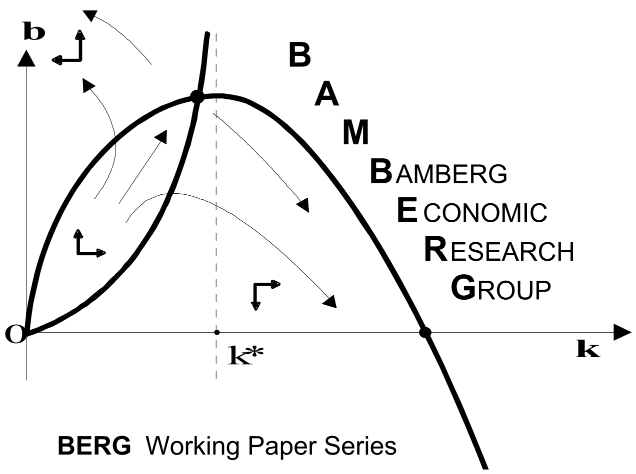

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Drivers of productivity change in global value chains: reallocation vs. innovation

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Abstract

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

Keywords: input-output analysis; market share reallocation; productivity decomposition; production network; technological improvement

JEL Classification: C67; E24; L14; L16; O47

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1. Introduction

Aggregate productivity dynamics have long been recognized as a major source of industry evolution, economic growth and development. Prior studies identified two main channels of aggregate productivity change (Metcalfe, 1994). One of them operates at the intensive margin and stresses the role of technological improvement within production units (Mohnen and Hall, 2013). The second mechanism operates at the extensive margin and suggests that competition alters the market shares of individual producers over time (Alfaro and Chen, 2018).

To better understand how market share reallocation affects aggregate productivity, consider the following example. In a market populated by N producers with heterogeneous productivity, $N-1$ producers innovate and improve their productivity, whereas the Nth producer, which operates below the industry's average productivity, does not. Then aggregate productivity of this industry may still decline if the market share of the Nth producer grows fast enough. This phenomenon is reminiscent to Simpson's (1951) paradox, which was recently discussed in the context of GDP growth (Ma, 2015) and energy consumption (Gross, 2012). Under the hypothesis that competition reallocates market shares to more productive actors, the same phenomenon explains why aggregate productivity can improve even in the absence of innovation.

Recent literature suggests that input linkages in global value chains affect both aforementioned channels of aggregate 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 depending on this intermediate input, 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. Against this background, the purpose of the subsequent empirical analysis is to provide new evidence on the quantitative importance of the two channels in global production networks.

2. Productivity measure and decomposition

The main idea of the present investigation is to measure productivity on the level of entire value chains instead of individual producers in a given sector. 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 goods and services. Hence, our measure reflects that producers source a substantial amount of indirect labor through the use of their suppliers' inputs. Since the present study explores the driving forces behind aggregate productivity change in global value chains based on multinational input-output tables, we conduct our analysis on the level of countries.

Direct and indirect labor demand is derived from

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

where $\mathbf{l}$ is a matrix with direct labor coefficients on the main diagonal and zero otherwise. These labor coefficients quantify the direct labor demand of a particular producer per unit of gross output. $(\mathbf{I}-\mathbf{A})^{-1}$ is the Leontief-inverse with the identity matrix $\mathbf{I}$, where $\mathbf{A}$ is a matrix of technical coefficients, defined as output shipped from the supplier in the row to the customer in the column, divided by the output of the receiving producer. **f** represents a diagonal matrix with final demand. Building on this approach, we compute the sum of direct and indirect labor necessary to produce final output from the column sum of **L**. Using the accounting identity, which implies that the sum of value added along all layers of the production chain must coincide with the output sold to end consumers, we measure the former as final demand.

To compare the importance of technological improvement and market share reallocation for productivity, we consider an aggregate (global) productivity index $\Pi_{j,t}$ for sector j at time t

$$\Pi_{j,t} = \sum_{i \in j} s_{i,t} \pi_{i,t}, \tag{2}$$

which is an average of productivities $\pi_{i,t}$, weighted by the shares $s_{i,t}$ of the respective countries (indexed by i) in that sector, measured in terms of labor used to produce the value added. Contrary to prior studies, however, $\pi_{i,t}$ in Eq. (2) is not interpreted as the idiosyncratic productivity of country i in that sector, but as the productivity of the value chain that ends in i and includes all of its direct and indirect upstream suppliers domestically and abroad.

In line with (Foster et al., 2001; Griliches and Regev, 1995), we decompose the change in $\Pi_{j,t}$ into two components: (i) technological improvement (within effect), and (ii) reallocation of market shares (between effect). Formally, this is expressed as

$$\sum_{t} \Delta \Pi_{j,t} = \sum_{t} \sum_{i \in j} \bar{s}_i \Delta \pi_{i,t} + \sum_{t} \sum_{i \in j} \Delta s_{i,t} \bar{\pi}_i, \tag{3}$$

where Δ is the difference operator, and a bar over a variable stands for its average over two consecutive periods. The first term on the RHS of Eq. (3)

denotes the within effect, whereas the second term captures the between effect. Our comparison of the two effects is eased by reporting their percentage shares in aggregate productivity improvement. In this setting, a positive and dominant within effect would imply that global labor productivity in a given sector improved mainly because individual layers of the different value chains have increased their productivity through technological change. In contrast, a dominant between effect would suggest that the majority of aggregate productivity improvement originates in growing market shares of countries with a higher value chain productivity in that sector. Negative values of the within and between effects may be interpreted as technological regress and a reallocation of market shares towards countries embedded in less efficient value chains, respectively.[1]

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 information on sector-level production linkages between 35 ISIC Rev. 3 industries in 40 countries for the period 1995-2009. These countries include the current 27 members of the European Union and 13 other major economies such as the United States, China, Japan, India, Russia, Brazil, United Kingdom, and Canada. For comparison, we repeat the analysis for the 2016 WIOD release, including 56 ISIC Rev. 4 industries in 43 countries for the more recent period from 2000 to 2014.

Considering the median across all industries, we find that 60% of aggregate productivity improvement in the period 1995-2009 are due to market

[1] These interpretations hold when global productivity change in a given sector is strictly positive (Savin and Letyagin, 2022).

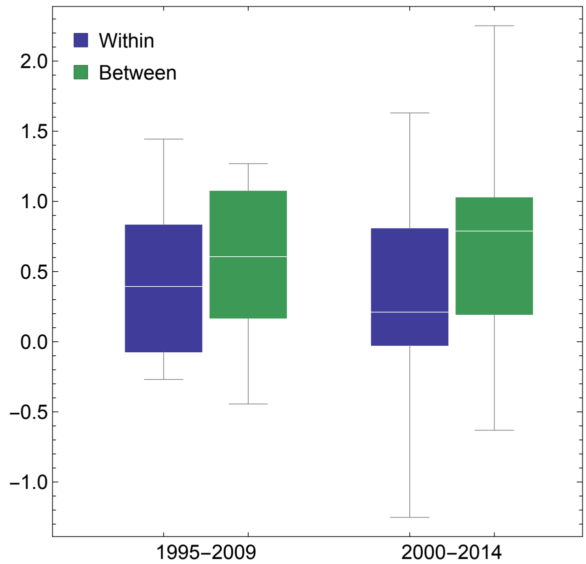

Figure 1: Decomposition of aggregate productivity change. The productivity measure is value added (in USD) per labor hour. Box plots for the within and between effects across all industries are shown, expressed in percentage terms. White markers indicate median values.

share reallocation, and only 40% originate in innovation (Fig. 1). If we consider the most recent WIOD release covering the period 2000-2014, we find that reallocation accounts for even 80% of total productivity growth. Therefore, our results suggest that (i) market reallocation outweighs technological improvement as the main driving force behind productivity change in production networks, and (ii) the role of competitive selection and reallocation has increased in recent years, which may testify to fiercer competition in international markets in this period.

The decomposition results by economic activity in Table 1 further show that the between effect consistently dominates the within effect in agriculture, manufacturing, and services, whereas the opposite holds for the con-

Table 1: Productivity decomposition by economic activity.

Economic Activity	Within	Between
Panel A: 1995-2009		
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: 2000-2014		
Agriculture	0.09	0.91
Manufacturing	0.15	0.85
Construction	0.76	0.24
Mining and quarrying, utilities	1.20	-0.20
Services	0.30	0.70

Note: The 35 ISIC Rev. 3 and 56 ISIC Rev. 4 industries are aggregated into five broad categories of economic activity. Reported values represent the median within and between effect across the industries in a given category.

struction sector.[2] 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.

[2]The mining sector yields somewhat inconclusive results since it exhibits a large variation of within and between effects over time. Since the total productivity change in mining is positive, we can interpret the negative between effect as a reallocation of market shares towards less efficient countries. By contrast, the aggregate productivity change in agriculture is negative in both samples, implying that the negative within effect observed for the period 1995-2009 testifies to an idiosyncratic productivity improvement, whereas the positive between effect points to a reallocation of market shares towards less efficient producers.

4. Discussion and conclusions

Although production networks have been a vital research topic in macroeconomics and international trade in recent years (see, e.g., the survey by Bernard and Moxnes, 2018), a quantitative assessment of the different channels of productivity change in the setting of a production network has been largely missing in previous studies. Against this background, we measure productivity in global value chains and compare the importance of technological improvement and market share reallocation in aggregate labor productivity improvement. Our analysis suggests that reallocation effects are quantitatively more important than innovation in the aggregate across all industries, but the result also holds under sectoral disaggregation in agriculture, manufacturing and service sectors.

Our findings have implications for investigations into growth and development, where they challenge the view that technological change is the most important cause of economic growth (McNerney et al., 2022) and instead emphasize the importance of market reallocation. In this context, our systemic perspective on multinational production highlights the relevance of network effects in the reallocation process, implying that the selection of upstream suppliers and a country's positioning in the global value chain is another source of productivity improvement, complementary to innovation spillovers along input linkages. Our results may also have implications for competition analysis since network effects may counteract and potentially even overcompensate disadvantages in productive performance at the level of individual producers. An important direction for future work would thus be to estimate the relative contributions of individual and network-related effects in productivity growth. We will address this question in future research.

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