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Understanding Productivity and Employment in a Fragmenting Economy

The Global Value Chain Approach

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Abstract and Keywords

This chapter introduces a new approach to better understand productivity and employment growth in the global economy. As production fragmentation takes place across borders, countries specialize in particular tasks within global value chains, such as R&D, logistics, manufacturing, and marketing activities. To understand the effects of this on domestic labour demand, one needs to model the full interactions between the various participants in production. The global value chain approach is introduced, and its usefulness is illustrated with a study of the value added distribution of German cars across countries and production factors. It is argued that further study of the substitution possibilities across workers of

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different types and countries, as well as between labour and (intangible) capital is needed.

Keywords: global value chains, production fragmentation, specialization, intangible capital, productivity

3.1 Introduction

Production processes in today's world no longer take place in one location: instead goods and services are produced in intricate regional production networks feeding into each other. This fragmentation of production across sectors and countries has pervasive implications for local labour markets, driving new patterns of productivity and employment growth. Take the production of the iPod, which is exemplary: designed in the United States (US), assembled in China based on several hundreds of components and parts that are sourced from around the world. In a seminal study Linden, Dedrick, and Kraemer (2011) found that 'in 2006, the iPod supported nearly twice as many jobs offshore as in the US. Yet the total wages paid in the US amounted to more than twice as much as those paid overseas. Driving this result is the fact that Apple keeps most of its research and development (R&D) and corporate support functions in the US, providing thousands of high-paid professional and engineering jobs that can be attributed to the success of the iPod.'¹ Anecdotal evidence like this suggests that advanced countries are increasingly specializing in skill- and capital-intensive activities within global value chains (GVCs), more popularly described as a process of (p.69) turning into 'headquarter economies'. As a result firms and countries no longer trade goods, but tasks.

How to measure and analyse productivity, employment, and wages in such a fragmenting global economy? Foxconn in China is producing iPods using intangible designs and technology from Apple. But these services are typically not recorded in production and trade statistics, such that any study of the productivity of Chinese and US manufacturing is seriously hampered. Likewise, without the explicit modelling of substitution possibilities between Chinese and US workers, shifts in local labour demand are difficult to analyse. A new conceptual framework is needed which goes beyond the

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traditional analysis of separate firms, industries, or countries. In this chapter we introduce the GVC approach, which combines recent new insights in the literature on international trade, the so-called ‘trade in tasks’, see Grossman and Rossi-Hansberg (2008), and in labour economics, the ‘task-approach to employment and earnings’, see Acemoglu and Autor (2011).² In the GVC approach we model production as a set of discrete activities in distinct locations, which altogether form a supply chain starting at the conception of the product and ending at its delivery. We trace the value added by labour and capital in each activity by means of input-output (IO) analysis rooted in the seminal work by Leontief.³ This provides new opportunities to analyse substitution possibilities between various types of labour, both domestic and foreign, as well as between capital and labour. It also offers for the first time the opportunity to measure the possible factor biases in technological change.

Apart from being conceptually appealing, this approach also bypasses some of the empirical problems that confront current productivity analyses. When fragmentation is high, accurate measurement of prices of intermediates becomes paramount to measure productivity. However, there is increasing doubt about the reliability of price indices for imported intermediates.⁴ Even more serious is the problem of measuring flows and prices of intangible services such as the use of software, patents, brand names, or logistics. Intangibles are becoming increasingly important in production and are making up a major share of (p.70) investment by firms. But so far the measurement of intangible output, and in particular use, appears to be challenging.⁵ For example, the use of Apple’s intangible designs and technology by Foxconn is typically not recorded in production and trade statistics. How to measure productivity of firms and sectors without information on the quantity and price of the most valuable inputs? The GVC approach offers a first step towards a new framework that takes this important but elusive characteristic of modern production systems as a point of departure.

The rest of the chapter is organized as follows. We first outline in Section 3.2 evidence for the pervasiveness of the

international fragmentation process. The GVC approach is presented in Section 3.3 and illustrated with an analysis of German car manufacturing. Functional specialization in GVCs is discussed in Section 3.4. Section 3.5 offers some concluding remarks on whether the emergence of GVCs can explain, or raises doubt about, the recent slowdown in measured productivity in the EU.

3.2 Increasing Fragmentation of Production across Borders

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With the increasing sophistication of coordination technology, declining prices for

Figure 3.1. Foreign value added shares in 560 global value chains

Notes: Each dot represents the share of foreign value added in the output of a final manufacturing good in 1995 and 2008. Shares are plotted for 560 global value chains, identified by fourteen manufacturing industries of completion in forty countries. Squares indicate global value chains of electrical equipment (ISIC rev. 3 industries 30-33) and diamonds indicate petroleum refining (ISIC 23). The dashed line is the 45 degree line.

Reproduced from Figure 2 in Timmer et al. (2014)

transportation, and the opening up of major emerging economies to international trade and investment, fragmentation and international task-division has taken flight. While this process is not new (Feenstra, 1998), it has accelerated in the 2000s. This is illustrated in Figure 3.1, taken from Timmer et al. (2014). It shows the so-called ‘foreign value added shares’ in 1995 on the horizontal axis and 2008 on the vertical axis, together with a 45-degree line. The foreign value added share indicates what percentage of the

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value of a final good is added *outside* the country where the last stage of production took place (see Section 3.3 for more details on measurement). There are data for 560 final product groups from fourteen manufacturing industries in forty countries for each year. For 85 per cent of the product chains, the foreign value added share has increased, indicating the pervasiveness of international fragmentation. The (unweighted) average foreign share rose from 28 to 34 per cent. There is a large variance in fragmentation across products. Petroleum products have very high foreign value added shares because most countries do not have access to domestic oil feedstock, (p.71) reflected in a cluster of diamond-shaped points in the upper part of the figure. Value chains for electrical equipment, typically regarded as the paragon of international production fragmentation, are shown by square points. For these products, foreign value added shares are indeed above average and increased from 33 to 40 per cent. In contrast, manufactured food stuffs have relatively low shares, as most of the intermediates are sourced from local agriculture. But even for these products, foreign shares have increased over time.

Fragmentation of production across borders goes hand in hand with fragmentation across sectors. Since the 1970s a steady process of outsourcing has taken place in advanced economies. In order to benefit from economies of scale and specialization, manufacturing firms outsourced non-core activities such as cleaning, catering, accounting, and (p.72) other administrative back-office activities to other firms. As a result the scope of activities of manufacturing firms is shifting away from manufacturing production towards pre- and post-production services, such as R&D, design, after sales services, and marketing. The quintessential examples are so-called 'factoryless' or 'factory-free' manufacturing firms. These are firms that are manufacturing-like in that they perform many of the tasks and activities found in manufacturing establishments themselves, except for the actual manufacturing production process. In the current US statistical system they are classified in wholesaling, and their output is recorded as a wholesale margin, rather than manufacturing sales.⁶ This underlines the increasing weakness of current statistical

systems in capturing fundamental shifts in production as they are based on classification of firms as if all stages of production are performed in-house.⁷ And by modelling output of a firm only as a function of labour and capital used by the firm itself, economic analysis is increasingly losing sight of the important interactions with other firms, both domestic and foreign. The standard production function approach needs amendment.

3.3 The GVC Approach to Production

To understand the consequences of fragmentation processes for productivity, employment, and wages a new conceptual framework is needed that goes beyond the traditional analysis of separate firms and industries. Timmer et al. (2013) introduced the GVC approach that takes fragmentation of production as the point of departure. The GVC of a final good is defined as the set of all value-adding activities needed in its production. It is identified by the industry-country in which the last stage of production takes place, which we call the industry-country-of-completion. A GVC includes the value added in the last industry, as well as in all other industries in the same country or abroad where previous stages of production take place. To decompose value added in production, we make use of (a variant of) Leontief's (1936) decomposition method in which the modelling of IO structures of industries is central. The IO structure of an industry (p. 73) indicates the amount and type of intermediate inputs needed in the production of its output. These intermediates are produced by other industries, domestically and abroad. Based on a modelling of the trade linkages across industries and countries, one can trace the gross output in all stages of production that is needed to produce one unit of final demand. To see this, take the example of car production in Germany, and suppose demand for German cars increases. This will in the first instance raise the output of the German car industry. But production in this industry relies on car parts and components that are produced elsewhere, such as engines, braking systems, car bodies, paint, seat upholstery, or windscreens, but also energy, and various business services such as logistics, transport, marketing, and financial services.

These intermediate goods and services need to be produced as well, thus raising output in the industries delivering these: let us say the German business services industry, the Czech braking systems industry, and the Indian textile industry. In turn, this will raise output in industries delivering intermediates to these industries, and so on. These indirect contributions from both manufacturing and non-manufacturing sectors will be explicitly accounted for through the modelling of IO linkages across sectors. When we know the gross output flows associated with a particular level of final demand, we can derive the value added by multiplying these flows with the value added to gross output ratio for each industry. By construction the sum of value added across all industries involved in production will be equal to the value of the final demand. Following the same logic, one can also trace the number of workers who are directly and indirectly involved in GVC production, or the amount of capital. For a more technical exposition, see Timmer et al. (2013). Data for this type of analysis is publicly available from the World Input-Output Database.⁸

The GVC approach allows for a rich analysis of international production, based on tracing changes in the regional and functional distribution of value added in production chains. In particular, one can analyse the (p.74) degree of international fragmentation in the production of a particular set of products (see Los, Timmer, and de Vries, 2015), or the substitution of domestic for foreign production factors, or capital for labour (see Timmer et al., 2014). Changes in the value added by a country in one or more value chains can also be viewed as an indication of its competitiveness in these chains. Extending this idea, Timmer et al. (2013) suggested the use of the label ‘GVC Income’ for the value added generated by a country in the production of all final manufactured products completed anywhere in the world. Trends in GVC incomes provide a better indication of changes in a country’s competitiveness than shares in global exports as traditionally used.

**Table 3.1. Value added to GVC of German cars
(percentage of final output value)**

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	1995	2008
<i>Value added in Germany</i>	79	66
High-skilled labour	16	17
Medium- and low-skilled labour	42	29
Capital	21	20
<i>Value added abroad</i>	21	34
High-skilled labour	3	6
Medium- and low-skilled labour	10	13
Capital	8	15
Total final output	100	100

Note: Breakdown of the value added to final output from German transport equipment manufacturing (ISIC rev. 3 industries 34 and 35).

Source: Based on Timmer et al. (2014), Table 1

In Table 3.1, we provide a real world example of a decomposition for the final output of transport equipment manufacturing in Germany, in short German cars. By summing over all value that is added by labour and capital employed in German industries, the domestic value added content of the product can be calculated. This includes value added in the car industry itself, but also in other German industries that deliver along the production chain, including service industries. Perhaps surprisingly, the latter account for up to half of domestic value added. Between 1995 and 2008, the domestic value added content dropped from 79 to 66 per cent. On the flipside, the foreign value added share increased as intermediates were increasingly imported, generating income for labour and capital employed outside Germany. The factor content of the GVC of German cars changed as well. To see this, one can add the contributed value added by all labour, irrespective of its location, and similarly for capital. It follows that the value added by capital (p.75) increased from 29 to 35 per cent, while the share of labour dropped from 71 to 65 per cent. The drop in labour was almost exclusively for less-skilled workers in Germany. The share for high-skilled workers both

within and outside Germany increased. The patterns of shifting location and factor content of activities in the global value chain of German cars are representative for many other chains of manufacture, as shown in Timmer et al. (2014).

3.4 Functional Specialization in GVCs

What might account for the particular patterns of fragmentation? In traditional models of production, factor shares are determined by the interplay of relative prices of factors, their elasticities of substitution, and the nature of technical change. Given fragmentation, it seems insightful to model the generation of output as a result of a set of activities which are to be completed by various combinations of production factors. So rather than a direct mapping from labour and capital inputs to output, factors map into activities (or tasks),⁹ which subsequently map into output. This framework allows for a much richer modelling of complementarities and substitution possibilities between various factors of production, both domestic and foreign. Acemoglu and Autor (2011) outline a general framework that revolves around differences in comparative advantages of factors in carrying out tasks: all workers can carry out all tasks, but some are relatively better at carrying out certain tasks (hence are said to have a comparative advantage in this task). Substitution of skills across tasks is possible, such that there is an endogenous mapping from workers to tasks depending solely on labour supplies and the comparative advantages of the various skill types. Functional specialization arises naturally in such a framework, as skilled workers in advanced countries have a comparative advantage in headquarter activities, while less-skilled workers in emerging economies have a comparative (but perhaps no absolute) advantage in carrying out low-tech activities such as assembly, testing, and packaging. The framework also allows for capital as an input, by modelling it as another source competing with labour for the supplying of certain tasks. For example, new information technology capital might be much better in handling routine administrative tasks than skilled white-collar labour, (p.76) known as the ‘routinization hypothesis’ put forward by Autor, Levy, and Murnane (2003).

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Table 3.2. Value added by workers in GVC of German cars

	1995	2008	Change
<i>Headquarter activities, of which:</i>	52.4	49.8	-2.7
Management	6.5	6.4	-0.2
Back office	17.1	11.9	-5.2
R&D	15.6	17.3	1.6
Logistics	4.5	5.9	1.4
Marketing	8.7	8.3	-0.4
<i>Production activities</i>	31.0	21.8	-9.2
Total value added by workers in Germany	83.5	71.6	-11.9
Total value added by workers abroad	16.5	28.4	11.9

Notes: Value added by workers in final output of the transport equipment manufacturing industry in Germany (ISIC rev. 3 industries 34 and 35). Value added is measured as income of workers. Activities are identified by occupation of workers involved.

Sources: Timmer and de Vries (2015), based on World Input-Output Database (November 2013 release) and occupation database

How might one measure and analyse the mapping of labour and capital to various activities in production? Timmer and de Vries (2015) offer a first attempt by collecting additional data on the occupational structure of the labour force to provide a first indication. They distinguish between production activities, carried out by production and assembly workers and technicians, and headquarter activities carried out by workers doing R&D, management and back office, logistics, and marketing. Value added in an activity is measured by the income of the workers involved. We continue our example of German cars in Table 3.2.¹⁰ The table suggests that the declining share of value added by activities in Germany is largely accounted for by the decline of production activities (-9.2 percentage points) and administration and back-office

functions (-5.2). The offshoring of fabrication tasks for German cars to Asia and Eastern Europe is well known. For example, Dudenhöffer (2005) shows that the last stage of production of a Porsche Cayenne takes place in Leipzig. But the activity involved was the placement of an engine in a near-finished car assembled in Bratislava, Slovakia. Slovakian workers assembled a wide variety of components such as car body parts and interior and exterior components, some of which were (partly) made in Germany itself, but others sourced from (p.77) around the world. But the results suggest that a lot of administration and back-office tasks were offshored and/or automated as well. In contrast, the shares of R&D and logistics activities in Germany increased, respectively by 1.6 and 1.4 percentage points. This suggests specialization in some of the core functions of GVCs by lead automotive firms at home.

3.5 Concluding Remarks

As production fragments across borders, countries specialize in particular tasks within global value chains, such as R&D, logistics, manufacturing, and marketing activities. To understand the effects of this on domestic labour demand, one needs to model the full interactions between the various participants in production. We outlined the GVC approach and illustrated its usefulness with a study of the value added distribution of German cars across countries and production factors. We found evidence of functional specialization within global value chains. The results provide a number of suggestions when trying to understand productivity trends and employment growth in Europe and the global economy.

First, studies of local labour demand should take into account and model possible substitution possibilities across workers from different countries. Given the pervasiveness of international fragmentation this can no longer be ignored: including a simple variable representing 'offshoring' will no longer do in empirical work.

Second, it is important to note that with fragmented production, sectors such as 'manufacturing' are becoming the wrong way to evaluate economic performance and to frame

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public policies. In a world of fragmented production competitiveness is no longer solely determined by a domestic cluster of manufacturing firms, but relies increasingly on the successful integration of other activities in the chain, domestic and abroad, within and outside manufacturing. Indeed in almost all high-income countries the number of services jobs related to manufacturing production has increased since 1995, with the notable exceptions of the United Kingdom and the US. In Germany and Italy, this increase was even faster than the decline in manufacturing jobs such that the net effect was positive (Timmer et al., 2013).

Third, much more insight is needed into the role of intangibles, such as software, patents, trademarks, and finance in (cross-border) production. Without a proper measure of the quantity and price of these intangibles productivity is difficult to measure. Our finding of increasing income shares of capital in GVCs suggests that the importance of (p.78) intangibles is increasing in value terms. But as yet it is hard to say whether this will lead to particular biases in current productivity measures for European countries. If anything, the findings suggest that measures of *multifactor* productivity should be cautiously considered. While at more aggregate levels, such as gross domestic product (GDP), biases might cancel out as output of one industry is an input for another, this is not the case for more detailed industry studies.¹¹ Measurement of productivity trends in manufacturing industries of small open economies will be particularly vulnerable.

It should be noted that the empirical analysis provided in this chapter is based on rather crude data and does not (yet) offer a full-blown alternative to growth accounting. The use of synthetic world IO tables, albeit an improvement upon previous attempts, is still only a first approximation as it relies on strong assumptions owing to lack of direct information about inputs used in various stages of production. Given firms' secrecy or even ignorance about their own position in global production chains, this situation will not easily improve without major new data collection efforts. Fortunately, there are ongoing attempts in other areas to provide fresh evidence

about the type of business functions that are carried out domestically and those that are offshored (Sturgeon et al., 2013; Brown, Sturgeon, and Lane, 2014; Fontagné and d'Isanto, forthcoming). Information of this type collected on a national scale could potentially provide a link to help identify the spatial distribution of activities within global value chains of firms. As yet, these surveys are in a testing phase and not part of a regular statistical program. But our hope is that they will eventually result in a more comprehensive understanding of the consequences of functional specialization for productivity growth and employment in the world economy.

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Notes:

(¹) Dedrick et al. (2010) show similar results for some other high-end electronic products such as notebooks. See also Ali-Yrkkö and Rouvinen (2015) for a wide set of Finnish goods.

(²) The GVC approach is also used to denote a longer research tradition in economic sociology, and was introduced by Gary Gereffi and co-workers. In this line of work emphasis is mainly put on analysis of the governance in production chains, and in particular the prospects for upgrading for less advanced

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countries and firms. Gereffi (1999) provides a good introduction to this work for economists.

⁽³⁾ See Miller and Blair (2009) for an overview.

⁽⁴⁾ See contributions in Houseman and Mandel (2015) for studies of the possible mismeasurement of the import price of semi-conductors and its implications for measured productivity in US manufacturing.

⁽⁵⁾ See Corrado et al. (2012) for pioneering attempts.

⁽⁶⁾ For overviews see Bernard and Fort (2013) and contributions in Houseman and Mandel (2015, Volume 2).

⁽⁷⁾ Important statistical data classifications such as the International Standard Industrial Classification (ISIC) of All Economic Activities have not been oblivious to this. For example, ISIC Revision 4 has a separate industry called 'Activities of head offices', but this is related to other units of the same firm.

⁽⁸⁾ The World Input-Output Database is freely available at <www.wiod.org> and has been specifically constructed for analyses like this (Timmer et al., 2015). The second release provides a time series of World Input-Output Tables (WIOTs) from 1995 to 2011. It covers forty countries, including all twenty-seven members of the European Union (as of 1 January 2007) and thirteen other major economies: Australia, Brazil, Canada, China, India, Indonesia, Japan, Mexico, Russia, South Korea, Taiwan, Turkey, and the US, plus a model for the remaining non-covered part of the world economy. It contains data for thirty-five industries covering the entire economy, including agriculture, mining, construction, utilities, fourteen manufacturing industries, and seventeen services industries. It also contains numbers and incomes of workers of three skill types, identified on the basis of educational attainment levels, as well as capital.

⁽⁹⁾ We prefer to use the term 'activity' instead of 'tasks', as the latter often refers only to activities of workers, while we want to analyse the role of capital as well.

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(¹⁰) Note that in contrast to Table 3.1, only value added by labour is analysed. Value added by capital cannot be allocated to any of the activities without additional information on the type and use of the capital good.

(¹¹) This is akin to the problem in measuring and attributing productivity growth in the computer and semi-conductor industries owing to mismeasurement of semi-conductor prices. While this bias measured productivity in both industries, it will not affect productivity measured in the aggregate, as output of one serves as input for the other industry.

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