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Analyzing the production structure by the subsystem approach to the input-output model: a cross-country perspective

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Abstract

The structure of the international production system has changed a lot over the last few decades. The principal aspects are two: a) a great growth of the services; b) an increase of the inter-industry linkages. These aspects have contributed to overcome the traditional distinction of sectors. The different economic activities can indeed be complementary rather than substitutable. This paper aims to provide new empirical evidences through the analysis of structural change within six major developed countries (Germany, Italy, France, Spain, UK and US). By using the World Input-Output Database, the paper adopts a subsystem approach to the Input-Output model during the time period 1995-2011.

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Abstract

The structure of the international productive system has changed a lot over the last few decades. The principal aspects are two: a great growth of the services sector and an increase of the integration and the interdependence among the different sectors. These aspects have contributed to overcoming the traditional distinction of sectors. The different economic activities can indeed be complementary rather than substitutable. It follows that in most economies, two specific trends can be observed, such as the tertiarization of manufacturing and the industrialization of services. This paper aims to provide new empirical evidences through the analysis of structural change within six major developed countries (Germany, Italy, France, Spain, UK and US). By using the World Input-Output Database, the paper adopts an Input-Output subsystem approach during the time period 1995-2011.

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1. Introduction

Over the past few decades, the evolution of the world economy has deeply transformed the structure of the production system. Developed economies have shown gradual growth of employment in the services and a simultaneous decrease in the share of the manufacturing sector both in absolute terms and as a percentage of total employment. On this theme, economic theory has elaborated different formulations that have contributed to intensifying the economic debate.

The technological revolution has increased the diffusion of inter-industry linkages in the economic system, and these intermediate phases have become increasingly important in final production. According to Jones (2011), the traditional macroeconomics growth models, which do not account for intermediate goods, could lead to an incorrect perspective. Inter-industry linkages allow us to capture the consequences of a misallocation of resources, which enables us to explain economic differences across countries. In other words, the economic system can be represented as a set of interconnected functions, some of which are related to manufacturing and other activities included in services. Interactions between these activities have become a driving force of wealth generation. A consistent part of employment growth in the tertiary sector is attributed to growing employment in services as an input of manufacturing firms (outsourcing) due to increasing vertical integration among different sectors (François and Woerz, 2008; Pilat and Wölfl, 2005).

The greater integration of the input of services in the economic system and the use of information and communications technology (ICT) in the services have made the traditional distinctions between sectors obsolete (Preissl, 2007). Empirical evidence confirms an increased blurring of distinctions between manufacturing and services and indicates that the various industrial activities could be complementary rather than substitutable (Pilat et al., 2006). It is possible to highlight greater convergence between these sectors, with manufacturing increasingly oriented to services and services, in turn, gradually more industrialized (Gallouj, 2002). In a highly interconnected context, one of the most important sources of economic growth, and thus of the competitiveness and diversification of the economy, increasingly depends on the spillover effects between the different activities that characterize the production system (Barriero De Souza et al., 2016).

The evidence presented in most studies on structural change is insufficient for an adequate understanding of these phenomena because they take a sector-based approach. In particular, these analyses do not account for the shifting boundaries between the market and in-house firms' activities (Franke and Kalmbach, 2005), and they can lead to over/underestimation of the different relationships between manufacturing and services (Ciriaci and Palma, 2016). What emerges from these approaches is that, notwithstanding the relevant results obtained, they suffer from an intrinsic difficulty in measuring the indirect effects of the reorganization of the economic system. The traditional analysis is based on a "horizontal" perspective of the production system, which considers the economic sectors separate from one another. In this respect, user-producer interactions are neglected, and an analysis of structural changes could result in some misspecification problems.

The present paper, based on Pasinetti's subsystem approach, allows investigation of the complexity of structural transformations by adopting an analytical scheme that differs from the traditional framework. According to the "vertical" perspective, we transform the input-output (I-O) tables into a set of vertically integrated sectors, so that the number of hours worked that directly and indirectly satisfy final demand for goods and services can be estimated. This empirical scheme emphasizes demand-driven growth, in which the inter-industry relationships are identified according to the linkages between final goods and all production inputs.

In this I-O scheme, a sector can affect the economic structure in different ways. In particular, we refer to the input multiplier, or the forward linkages, as the ratio of intermediate inputs (direct and indirect) from a sector to each subsystem over the hours worked in the sector. These linkages allow us to capture the available supply used for production in the economic system. In this manner, we can shed light on two-way integration by highlighting the differences in the patterns of change in the manufacturing and services sectors, respectively.

However, the literature focuses mainly on evidence of deindustrialization while the various kinds of interaction between manufacturing and services is a topic that has attracted less attention. Furthermore, in this strand of research, the main studies do not conduct comparative analyses of different national production systems. Momigliano and Siniscalco (1982), for instance, explore structural change in the Italian economy, and Montresor and Vittucci Marzetti (2011), neglecting national characteristics, take a global view by aggregating data from different countries in an idea of a pseudo-word.

The present paper, using the World Input-Output Database (WIOD), aims to provide new empirical data through an analysis of structural change in six developed countries: Germany, Italy, France, Spain, the United Kingdom (UK), and the United States (US) during the period 1995-2011. This analysis reveals several important differences in the structural characteristics of these economies that cannot be captured at a global scale. The paper not only underlines the growing heterogeneous patterns related to deindustrialization but also highlights the main differences between manufacturing and service-oriented economies. Unlike the traditional approach, we provide evidence of underestimation in manufacturing when we discuss its ability to create employment and the peculiarity of market services that are the most important providers of intermediate inputs to production.

The remainder of the paper is structured as follows: section 2 presents the role of direct intermediate inputs in the economy; in section 3, the differences between the traditional and the subsystem approach are outlined; section 4 provides a disaggregated analysis of inter-industry linkages. A discussion of the results and some directions for further research are given in the last section.

2. How is the structure of production changing? The role of intermediate inputs

This paper offers a medium-term analysis, which covers a time span of more than 15 years (1995-2011).[1] The study considers employment in terms of hours worked, obtained from the Socio-Economic Accounts (SEAs) in the WIOD database. The adoption of the I-O matrix allows us to determine which portion of the hours worked was used for meeting final demand and which portion was used to satisfy intermediate demand. In line with the purpose of the paper, we focus on the amount of employment necessary for intermediate uses in production.

Table 1 shows a strong decrease in the number of hours worked in manufacturing for intermediate uses. This trend, in particular, permits us to capture some preliminary differences among the countries considered. For instance, in the UK and the US, which are service-oriented economies, the number of hours worked fell dramatically (-44.9% and -36.1%, respectively), in line with the general loss of centrality of manufacturing in their production systems. In Germany, by contrast, the strong decrease (-35.9%) is primarily associated with a gradually smaller share of domestic manufacturing. The ratio of intermediate uses over the total in 2011 is 28.6%. In the other countries (France, Italy, and Spain), although employment is decreasing (from -18.1% in Spain to -29.9% in France), the

[1] The last available year of the dataset for the US is 2009.

ratio of intermediate uses over total manufacturing remains high (about 39% in Italy and France and over 44% in Spain).

The use of intermediate services, instead, has strongly increased over time. In particular, market services[2] take a leading position in the economic system. This phenomenon mostly affected countries such as France, Germany, and Italy, where over 56% of market services are destined for intermediate uses.

Table I. Intermediate uses in manufacturing and services
(in millions of hours worked and in percentage)

		1995	2011	Var. % 1995-2011
Germany	Intermediate manufacturing	4,940.5	3,168.3	-35.9
	Share of total manufacturing	36.5	28.6	
	Intermediate services	12,512.0	17,266.5	38.0
	Share of total services	34.3	40.0	
	Intermediate market services	10,938.5	14,868.6	35.9
	Share of total market services	51.4	56.2	
Italy	Intermediate manufacturing	4,003.7	3,083.2	-23.0
	Share of total manufacturing	43.2	38.2	
	Intermediate services	9,272.0	12,191.4	31.5
	Share of total services	36.3	39.8	
	Intermediate market services	8,388.3	11,089.5	32.2
	Share of total market services	52.8	56.4	
France	Intermediate manufacturing	2,548.7	1,786.8	-29.9
	Share of total manufacturing	39.8	39.1	
	Intermediate services	8,848.3	10,139.9	14.6
	Share of total services	36.1	35.3	
	Intermediate market services	7,684.9	9,179.5	19.4
	Share of total market services	56.1	55.6	
Spain	Intermediate manufacturing	2,120.2	1,735.8	-18.1
	Share of total manufacturing	48.8	44.3	
	Intermediate services	5,255.6	7,769.1	47.8
	Share of total services	36.0	34.5	
	Intermediate market services	4,635.8	6,558.5	41.5
	Share of total market services	51.6	47.4	
UK	Intermediate manufacturing	2,771.9	1,527.6	-44.9
	Share of total manufacturing	37.5	29.1	
	Intermediate services	11,623.3	14,505.6	24.8
	Share of total services	34.6	35.4	
	Intermediate market services	10,186.8	10,079.7	-1.1
	Share of total market services	50.0	40.3	
US	Intermediate manufacturing	23,379.6	14,935.3	-36.1
	Share of total manufacturing	56.6	51.1	
	Intermediate services	58,101.0	60,777.5	4.6
	Share of total services	32.1	29.2	
	Intermediate market services	49,708.3	51,821.1	4.3
	Share of total market services	47.2	45.1	

Source: WIOD database.

[2] Following Momigliano and Siniscalco (1982), to measure the degree of integration of services in the production system, we divide tertiary activities into two groups: market services and non-market services. The authors point out that the I-O tables are based on exchanges and not on actual uses, so non-market services must be excluded as they are recorded entirely as final demand.

The following step aims to investigate the changes in the structure of the economic system by analyzing the composition of intermediate uses required for the production of goods and services. To this end, Table 2 shows the configuration of domestic intermediate uses, divided into manufacturing, total services, and other sectors.[3] Moreover, we disaggregate the services category in order to observe the role of market services, which represent the tertiary activities mainly involved in production. In particular, each country shows a decrease in the manufacturing sector, from -6.0 (France) to -10.1 (Germany) percentage points. Some countries, such as the US and Italy, maintain a level of around 18%, which is more than in other economies. In Germany, indeed, it is 14.4% in 2011 (down from 24.5% in 1995), while in the UK it is much smaller, 8.5% (down from 17.0% in 1995). The share of services, by contrast, almost everywhere exceeds 70%, with a growth rate between 7.6 percentage points in the US and 16.5 percentage points in Germany. These trends highlight the increasing importance of intermediate services in the economy as a whole. It is also worth noticing that most of these activities consist of market services, which comprise on average more than 80% of the tertiary sector.

Table II. Composition of intermediate uses (in percentage)

		1995	2011	Var. 1995-2011 in percentage points
Germany	Share of manufacturing	24.5	14.4	-10.1
	Share of total services	62.2	78.7	16.5
	Share of market services	54.4	67.8	13.4
	Share of other sectors	13.3	6.9	-6.4
Italy	Share of manufacturing	25.2	17.8	-7.4
	Share of total services	58.3	70.3	12.0
	Share of market services	52.7	64.0	11.3
	Share of other sectors	16.5	11.9	-4.6
France	Share of manufacturing	19.5	13.5	-6.0
	Share of total services	67.9	76.4	8.5
	Share of market services	59.0	69.2	10.2
	Share of other sectors	12.6	10.1	-2.5
Spain	Share of manufacturing	22.3	15.3	-7.0
	Share of total services	55.1	68.3	13.2
	Share of market services	48.6	57.7	9.1
	Share of other sectors	22.6	16.4	-6.2
UK	Share of manufacturing	17.0	9.3	-7.7
	Share of total services	71.0	78.3	7.3
	Share of market services	63.3	54.4	-7.9
	Share of other sectors	12.0	12.4	0.4
US	Share of manufacturing	26.5	18.0	-8.5
	Share of total services	65.7	73.3	7.6
	Share of market services	56.2	62.5	6.3
	Share of other sectors	7.8	8.7	0.9
Total intermediate use		100	100	-

Source: WIOD database.

[3] "Other sectors" includes "agriculture" and "construction."

These results seem to confirm our assumptions regarding fragmentation of the value chain, which leads to more intensive use of intermediate inputs by different activities. However, these analyses are based on the direct needs of domestic production while neglecting the indirect effects related to inter-industry linkages.

3. A look at the production structure: Traditional approach vs. subsystem approach

Following a method illustrated by Sraffa (1960) and Pasinetti (1973) and later adopted by Momigliano and Siniscalco (1982), an inter-industrial analysis can be conducted starting with Wassily Leontief's I-O matrix. The I-O tables are reworked to define an "operator" that can decompose a vector to express an entity classified for a sector in a square matrix in which the same entity is remapped from the "sector" or "branch" to a "subsystem" (or "vertically integrated sector" or "block").

The subsystem is an aggregation that analytically represents all the activities used (directly or indirectly) to satisfy final demand for a specific good or service, given the stock of fixed capital. In this way, it can identify a causal relationship that involves inter-industry linkages.

The operator for the conversion from branches to subsystems is obtained as follows:

$$\Gamma = (\hat{\rho})(I - A)^{-1}\,\hat{\alpha} \qquad (1)$$

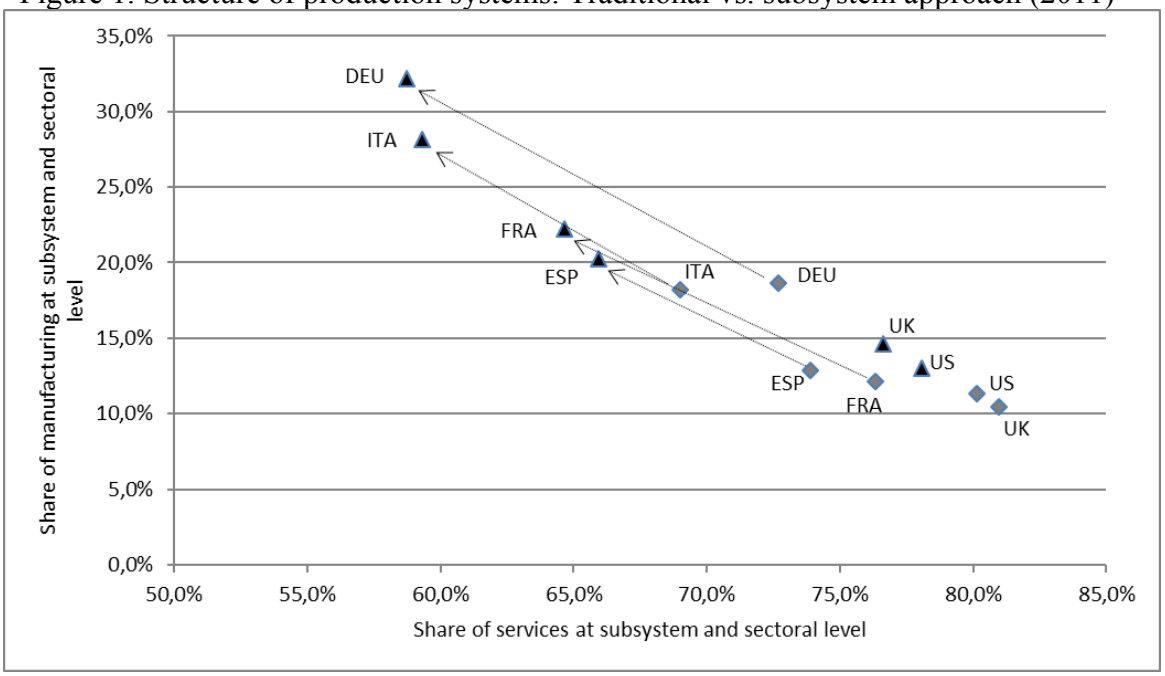
where ρ represents the vector of labor coefficients (the ratio between hours worked and total output of each branch *i*), $(I\text{-}A)^{-1}$ is the Leontief inverse, vector α measures output at current prices of each branch *i* destined for final use.[4]

The Γ matrix can be examined from two different sides: (1) each row shows the portion of hours worked related to branch *i* that are directly or indirectly used by each subsystem *j*; (2) each column *j* indicates the number of hours worked related to each branch that are directly or indirectly used by the specific subsystem *j*. Therefore, the integration can be seen as a process that modifies the production boundaries and changes the sectoral contribution to the economy.

Figure 1 illustrates the production structure in terms of the share of manufacturing and services in the six countries considered in the last available year by adopting two different approaches. It is shown that, in general, the subsystem approach seems to reposition the economic system to have a higher share of manufacturing and a lower share of services.

[4] See Di Berardino and Onesti (2017) for a detailed presentation of the theoretical framework and the methodological application.

Figure 1. Structure of production systems: Traditional vs. subsystem approach (2011)



Source: WIOD database.
Note: ▲ = subsystem approach; ♦ = traditional approach.

The findings concerning the distribution of hours worked obtained by applying the subsystem approach show large differences in comparison to the sectoral approach (Table 3). This gap appears to be more sustained in manufacturing-oriented economies. On average, the share of manufacturing rises by about 10 percentage points in the total economy when we adopt the subsystem approach. This result shows that these economies clearly underestimated the ability to generate employment in manufacturing. In countries with a higher level of services, the discrepancies are less apparent (in particular in the US and the UK), demonstrating that services tend to be more independent from other sectors in these economies. However, with the exception of Germany, a deindustrialization trend seems to emerge, although the intensity and characteristics of this process appear to vary among the countries.

Therefore, by adopting a vertically integrated perspective of the production system, the direct effects of the higher impact of indirect investment on employment become evident. The traditional approach, however, does not fully reveal these effects (Ciriaci and Palma, 2016; Park and Chan, 1989). The strong density of inter-sectoral links demonstrates that the evolution of services and manufacturing is actually symbiotic, and thus, if the growth in services depends on manufacturing, then, at the same time, structural changes in services affect manufacturing.

However, in services, we obtain a substantial overestimation. This phenomenon seems to be lower in the service-oriented economies. The data clearly show that, in these economies, employment interactions among many service activities increase, highlighting that value creation includes much larger amounts of intermediate services.

Table III. Share of hours worked in terms of subsystem level and sectoral level (in percentage)

		Manufacturing		Services	
		1995	2011	1995	2011
Germany	Sector	23.5	18.6	63.2	72.7
	Subsystem	31.8	32.1	55.2	58.8
	Differences	*+8.3*	*+13.5*	*-8.0*	*-13.9*
Italy	Sector	22.8	18.1	62.9	69.0
	Subsystem	32.9	28.1	54.6	59.4
	Differences	*+10.1*	*+10.0*	*-8.3*	*-9.6*
France	Sector	18.1	12.1	69.3	76.4
	Subsystem	26.8	22.2	59.8	64.7
	Differences	*+8.7*	*+10.1*	*-9.5*	*-8.7*
Spain	Sector	18.5	12.9	62.2	73.9
	Subsystem	26.2	20.2	55.8	65.9
	Differences	*+7.7*	*+7.6*	*-6.4*	*-8.0*
UK	Sector	16.4	10.4	74.6	81.0
	Subsystem	22.9	14.6	68.2	76.7
	Differences	*+6.5*	*+4.2*	*-6.4*	*-4.3*
US	Sector	17.0	11.3	74.5	80.2
	Subsystem	18.8	13.0	71.4	78.1
	Differences	*+1.8*	*+1.7*	*-3.1*	*-2.1*

Source: WIOD database.

4. An assessment of integration between manufacturing and services

The different results obtained from adopting sectoral and subsystem approaches for the two groups of countries suggest that a high number of hours were worked, formally identified in the one sector that is effectively engaged in satisfying final demand in other sectors. A subsystem accounts for the direct and indirect effects of all the inputs and thus reveals the interconnections through different linkages. Following Momigliano and Siniscalco (1982), we focused on forward linkages, which allows us to compare the changes in organizational composition in manufacturing and services.

The different characteristics in national production systems significantly affect the two-way integration process (Tables 4 and 5). With the exception of Italy, in manufacturing-oriented economies, the manufacturing sector has become a smaller contributor of intermediate inputs in the domestic economy. The share of hours worked in total services ranges between 5% and 10.8% of the manufacturing sector in 2011. In Italy, instead, this share is higher and remains quite stable over the period (from 10% to 10.8%). In general, these percentages are lower when we analyze the link between manufacturing and market services. The opposite is true in the services sector. In this case, the forward linkages show that the number of hours worked in services to satisfy final demand in manufacturing in 2011 fluctuates between 14% and 19%. In addition, market services are also characterized by a high degree of integration, considering that the shares of market services are respectively between 13.1% and 17.3%.

In the service-oriented economies, a very different picture seems to emerge regarding the size of inter-industry linkages and the dynamics of structural change. In particular, in 2011 the integration of manufacturing with tertiary activities is about 13.9% in the UK and 22.8% in the US; and it has increased in comparison to 1995. The integration of tertiary activities involves both market and non-market services. These inter-sectoral dynamics are

related to the wide spectrum of ICT. Efficiency in services can require huge investments in many parts of value chains that are associated with efficiency in manufacturing.

The following tables demonstrate inter-industry linkages in disaggregated terms. In this context, we can see the relevant disparities among sectors and among countries. With regard to manufacturing, Table 4 shows that labor intensive branches, such as "food," "electricity and water supply," "pulp," and "other nonmetallic minerals," are more integrated. In European countries, "food" plays an important role in the UK, Spain, and Italy. In the UK, the hours worked in this branch in the services subsystem total around 31.1% of total branch. In Germany and France, however, this share is only 8.1% and 11.3%, respectively. In Germany, all the manufacturing branches show a decrease in the number of hours worked in services. In France, this situation occurs only in part, because employment is more concentrated in fewer branches, such as "pulp" and "other metals," and integration has increased over the past few years. In Italy and Spain, many branches have become more integrated over time and coincide with some labor-intensive sectors. In Italy, the most interesting areas are "electricity," "pulp," and "food," in which integration has expanded by about six, three, and two percentage points, respectively. In Spain, however, a strong increase in integration has occurred in "manufacturing nec" (+12.1). Moreover, the branches "pulp" and "electricity" show growth of about nine and six percentage points, respectively.

As observed, the US shows a clear pattern of manufacturing integration in the tertiary subsystem. The data underline that, in this context as well, labor-intensive sectors are more interconnected. In "leather" and "textiles," the share of hours worked in the services subsystem has grown about 20 and 6 percentage points, respectively.

Table IV. Manufacturing integration in the services subsystem
(share of hours worked in the total branch, in percentage)

	Germany		Italy		France		Spain		UK		US	
BRANCHES	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Food, Beverages, and tobacco	12.2	8.1	16.7	18.3	14.2	11.3	23.6	22.0	24.5	31.1	22.6	18.1
Textiles and textile	1.7	0.6	4.1	5.0	3.9	2.5	6.0	2.6	4.7	2.5	20.2	26.3
Leather: leather and footwear	1.8	0.5	4.2	4.5	0.4	0.0	2.2	1.3	16.1	1.7	19.9	42.3
Wood and Cork	14.4	8.7	8.2	10.4	11.7	9.5	14.6	19.6	16.5	15.3	24.7	33.1
Pulp and paper	20.9	12.6	24.3	27.5	28.5	30.8	28.1	37.4	30.5	35.6	39.4	38.3
Coke: refined petroleum and nuclear fuel	16.6	17.9	23.4	20.7	20.7	19.4	20.9	15.3	14.3	8.1	33.4	35.9
Chemicals and chemical products	5.5	2.0	10.8	9.8	6.5	0.7	12.4	11.1	10.0	3.1	24.7	21.2
Rubber and plastics	9.4	4.7	15.2	12.7	10.4	8.8	13.5	12.7	16.9	17.8	32.2	34.1
Other non-metallic minerals	10.6	6.6	9.3	12.2	10.8	11.6	15.9	14.9	18.1	18.1	24.4	26.1
Basic metals and fabricated metals	7.1	4.2	9.1	7.7	7.4	6.2	11.5	9.6	7.6	6.1	21.6	24.2
Machinery, NEC (not elsewhere classified)	3.9	2.9	5.1	5.1	7.9	6.6	12.9	11.9	6.2	6.9	10.3	9.5
Electrical and optical eq.	7.9	2.9	9.7	10.5	9.3	5.4	10.9	7.5	5.9	3.4	17.0	18.3
Transport equipment	2.1	1.7	11.7	8.3	6.4	1.8	7.1	3.3	8.5	5.6	14.4	16.2
Manufacturing NEC; Recycling	3.8	4.9	4.6	9.0	7.7	5.3	6.1	18.2	6.1	7.5	15.3	16.1
Electricity, Gas and Waters supply	19.9	17.0	21.5	27.2	22.4	20.8	29.5	35.0	18.8	20.3	33.7	30.0
Manufacturing in Market Services	4.5	2.4	6.9	7.3	5.6	5.3	9.1	9.7	7.6	8.2	10.0	8.7
Manufacturing in Total Services	8.7	5.0	10.0	10.8	11.0	9.5	14.1	15.5	13.6	13.9	22.4	22.8

Source: WIOD database.

With respect to the extent of services destined for manufacturing (Table 5), we primarily note that market services are characterized by a high level of integration with manufacturing. In particular, distributive trades (wholesale and retail trade and transportation) and business services (leasing and other business activities) seem to play an important role. In this respect, our findings show that in manufacturing-oriented countries, the hours worked in business services, directly and indirectly for final demand in manufacturing, are very high, particularly in Germany, where the rate is above 30% of total branch. Moreover, growth in business services is related to a reinforcement of the industrial structure, which is confirmed by an increase in manufacturing as a share of the economy.

These findings, which confirm the characteristics of "producer input," indicate the essential role of market services as a crucial actor in enhancing the integration of production. Therefore, forward linkages take on greater importance as intermediate consumption in production. Hence, the contribution of services cannot be explained exclusively in static terms (on the basis of their share of the economy) but also from a dynamic perspective as a vehicle of qualitative transformation in the means of production.

Table V. Services integration in the manufacturing subsystem
(share of hours worked in the total branch, in percentage)

	Germany		Italy		France		Spain		UK		US	
BRANCHES	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011	1995	2011
Sales and repairs	17.7	24.7	18.7	18.3	16.9	16.7	20.7	17.3	17.5	12.3	3.4	1.9
Wholesale trade	27.9	32.6	34.3	32.0	28.3	28.8	27.1	26.3	25.4	18.5	21.6	16.2
Retail trade	27.5	33.7	29.1	26.9	27.2	27.0	25.8	23.3	23.8	17.5	3.2	1.6
Hotels and restaurants	4.1	1.3	8.9	8.2	6.4	7.0	2.8	1.5	1.9	0.6	4.5	2.6
Other inland transport	16.1	36.0	29.0	28.6	16.6	17.0	31.0	25.4	24.6	17.5	26.7	21.4
Other water transport	9.9	11.1	5.7	8.6	2.0	7.1	11.8	12.3	0.3	0.1	11.2	3.9
Other air transport	9.7	16.6	17.8	10.0	2.7	1.2	14.6	4.3	0.9	3.0	7.3	3.6
Other supporting transport	20.4	29.6	19.2	22.4	29.4	27.7	27.9	20.1	21.2	13.6	15.1	12.1
Post and telecommunications	18.3	15.4	17.3	16.1	17.4	13.0	17.0	13.1	13.2	7.1	10.6	6.6
Financial intermediation	22.6	15.3	18.0	17.6	14.2	18.1	22.4	12.7	18.0	6.0	8.6	6.0
Real estate activities	9.3	12.3	8.9	8.0	4.7	4.8	7.0	6.4	5.9	3.6	3.2	2.1
Renting and business activities	32.8	36.5	29.8	27.2	31.2	28.7	24.1	19.0	18.2	10.2	19.4	12.4
Public administration	3.5	4.6	0.4	0.3	10.1	1.4	2.0	2.8	0.7	0.8	1.2	0.8
Education	0.8	4.0	1.4	1.7	0.8	3.1	1.0	2.0	1.7	1.0	1.5	0.5
Health and social work	0.5	0.2	0.6	0.2	0.0	0.6	1.5	1.2	1.0	0.4	0.0	0.0
Other social services	11.6	14.7	12.3	11.5	0.7	6.9	5.9	5.5	5.6	3.4	6.4	4.4
Private households	0.0	0.0	0.0	0.0	0.4	0.3	0.0	0.0	0.1	0.0	3.4	1.9
Market Services in Manufacturing	13.5	17.3	15.2	14.8	12.7	13.1	12.9	10.5	10.3	6.3	6.8	4.4
Total Services in Manufacturing	14.9	19.0	16.1	15.6	14.2	14.0	13.9	11.7	11.0	6.7	7.5	4.9

Source: WIOD database.

5. Concluding remarks

Integration between manufacturing and services has been investigated by adopting various perspectives. In particular, our study shows that the implementation of a subsystem methodology can capture, in a deeper and wider manner, the relationships between two fundamental sectoral aggregates in an economic system. Furthermore, our empirical analysis provides evidence of an increase in services, particularly of intermediate market services, and a deep reorganization of the manufacturing sector. In this framework, our findings about the two-way integration between manufacturing and services show the following important patterns.

In manufacturing-oriented economies (France, Germany, and Italy), we observe that manufacturing plays a central role in economy because of growing demand for intangible inputs to satisfy final production. As a consequence, the share of services required for manufacturing is larger than the share of manufacturing required for services. In service-oriented countries (the UK, Spain, and the US), the role of services as a primary driver in inter-sectoral integration is reinforced.

The results, therefore, underline a certain heterogeneity in the sectoral composition of the economies. In the dynamics of inter-sectoral integration, indeed, business services play a leading role and, as shown in different studies, can contribute to improvement in the quality and competitiveness of manufacturing and of the overall structure of production. This trend is in line with the deep changes that, in the past few decades, have affected trends in the world economy, such as rapid growth in developing economies and globalization. These circumstances are forcing developed countries, especially those oriented toward manufacturing, to engage in a competitive relocation toward higher quality levels in supply and greater efficiency in overall production. This process is characterized by a tendency in developed countries to move toward a system based on advanced services. Although several authors explain this trend as characteristic of a post-industrial society, it has to account for the renewed necessity of increasing the share of manufacturing activities in the national context.

This is confirmed by the inclusion of “industrial leadership,” a pillar of the Horizon 2020. Moreover, after a decline in the past few decades, the European Commission aims to promote a reorganization of manufacturing. This is related to the idea that a strong and modern industrial structure is fundamental for boosting economic growth and strengthening Europe's global competitiveness. In this respect, Germany is the only country that is reacting positively to this necessity of changing. Our results show that Germany has attained a sustainable equilibrium between a high level of growth in business services destined for manufacturing and the simultaneous reinforcement of manufacturing , as shown in the subsystem approach, which has retained its share of the German economy. In the other countries, where manufacturing has lost its centrality, this equilibrium still seems to be far away.

From a policy point of view, our findings highlight the necessity of taking such differences into account, especially in strategic policies aimed at supporting manufacturing or services. In the modern organization of the global economy, industries interact in an increasingly integrated way. The ability of policy makers to understand these interdependencies will play a central role in the effectiveness of industrial policy. These results call for further deep investigation of this issue, with special attention paid to countries at different levels of development.

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