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Productive linkages in a segmented model: analyzing the role of services in the exporting performance of German manufacturing

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Abstract

This article analyzes the causes of the exporting performance of the German manufacturing sector. By applying a subsystem approach to the input-output analysis, we take into account the interlinkages that exist between manufacturing and services. Particularly, two types of relationships that influence manufacturing competitiveness are considered: the wage squeeze in services due to institutional factors and outsourcing; and the role played by the knowledge-intensive business services (KIBS) as innovation drivers. With vertically integrated sectors as observations, an export model is estimated. Overall, our results point to the minor importance of labor costs for international competitiveness. We also capture a significant but small effect of service suppliers' labor cost on manufacturing exports. We find that KIBS have helped manufacturing gain international competitiveness. The paper concludes that non-price factors are the main drivers of German exports and that the relationship between manufacturing and services is not only a matter of cost reduction.

JEL Classification: J3, F16, O14, C67, L60
Keywords: Unit labor costs, Competitiveness, Germany, Manufacturing, Productive linkages, Input-output

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1. Introduction

The German export-led growth model has drawn attention from many scholars. From 2000 onward, exports started to grow much more rapidly than imports, and foreign demand became the primary source of growth. Trade balance reached 7% of the GDP in 2007, and has remained at similar values so far (*OECD.statistics*, own calculations). Together with a stagnant domestic demand, the commercial surplus was obtained thanks to the rapid growth of both manufacturing and service exports. The process was, in turn, led by high and medium high technology manufacturing industries, which accounted for around 70% of total exports between 1995 and 2007 (COMEXT, own calculations).

This performance coincided in time with an unequal process of wage devaluation, by which Germany managed to slow down the growth of its nominal unit labor costs (ULC) against other competitors. This strategy was accomplished by a long path of decentralization of the wage bargaining (Hassel, 2014) and labor market reforms (Hüfner and Klein, 2012), and gave rise to a dual or segmented economy. More specifically, the weakening of labor institutions has been concentrated in service industries, where wages experienced a dramatic fall and the overall erosion of working conditions have been particularly tough. On the other hand, sectoral wage bargaining and work councils are still well grounded in manufacturing firms, particularly in the larger ones. Here, wages have slowly increased and working conditions have been better preserved. Furthermore, German manufacturing firms engaged, at the same time, in a process of production restructuring, characterized by the outsourcing of certain service activities with the aim of reducing costs (Goldschmidt and Schmieder, 2017). Hence, they contributed through this channel to the consolidation of the dual economy (Doellgast and Greer, 2007).

There is a consensus about the negative effect of this process on domestic demand and import growth. However, the debate on how wage dynamics impact exports is much more open. Some observers have pointed out that the liberalization of the service periphery has been functional to the performance of the manufacturing sector because it has helped to protect the working conditions of core workers, while containing the labor costs throughout the value chain by supplying cheap service inputs (Hassel, 2014; Thelen, 2014). As a consequence, manufacturing exports became more cost-effective, thus fostering export growth (Dustmann et al, 2014; Baccaro and Benassi, 2017).

On the contrary, we consider that these elements, although significant, are of secondary importance for German competitiveness. We agree with the strand of literature that stresses that the link from ULC to exports is fragile for this economy, which is specialized in the production of high quality and complex products (Danninger and Joutz, 2008; Felipe and Kumar, 2014). Therefore, German exporting performance should rely on non-price factors, which in turn are related with the institutional foundations of German capitalism (Storm and Naastepad, 2015).

Furthermore, we highlight that the relationship between services and manufacturing is not just a matter of saving costs. In the last few years, knowledge-intensive business services (KIBS) became more important for manufacturing productive strategies. These advanced services are knowledge suppliers and innovation drivers, and support manufacturers to compete in the international market via non-price strategies (Franke and Kalmbach, 2005; Ciriaci et al, 2015). Given the sophistication of German exports, we argue that this linkage with services, and not the cost-saving one, has a predominant role in explaining the exporting performance.

This paper aims to contribute to the debate on the sources of German manufacturing competitiveness. Concretely, we research the existing channels through which domestic services could have contributed to the manufacturing export boom: the wage moderation in supplier firms; and the integration of advanced services (KIBS) into manufacturing productive strategies. To that end, we draw on the subsystem approach to the input-output analysis (Pasinetti, 1973). We compute vertically integrated ULC and the participation of KIBS services into manufacturing sectors. Afterward, with manufacturing subsystems as units of analysis, we estimate an export model to capture the causal effect of the variables of interests. Hence, the novelty of our approach is that it allows us to assess the productive relations that exist within the German dual model, and estimate their impact on the commercial success. Our calculations are based on the World Input-Output Database (WIOD, release 2016). We consider 18 manufacturing subsystems and the research period is 2000-2014.

It is worth mentioning that we are conscious that offshoring strategies of German manufacturing have played a role in the evolution of its competitiveness, nonetheless we only focus on the aforementioned two processes because our interest relies on the domestic level and on making sense of the dual model.

The hypotheses to be tested are the following:

HI. Labor cost competitiveness is of secondary importance for Germany, the non-price factors being the drivers of the export success.

HII. Wage restraint in the service part of the value chain is the centerpiece in the contention of ULC and export prices.

HIII. Nonetheless, due to the high quality production strategies of German manufacturers, wage restraint in the services is of minor importance for export growth.

HIV. Lastly, we hypothesize that the growing integration of KIBS into manufacturing production strategies has a positive effect on non-price competitiveness and has driven export volumes up.

The remainder of the article is organized as follows. The next section reviews the literature on the price-elasticity of German exports. Section 3 briefly describes some features of the wage devaluation process and the reorganization of production in the manufacturing sector. The fourth section presents the input-output methodology and describes the empirical results regarding ULC and the interlinkages between manufacturing and services. Section 5 presents the econometric model and its results. Section 6 concludes.

2. A review on the price-elasticity of German exports

The issue of how responsive German exports are to changes in relative prices in general, and labor costs in particular, is a hot debate.

On the one hand, an important strand of the literature has highlighted that ULC are non-reliable predictors of export success. The well-known Kaldor's paradox states that those economies in which the market share for exports grows more, are usually those in which ULC grow faster (Kaldor, 1978). This finding suggests that what really determines competitiveness in the long-run are non-price factors, such as technical progress and investment levels (Fagerberg, 1988). Furthermore, the composition of countries' export baskets is crucial for making international comparisons, and so is the economy against which ULC evolution is evaluated. For instance, as Felipe and Kumar (2014) observe, a simple comparison between German and Southern European countries ULC is misleading a significant part of the picture. Germany is highly specialized in complex products and does not compete directly with these less advanced economies, which should benchmark their cost-competitiveness against others with the same type of productive specialization. In addition, institutional features of coordinated economies entail competitive advantages to produce high value added goods (Soskice, 1999). Furthermore, although the corporatist wage-setting system – characterized by an export-led pattern bargaining - has always promoted moderate pay hikes to ensure price stability, wage costs have been traditionally higher in Germany than in most countries, compelling manufacturing firms to compete through differentiation strategies (Streeck, 1991).

Regardless of this clarification, many observers pointed to the wage devaluation as the main explanatory cause of the German commercial success (Dieppe et al., 2011; Thorbecke and Kato, 2012). Price competitiveness is the result of the evolution of domestic export prices against the prices of foreign competitors. The latter variable is exogenous and the former, according to these works, is the central component of firms' cost structure and thus the main determinant of prices. Therefore, anti-inflationary wage policies like the ones undertaken by Germany should be the first option to improve international competitiveness in the short-run.

Nonetheless, wage devaluation is not the only way to reduce labor costs. In fact, firms with higher productivity can offer reduced prices because their costs per unit of output are lower. Indeed, some articles have pointed out that Germany owes more to that than to the nominal wage squeeze (Storm and Naastepad, 2015). Nonetheless, the policy debate in the context of the European Union has been predominantly focused on wages rather than productivity[1].

Regarding empirical work, most authors estimate a standard export equation in which real exports are a negative function of relati-

1 For instance, the *Euro Plus Pact* constituted a central policy at the European level, in which most member states committed to implementing an internal devaluation to become more competitive.

ve prices and a positive function of the world demand. Two main indicators of cost-competitiveness are employed: (a) the relation between export and import prices, (b) and the real effective exchange rate, deflated by either a consumer price index or ULC (or, in some cases, relative ULC adjusted by nominal exchange rates).

Table 1 summarizes the price-elasticities found by the literature. Overall, the size of the effect is quite different among studies. For instance, Storm and Naastepad (2015) estimate a non-significant coefficient, while Stockhammer et al (2011) find an elasticity below -1 for the period 1987-2005, meaning that a 1% increase in relative prices is associated with a more than proportional fall in exports. It also seems that the estimated effect is slightly higher in the more recent time period. Furthermore, those models based on export and import prices tend to capture a larger coefficient than those based on relative labor costs measures (average elasticity of -0.67 and -0.30, respectively).

The relative price indicator is normally accompanied by a measure of world demand, which captures the income-elasticity of exports. It is assumed that this variable comprises non-price factors, such as technology, quality or the ability to hook into global demand thanks to marketing strategies or distribution channels. In most models, the estimated coefficient of world demand is the largest one.

In the majority of studies, the export function is referred to the whole economy. The only exception in the table below is the article by Carlin et al (2001), which performs several panel data models with manufacturing industries and countries as observations. Interestingly, they find German exports less sensitive to relative ULC changes than the exports of other advanced economies, such as Japan or the US. Moreover, they also capture a negative relation between the R&D intensity of the industry and its cost-elasticity, as well as an increasing price-sensitiveness in export markets over time.

Another important point is that, frequently, labor cost moderation is not fully passed

Table 1. Price-elasticities of German exports

Article	Data	Time	Coefficient	Measure of cost-competitiveness
Based on export prices				
Andersen (1993)	A	1960–1990	-0.48	pX/pM
Stockhammer et al. (2011)	A	1970-2005	-0.78	pX/pM
Stockhammer et al. (2011)	A	1970-1987	-0.67	pX/pM
Stockhammer et al. (2011)	A	1987-2005	-1.24	pX/pM
ECB model (Dieppe et al., 2011)	Q	1991q1-2007q2	-1.04	pX/pM
Onaran and Galanis (2012)	A	1971-2007	-0.43	pX/pM
Baccaro and Benassi (2017)	A	1971-2014	-0.86/-0.80	pX/pM
IMK model (Horn et al, 2017)	Q	1986q1/ 1991q1-2016q1	-0.5	pX/pX_world
Based on unit labor costs				
Carlin et al (2001)**	A	1970-1991	-0.12	RULC
Naastepad and Storm (2006)	A	1960–2000	-0.12	RULC
Danninger and Joutz (2008)	Q	1993q1–2005q4	-0.42/-0.14	REER/ULC
Bayoumi et al. (2011)	Q	1980–2009	-0.56	REER/ULC
Thorbecke and Kato (2012)	Q	1980q2-2011q1	-1	REER/CPI
Thorbecke and Kato (2012)	Q	1980q2-2009q3	-0.64	REER/ULC
Breuer and Klose (2014)	Q	1995q1-2012q2	-0.82	REER/ULC
European Commission (2014)	Q	1994q1-2014q1	-0.81	REER/export prices
Storm and Naastepad (2015)	Q	1996Q2-2008Q4	Insignificant	REER/ULC
Baccaro and Benassi (2017)	A	1971-2014	-0.40 / insignificant	REER/ULC
Average elasticity				
pX/pM	-0.67			
REER/ULC	-0.30			

**Notes*: A (annual), Q (quarterly), pX/pM (export prices relative to import prices), REER/ULC (real effective exchange rate based on ULC), REER/CPI (based on a consumer price index), RULC (relative unit labor costs). **Carlin et al (2001) use the export market share as dependent variable. *Source*: own elaboration onto sale prices, particularly when assuming market imperfections (Storm and Naastepad, 2015; Horn et al, 2017). Therefore, the relationship between ULC and price-competitiveness is much more complex. In this respect, German non-financial corporations have been increasing their profit share since the mid-90s, while their investment levels have remained constant (Braun and Deeg, 2019). Thus, it seems likely that part of the wage restraint has served, de facto, to increase profit margins at the price of lower economic growth (indeed, the German demand regime is overwhelmingly identified as wage-led, see among others Naastepad and Storm, 2007; Hein and Vogel, 2008; Stockhammer et al, 2011).

In sum, it is difficult to obtain a clear picture of the price sensitiveness of German exports. The calculated average elasticities suggest, however, that the effect of relative prices is not superfluous. Nonetheless, these elasticities do not indicate how relevant labor costs are to the formation of export prices, which in turn are determined by other variables. As we will show in Section 5, our export equation does take into account these considerations.

3. Production reorganization in the manufacturing sector: wage moderation, outsourcing and increasing demand of KIBS

We argue that non-price factors are behind the exporting performance of German manufacturing. This is not to say that relative prices are not relevant, but, given the advanced productive specialization of the sector, we consider that high value added strategies, based on innovation and differentiation, should be more important. Actually, services can enhance manufacturing competitiveness through these two channels: they can help to contain costs, and to improve the quality of manufactured goods. This section reviews the literature on both channels.

3.1 The relationship between services and manufacturing: wage growth in a dual model

Previous works have highlighted the relevance of taking into account the whole supply chain when analyzing the cost-competitiveness of the manufacturing sector (Dustmann et al, 2014; Albu et al, 2018). In Germany this issue is particularly important because of the nature of the wage policies pursued. Since the mid-90s, the country experienced a dramatic evolution of wage inequality. The fall of wages at the lower end of the income distribution was particularly severe. As a result, the low-wage sector expanded strongly, and it is currently one of the largest among advanced economies (Gräbka and Schöder, 2019).

The increase in low-end inequality has been driven by the erosion of labor institutions (Dustmann et al, 2009; Card et al, 2013). Overall, the wage bargaining was decentralized and the margins of the labor market were flexibilized through the liberalization of atypical employment. Nonetheless, the weakening of labor institutions has been concentrated in some segments of the economy, giving rise to a dual or segmented German model (Hassel, 2014; Eichhorst, 2015).

Observers have identified an institutional core around the manufacturing sector, where social partners and sectoral bargaining are still strong and keep considerable bargaining power. Some industries within the core set the limit which bargained salaries growth cannot surpass in the rest of the economy (Traxler and Brandl, 2012). Furthermore, although wage negotiations have been decentralized here as well, workers are represented by powerful work councils at the firm level, which renegotiate sectoral agreed working conditions with guarantees. In this respect, core workers have tended to reach plant-level agreements with the management, by which job protection was exchanged for internal flexibility regarding wages and working time (Seifert and Massa-Wirth, 2005; Herzog-Stein et al, 2018). Besides, non-standard work levels are much below-average, despite the liberalizing reforms which predominantly contribute to the expansion of agency work (Spermann, 2011; Benassi, 2016).

On the other hand, the margin or periphery of the German labor market is mainly identified with services. In these industries, the coverage of collective bargaining fell abruptly and union density has always been much lower (Eichhorst, 2015). Moreover, the presence of work councils is more unusual. Yet, an important amount of service workers have been, in fact, expelled from collective bargaining. Besides, firms tend to rely much more on atypical contracts and precarious work.

This segmented system generates a particular structure of wage inequality, which partially lies in the divergent evolution of pay hikes between service and manufacturing industries. Actually, the core and the periphery are seen as the two sides of the same coin.

The liberalization of the service periphery acts as a mechanism to protect the working conditions of core workers, while containing labor costs throughout the manufacturing value chain (Hassel, 2014; Thelen, 2014).

It is worth mentioning that this picture is somewhat simplistic, and other variables like the skill level or the firm size play a role in shaping the dualization (see Eichhorst and Marx, 2011; Eichhorst, 2015; Addison et al, 2017, for a more detailed analysis). Nonetheless, it helps to explain why the decoupling of wages from productivity growth has been deeper in services than in manufacturing (Baccaro and Benassi, 2017). Moreover, Germany is the only European economy, along with Austria, in which wages in services grew less than in manufacturing (Hassel, 2017). This is a quite remarkable fact given that services are more sheltered from international competition.

3.2 The relation between services and manufacturing: Outsourcing and increasing demand of KIBS

Two related processes of production reorganization have taken place throughout the last few years in advanced economies: the outsourcing of certain service activities from core manufacturing firms, and the increasing demand of knowledge-intensive business services (KIBS). The German case has been no exception.

First of all, the main incentives for a company to outsource are cost-saving and flexibility against changes in aggregate demand (Abraham and Taylor, 1996). Managerial strategies of leading companies have focused on their core competences, while subcontracting the remainder of the operations with external firms. Outsourced jobs are often worse paid than if they had been performed within the boundaries of the leading firm, allowing for cost-reductions. Furthermore, by substituting labor relations for market ones, firms are much less constrained and gain flexibility in taking rapid strategic decisions.

The fierce - price-competitiveness to get a service contract, along with the weakness of unions and the low coverage of industrial relation institutions, frequently result in wage compression within subcontractors. The pervasive use of outsourcing by manufacturing firms in Germany and its consequences on wages has been well documented. For instance, Silvia and Schroeder (2007) pointed out that large manufacturing companies alleviate their cost-pressures by imposing low prices on their suppliers, which could not comply with collectively agreed wages. Another recent work by Goldschmidt and Schmieder (2017) reports a wage penalty of outsourcing between 10% and 15% in logistics, cleaning, security and food services. Moreover, according to this study, sourced-out jobs account for around 9% of the increase in German wage inequality.

Scholars in political economy and industrial relations have widely studied the effect of outsourcing of low-level services (such as call-centers or canteens) on the evolution of the system of labor relations. They conclude that the surge in outsourcing has contributed to enlarging the size of the periphery by transferring workers from the "coordinated" to the "liberalized" part of the economy (e.g. Doellgast and Greer, 2007; Holst, 2014, Doellgast and Berg, 2018).

Nonetheless, the interlinkages between manufacturing and services go far beyond cost-saving issues. Another source of productive restructuring in manufacturing -which has drawn much less attention from political economists -, is the importance of KIBS to satisfactorily meet their final demand.

KIBS firms could comprise outsourced jobs, but also new ones that require high levels of investment to be performed within core manufacturing firms. KIBS are high-level services, such as consultancy or engineering, that provide technical knowledge and assessment to other firms, acting as external knowledge suppliers (Den Hertog, 2000). They are highly innovative, and not only in their own right, but promote innovation and foster technical progress in the sectors with which they cooperate, like the manufacturing ones (Castellacci, 2008; Ciriaci et al, 2015). KIBS are more capital-intensive than any other services, and are major users of information and communication technologies. Moreover, they have become a significant part of the so-called systems of innovation. In sum, they currently constitute an important piece for manufacturing non-price competitiveness because they contribute to enhancing value added and productivity growth (Tomlinson, 2000; Castaldi, 2009).

Since German manufacturing is widely known for its high-quality products and for being established in a non-price competitive strategy, where product differentiation is a central concern (Felipe and Kumar, 2014), it would be expected that KIBS should be important for it. Indeed, Windrum and Tomlinson (1999), drawing on an input-output methodology, found that the development and integration of these advanced services into other activities of the economy was quite high during the 80s and the 90s, even when comparing the country with other service-intensive economies like the UK or the Netherlands. Furthermore, these authors estimate the impact of KIBS connections with other economic activities on total output and total productivity, and report a high and significant coefficient for Germany.

In another input-output analysis, Franke and Kalmbach (2005) highlight that the growth of business services in Germany is directly related with the intermediate demand of inputs from the export-oriented manufacturing due to technological and labor-saving reasons. Other works, adopting a comparative international perspective and also employing an input-output framework, have pointed out that German manufacturing is highly connected with KIBS. For instance, Ciriaci and Palma (2016) show that KIBS employment in the manufacturing sector has increased much more in Germany than in other European countries, and its actual level is only higher in France. Furthermore, the more technologically advanced the sector is, the greater the contribution of KIBS in its employment share.

Consequently, other relationships between manufacturing and services apart from the cost-saving ones should be taken into account to evaluate the impact of productive reorganization on competitiveness.

4. A subsystem approach to the study of manufacturing competitiveness

A subsystem approach to input-output (Pasinetti, 1973) is employed to analyze manufacturing cost-competitiveness and its relationship with services. This method considers that a final commodity is a composite good that requires from inputs from other industries to be manufactured. A vertically integrated sector or subsystem represents all the domestic activities that directly or indirectly satisfy the final demand of a particular good or service. It is thus a completely independent production system, in which every domestic input required to meet the final demand is included.

Vertical integration is a useful methodology to capture productive interlinkages among industries and to explore the labor cost structure of manufacturing final goods. Nonetheless, it is worth mentioning that a subsystem is an abstract economic entity that cannot be found in reality, where economic activities are interconnected among themselves. In contrast, the traditional approach to the economic analysis does not capture any sort of productive interdependence. On the contrary, it classifies commodities according to the industry that produces them, therefore implicitly assuming that each industry is an autonomous unit of production.

In order to disaggregate the economy into vertically integrated sectors, the IO matrix is reorganized through the following equations:

$$B = (\hat{q})^{-1}(I - A)^{-1}\hat{y} \quad (1)$$

$$C = \hat{h}B \quad (2)$$

Equation (1) reclassifies any variable from a sector base to a subsystem one. $\hat{q}$ is the diagonalized vector of production ."^" indicates that the corresponding vector is transformed into a diagonal matrix. The generic element q_i represents the total output at current prices of branch *i*. $(I\text{-}A)^{-1}$ stands for the Leontief inverse matrix and the generic element a_{ij} measures the output of branch *i* directly or indirectly required to produce a unit of final output of branch *j*. Lastly, $\hat{y}$ is the diagonalized vector of final demand, and its generic element y_i represents the output of branch *i* destined for final uses.

On the basis of B, the C matrix is derived (Equation (2)). In this matrix, $\hat{h}$ is the diagonalized vector of either employment, labor compensation or value added, i.e. the variables of interest. As can be seen, the operator B is used to remap our variables of interest, *h*, from industries to subsystems. Therefore, the generic element c_{ij} represents the amount of a given variable of branch *i* that is directly or indirectly used by the subsystem *j* to meet its final demand. For instance, if *h* were the vector of employment (measured in persons), each row would be the number of persons employed in branch *i* to satisfy the final demand of the subsystem *j*. The sum of each row of a column, would be the vertically integrated employment of the subsystem. This operation is repeated for each year of the period 2000-2014. We use data from the German National Input-Output Tables (NIOT), obtained from the WIOD Database, which offers data for 56 economic activities, classified according to the ISIC revision 4 (see Timmer et al, 2015, for further details). We consider 18 manufacturing sectors for the analysis[2].

Due to the fact that we are using domestic input-output tables, imported inputs are not taken into account. Therefore, the effects

2 We do not consider the coke and petroleum products sector due to its volatility in prices.

of the international division of labor are not analyzed in the present article. Nonetheless, in Germany inputs from KIBS, and services in general, are almost entirely provided domestically (Ciriaci and Palma, 2016). Furthermore, by introducing imported intermediate inputs, C would no longer be invariant to changes in relative prices, thus affecting the analysis (Montresor and Vittucci Marzetti, 2007).

Table 2 shows the important differences that arise between the subsystem and the traditional approach. When using the former method, the size of the manufacturing sector is around 10 percentage points (pp) larger. Besides, the underestimation of the size of the manufacturing sector tends to increase over time. In Germany, the share of manufacturing value added in the economy has increased according to the subsystem perspective, while it has decreased under the traditional one. Both approaches capture a fall in the employment share, but it is much greater when using the latter method. This pattern suggests that manufacturing increasingly relies on inputs from other sectors, as has been pointed out by previous works (Franke and Kalmbach, 2005; Dustmann et al, 2014; Ciriaci and Palma, 2016). It is worth noting that the differences between the changes in value added share and employment share are indicating a larger labor nominal productivity increase in manufacturing than in the rest of the economy.

Productive specialization of the German economy is also reflected in the table. A larger share of economic resources is involved in the production of high and medium-high technology (HMHT) manufacturing goods. These sectors increased their importance in the economy regarding both value added and employment. Besides, the underestimation of the traditional approach is greater for these advanced activities, particularly when looking at the employment share (which is lower than the share of medium and low-technology sectors). Furthermore, the differences in productivity levels among sectors can be appreciated. Holding an employment share 2.2pp higher, HMHT manufacturing produces 7.5pp of value added more than medium and low-technology manufacturing. The classification of manufacturing and service sectors is detailed in the appendix (Table A5).

As a first approximation, the connection between services and manufacturing can be shown by calculating the following indicator:

$$Service_{input} = \frac{\sum_{j=d}^{b} c_{s,m}}{\sum_{j=j}^{a} c_{s,j}} \quad (3)$$

Where the numerator indicates the amount of service inputs (either value added or employment) destined to satisfy the demand of manufacturing final products; and the denominator denotes total value added or employment in all services for both intermediate and final demand.

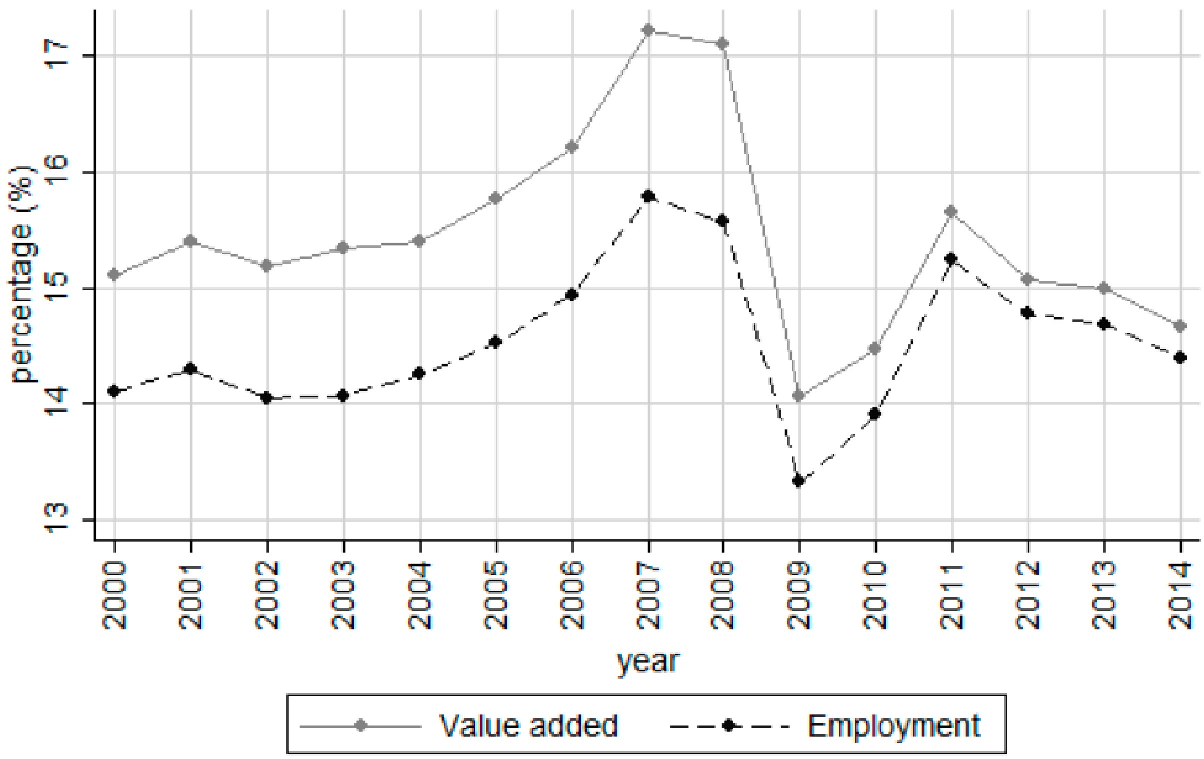
Figure 1 shows that around 14% of employment (15% of the value added) in services is destined for intermediate uses of manufacturing subsystems. The drop in 2009 is registering the effects of the crisis, when the intermediate demand of manufacturing declined due to the heavy fall in foreign demand. The subsequent increase from 2010 onward depicts the rapid economic recovery experienced by Germany.

Table 2. Size of the manufacturing sector according to the subsystem and the traditional approach (Average share and change 2000-14)

	VA		Employment	
	Subsystem approach	Traditional approach	Subsystem approach	Traditional approach
Total manufacturing	31.65%	22.46%	27.37%	18.32%
ΔChange (pp)	0.67	-0.35	-0.23	-2.07
HT and MHT manuf.	19.57%	12.97%	14.78%	8.22%
ΔChange (pp)	1.43	1.03	0.35	-0.55
MT and LT manuf.	12.08%	9.49%	12.59%	10.10%
ΔChange (pp)	-0.77	-1.38	-0.58	-1.52

**Note*: Subsystems are classified by technological intensity according to the OECD taxonomy (Galindo-Rueda and Verger, 2016) *Source*: WIOD, own calculations

Figure 1. VA and employment of services destined for intermediate uses in manufacturing as a % of total services



Source: WIOD, own calculations

Summing up, an important part of the service sector is connected with the industry, and the evolution of its labor costs directly affects manufactured goods. The next section explores the labor cost structure of manufacturing subsystems.

4.1. Exploring the cost-structure of German manufacturing subsystems

As previously described, the wage restraint process in Germany has been unequal, and the service sector has been much more affected than manufacturing. The subsystem perspective captures how the diverse dynamics of wage growth within sectors affect their labor cost competitiveness.

The main indicator of labor cost competitiveness is the nominal ULC, which is the result of dividing the nominal gross mean wage by the real productivity. In coherence with the subsystem approach adopted in this article, vertically integrated ULC are calculated. This indicator captures the mean wage costs directly or indirectly needed to produce one unit of a certain commodity in constant prices. Once real value added, employment and wages have been vertically integrated with the matrix C (Equation 2), the calculation of ULC is straightforward. This is formalized by Equation (4):

$$ULC_j = \left(W'_j/L'_j\right) \Big/ \left(VA'_j/L'_j\right) \qquad (4)$$

Where W is the labor compensation, L stands for the number of persons employed and VA is the real value added of the subsystem j. The apostrophe symbol indicates that the variable has been vertically integrated.

Furthermore, it is possible to calculate the mean wage and real productivity for the service part of each manufacturing subsystem, and compute the relationship between the mean wage in services and the total vertically integrated productivity:

$$ULC_{sm} = \left(W'_{sm}/L'_{sm}\right) \Big/ \left(VA'_m/L'_m\right) \qquad (4a)$$

In Equation (4a) the mean wage of service inputs is divided by the total productivity of the VIS and not by its own productivity. Note that if a service job (e.g. the staff of a canteen) is sourced out from a core manufacturing firm to a supplier, the associated wage costs for the supply chain would be lower (due to institutional factors), although the employee's productivity would remain exactly the same (he or she is performing exactly the same job). Therefore, this research strategy takes into account the cost-saving effects of outsourcing and the overall "benefits" of the wage restraint in services for manufacturing labor-cost competitiveness.

Table 3 reports the results of Equations (4) and (4a) for the 18 manufacturing subsystems. They are presented in yearly growth rates. Overall, a mild increase in ULC can be appreciated. Four sectors managed to cut costs down, whereas in only six of them the growth rate was above 1%. Such moderation in the ULC evolution was achieved despite the low growth rates of real productivity. It should be kept in mind that service activities tend to be much less productive per hour worked (Baumol, 1967; Fernández and Palazuelos, 2012), therefore productivity growth in manufacturing subsystems is usually lower than in manufacturing industries when using the traditional approach. As a matter of comparison, one could observe the marked gap existing between the service part and the rest of the VIS. In the former, productivity was stagnant, the latter being the one that drove total vertically integrated productivity up.

On the other side, nominal wage growth was also modest. Electronic and optical equipment was the only sector in which the growth was above 2%. Considering that inflation over the period grew around 1.5% per year[3], the increase in real wages remained close to zero. Here again, the differences between services and the rest of the VIS arise. Overall, wages grew more in the non-service part of the sector (the only exceptions are the manufacturing of paper products and printing and reproduction of recorded media). As expected, the divergence among manufacturing and service wages appreciated by other works across the whole economy also takes place within manufacturing subsystems.

In sum, the greater wage restraint in services along with the modest evolution of productivity served to contain labor cost over the period.

Furthermore, from 2008 onward, in several manufacturing subsystems service wages present a slight decline relative to wages in the whole service sector (Figure 2). This indicates that the small recovery registered in wages after the economic crisis has mainly affected services that do not supply manufacturing. Moreover, our results suggest that manufacturing is still a driver of the wage restraint in services, where suppliers suffer from sharp price pressures and workers are less protected from IIRR institutions (Palier and Thelen, 2010; Hassel, 2014). However, it should be borne in mind that the data do not capture the introduction of the statutory minimum wage in 2015, which might have changed the picture a bit.

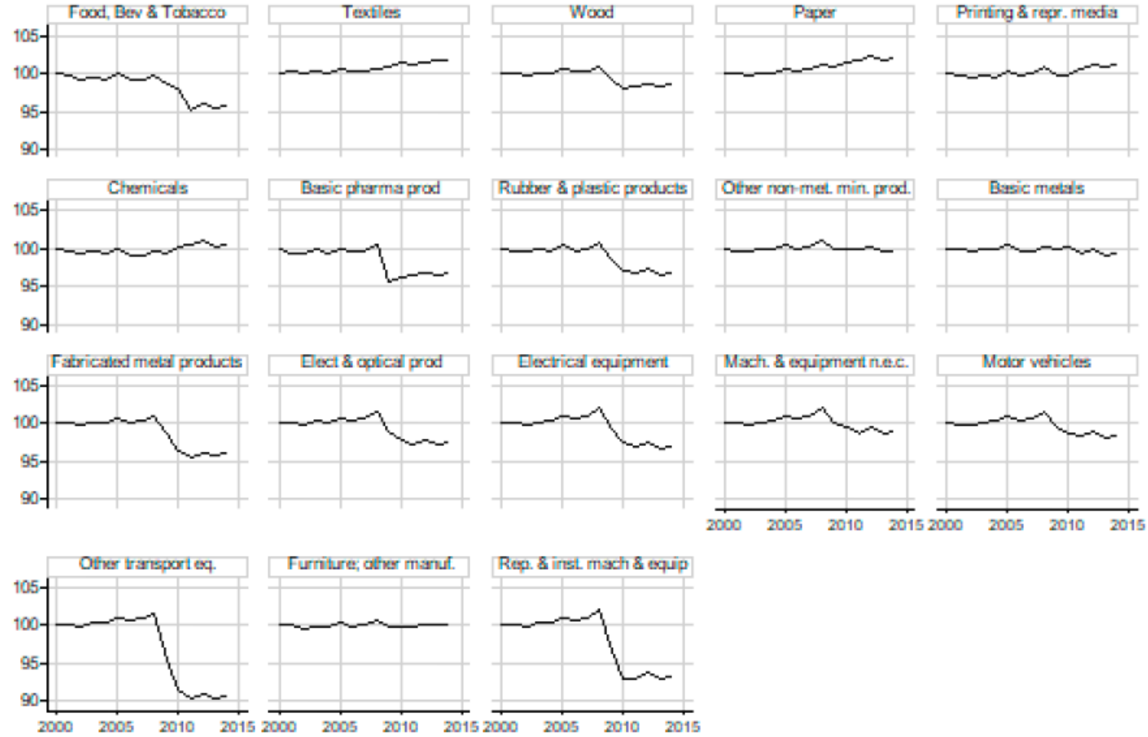
3 Own calculations based on the CPI index reported by OECD.stats

Table 3. Growth of vertically integrated nominal ULC, mean wage (*WL*) and real productivity (*P*), 2000-14

	Subsystem			Service part			Rest		
	ΔULC	ΔWL	ΔP	ΔULC	ΔWL	ΔP	ΔULC	ΔWL	ΔP
Chemicals	1.27%	1.74%	0.46%	1.04%	1.51%	-0.42%	1.58%	2.04%	0.97%
Basic pharma prod	-0.17%	1.50%	1.66%	-0.43%	1.23%	-0.92%	0.06%	1.73%	2.66%
Elect & optical prod	-2.71%	2.08%	4.79%	-3.51%	1.28%	-0.18%	-2.49%	2.30%	6.69%
Electrical equipment	1.70%	1.89%	0.19%	1.05%	1.25%	-0.18%	1.89%	2.09%	0.25%
Mach. & equipment n.e.c.	1.68%	1.64%	-0.04%	1.43%	1.40%	-0.04%	1.89%	1.86%	0.02%
Motor vehicles	-0.06%	1.74%	1.80%	-0.45%	1.35%	-0.24%	0.42%	2.22%	2.95%
Other transport eq.	0.97%	1.84%	0.87%	-0.10%	0.77%	-0.93%	1.76%	2.63%	1.88%
Food, Bev & Tobacco	1.70%	1.27%	-0.43%	1.59%	1.16%	-0.19%	1.74%	1.31%	-0.79%
Textiles	0.45%	1.82%	1.37%	0.21%	1.59%	0.47%	0.56%	1.93%	1.68%
Wood	0.78%	1.03%	0.25%	1.11%	1.36%	0.06%	0.78%	1.03%	0.13%
Paper	0.24%	1.54%	1.29%	0.31%	1.60%	0.11%	0.29%	1.58%	1.74%
Printing & repr. media	-1.18%	0.39%	1.57%	-0.02%	1.56%	-0.38%	-1.43%	0.14%	2.09%
Rubber & plastic products	0.30%	1.35%	1.05%	0.19%	1.24%	-0.36%	0.38%	1.43%	1.54%
Other non-met. min. prod.	0.61%	1.42%	0.82%	0.63%	1.45%	0.03%	0.66%	1.48%	1.13%
Basic metals	1.30%	1.58%	0.28%	1.14%	1.42%	0.16%	1.45%	1.73%	0.29%
Fabricated metal products	0.70%	1.32%	0.62%	0.56%	1.18%	-0.03%	0.79%	1.41%	0.76%
Furniture; other manuf.	0.85%	1.56%	0.71%	0.76%	1.47%	0.32%	0.93%	1.65%	0.78%
Rep. & inst. mach & equip	0.70%	1.34%	0.63%	0.35%	0.98%	-0.52%	0.92%	1.56%	1.04%

* *Note*: ULC of services and rest are computed as denoted in Equation (4a) *Source*: WIOD, own calculations

Figure 2. Wage growth in services integrated in manufacturing subsystems relative to wage growth in total services (2000=100)



Source: WIOD, own calculations

4.2. The integration of services into manufacturing productive strategies: outsourcing and the increasing demand of KIBS

Division of labor has advanced over time and services have been increasingly integrated with manufacturing. Consequently, the amount of resources dedicated to satisfy the final demand of manufacturing goods is still large, although more heterogeneous, as shown in Table 2.

The subsystem methodology captures this process of production reorganization by analyzing the evolution of service employment that satisfies the final demand of manufacturing products. This can be easily done by performing the following operation with the matrix C:

$$Services_m = c_{g,m} + \cdots + c_{u,m} = \sum_{i=g}^{u} c_{i,m} \quad (5)$$

In this equation, all industries that go from g to u, i.e. all of the services activities, are added up within a generic manufacturing subsystem m. Results can be expresed in absolute terms or as a share of vertically integrated employment. We opt for the latter option, because it is much more intuitive. This operation can be performed on each variable of interest.

The evolution of service employment in manufacturing subsystems has been used as a proxy of outsourcing by Montresor and Vittucci Marzetti (2007) or Sarra et al (2018), among others. Nonetheless, the increase in service jobs is not only induced by outsourcing, but also by the greater demand of new advanced services that were not previously performed within manufacturing firms (Ciriaci and Palma, 2016). In practice, it is not possible for the subsystem methodology to differentiate which of both factors is affecting the employment growth. However, the research done on Germany points out that low-level services are much more affected by subcontracting strategies than high-level ones. For that reason, two service categories are presented: KIBS (based on Ciriaci et al, 2015) and what we have called "personal services", which are more labor intensive and require low skills to be performed (Baumol, 1967; Fernández and Palazuelos, 2012), thus comprising potentially outsourced jobs due to cost-saving reasons. Both taxonomies are reported in the Appendix (Table A.5.).

Results of the Equation (5) are reported in Table 4 (data on value added are presented in the Appendix, Table A1). To make the outcome more readable, we have also grouped the 18 subsystems by technological intensity following the OECD criteria. Overall, service industries as a whole account for approximately one-third of the manufacturing subsystem employment share. The differences among observations are outstanding: advanced subsystems display higher share of service employment than non-advanced ones.

Outsourcing practices and the increasing demand of KIBS have been a central pillar in the manufacturing restructuring process. First, vertical integration of KIBS into manufacturing has advanced considerably over the period. Furthermore, high and medium-high technology manufacturing relies more on labor inputs from KIBS than less technological-intensive manufacturing (in the latter the share of KIBS employment is around 3pp lower). Nonetheless, there is much heterogeneity within both types of subsystems. For instance, more than 20% of employment in chemicals and pharma products sectors comes from KIBS. This proportion is much lower for machinery and equipment or transport equipment, although it has grown significantly (5pp and 9pp, respectively).

On the other hand, the degree of KIBS integration into less technological systems is much lower. One might think that these disparities in the employment structure are partially explained by the evolution of productivity levels, but it is clear from Table 3 that the relation is not so direct; hence productive strategies are playing a role here. These results are in line with Ciriaci and Palma (2016): the technological intensity of the manufacturing subsystem is a determinant of the degree of KIBS vertical integration. Our findings also suggest that the high connectivity found by Wildrum and Tomlinson (1999) between KIBS and the rest of the economy in Germany during the 80s and 90s, has moved forward throughout the 2000s, and is particularly profound in manufacturing.

On the other hand, personal services account for less than 5% of the manufacturing employment, but have gained relative importance. Here, the differences in the average levels between the high and low technological intensive subsystems are minimal, although again we find high heterogeneity within both high- and low-intensive technology subsystems.

As a general conclusion, the growth of the "service economy" is partly explained by the increasing demand of service inputs from manufacturing. Nonetheless, an important share of these inputs comes from high-level services (KIBS). This sort of relationship is frequently ignored by some scholars, who are mainly focused on the role of services as suppliers of cheap inputs. All things considered, this section's results point to the suitability of taking into account both types of productive linkages when analyzing the competitiveness of the manufacturing sector.

Table 4 Services vertical integration into manufacturing subsystems, employment (Average share and change 2000-14)

	Total services		KIBS		Personal services	
	Average	ΔChange(pp)	Average	ΔChange(pp)	Average	ΔChange(pp)
Total manufacturing	33.85%	3.95	14.10%	3.99	4.78%	1.34
HT and MHT manuf.	*36.09%*	*4.26*	*15.55%*	*3.80*	*4.70%*	*1.10*
Chemicals	43.13%	4.09	21.62%	2.98	5.12%	1.47
Basic pharma prod	42.90%	2.41	22.19%	1.87	6.77%	-0.30
Motor vehicles	39.65%	7.40	15.23%	3.99	4.59%	1.68
Elect & optical prod	39.05%	-2.60	15.31%	0.86	7.43%	1.16
Other transport eq.	33.38%	10.97	15.74%	8.99	4.56%	2.98
Electrical equipment	32.47%	-0.33	14.17%	2.57	4.47%	1.12
Mach. & equipment n.e.c.	28.94%	4.81	13.13%	4.88	3.43%	0.50
MLT and LT manuf.	*31.21%*	*3.42*	*12.39%*	*4.10*	*4.87%*	*1.64*
Basic metals	36.37%	2.81	14.27%	4.13	3.32%	0.52
Other non-met. min. prod.	34.94%	2.74	15.57%	3.90	3.45%	0.32
Food, Bev & Tobacco	34.17%	4.06	13.52%	3.85	5.61%	4.29
Paper	32.15%	2.80	13.73%	4.31	4.15%	-0.57
Textiles	31.23%	1.94	8.79%	3.71	10.27%	-0.90
Rep. & inst. mach & equip	28.75%	3.83	13.47%	5.14	3.93%	0.68
Wood	28.36%	7.62	10.45%	4.61	4.92%	2.20
Rubber & plastic products	27.67%	2.80	13.13%	4.21	3.35%	0.99
Furniture; other manuf.	25.38%	3.10	8.78%	3.19	5.17%	0.32
Printing & repr. media	20.39%	5.12	11.47%	3.87	2.57%	0.58
Fabricated metal products	20.14%	3.53	8.77%	4.16	2.57%	0.81

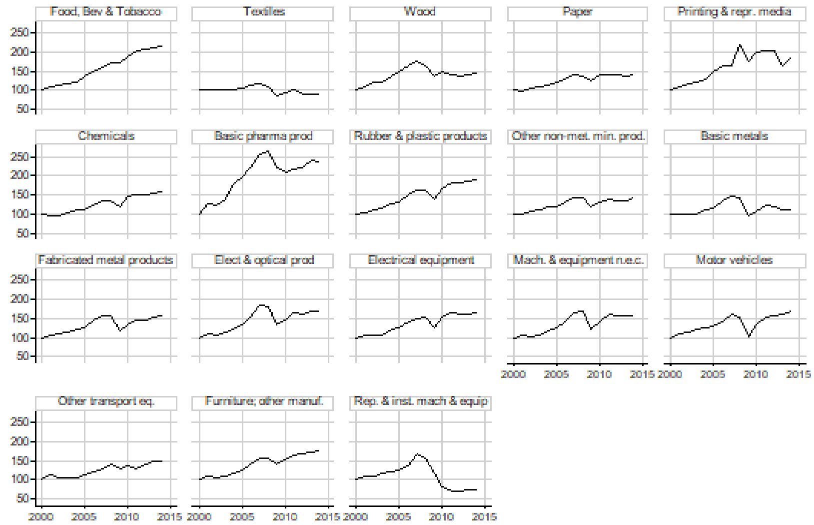
Source: WIOD, own calculations

5. The nexus between cost-competitiveness and export growth: an empirical analysis

The remainder of the article seeks to establish a causal relationship between the processes of wage squeeze and manufacturing restructuring and export growth. This way, we will be able to test our four hypotheses.

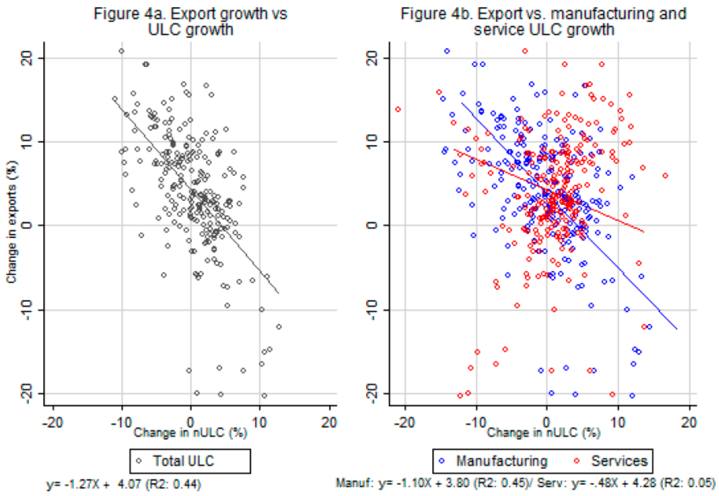
Before presenting our econometric model, we briefly show the evolution of exports (Figure 3). Overall, a steady growth can be appreciated throughout the period in all sectors except textiles and repairs and installation of machinery and equipment. A fall in 2009 is appreciated as well, followed by a subsequent rebound in the succeeding years, showing the rapid recovery experienced by the manufacturing sector. It should be noted that the input-output methodology considers any exported good as a final commodity, although it might be the case that it is an intermediate input of a foreign subsystem.

Figure 3. Export growth (constant prices, 2000=100)



Source: WIOD, own calculations

A first approximation to the relationship between labor cost competitiveness and exports growth is presented in Figures 4a and 4b. It seems that cost-saving policies have been important for the commercial success of the economy (Figure 4a). Moreover, when splitting up ULC into the manufacturing and service part of the subsystem, it seems that both of them present a strong effect on exports (Figure 4b). Nonetheless, this relationship is not so straightforward, because ULC impact exports indirectly through prices, which also depend on other variables. Hence, it requires introducing a price equation along with more controls to correctly asses this effect.



Source: WIOD, own calculations

5.1 The export model

This subsection in particular illustrates the theoretical model behind the empirical analysis. Our export model is a triangular system, in which ULC impact export prices, which in turn affect export growth through relative prices. Similar theoretical relationships are established in Stockhammer et al (2011).

The specification is written as follows:

$$\Delta\ln(pX)_{jt} = \alpha_{0j} + \beta_1\Delta\ln(ULC')_{jt} + \delta_2\Delta\ln(pM)_{jt} + \varepsilon_{jt} \quad (6)$$

$$\Delta\ln(pX)_{jt} = \alpha_{0j} + \beta_1\Delta\ln(ULC')_{mjt} + \beta_2\Delta\ln(ULC')_{sjt} + + \delta_3\Delta\ln(pM)_{jt} + \varepsilon_{jt} \quad (6a)$$

$$\Delta\ln(X)_{jt} = \alpha_{0j} + \rho_1\Delta\ln(pX - pM)_{jt} + \gamma_2\Delta\ln(wY)_t + +\alpha_3\Delta\ln(KIBS')_{jt} + \varepsilon_{jt} \quad (7)$$

Where *j*=1, ..., N, represents manufacturing subsystems (cross-sectional dimension) and *t*=1,..., T denotes the time dimension. Again, the apostrophe means that the variable has been vertically integrated. Variables are expressed in first differences of logarithms (Δ), so the results are interpreted as growth rate elasticities.

Equation (6) indicates that export prices are not only a negative function of vertically integrated ULC, but also depend positively on import prices (*pM*). The latter captures both the effect of imported intermediate inputs prices and the extent to which exporters set prices strategically (Horn et al, 2017). Hence, it is assumed that firms do not operate in perfect competitive markets and may charge a markup on their marginal costs. On the other hand, Equation (6a) is just an extension of the former one, and splits up the ULC growth within each VIS *j* in services *s* and the rest of activities *m*. As can be appreciated, both equations consider ULC to be an exogenous variable, which is previously determined by external institutional factors, such as the coverage of the collective bargaining or the union density. Furthermore, in the results section an additional model will be presented, in which the effect of both components of the ULC (wages and productivity, both vertically integrated) is differentiated.

Equation (7) illustrates the growth of real exports as a negative function of price competitiveness, expressed as the relationship between export and import prices (*pX-pM*), and a positive function of world demand excluding Germany (*wY*). In addition to these two standard explanatory variables, we introduce the growth in the share of KIBS employment (*KIBS'*) integrated in each subsystem *j*. As above mentioned, the increasing demand of these types of services is associated with the ability of manufacturing subsystems to innovate and compete through differentiation strategies. Therefore, it is expected that the sign of the effect will be positive. The definition of each variable is presented in the Appendix (Table A4).

Lastly, with the estimated coefficients of both equations, we will compute the contribution of each variable to export growth.

5.2 Estimation strategy

As a first step, and after performing the usual tests of cross-sectional dependence (Breusch-Pagan test), autocorrelation (Wooldridge test) and heteroskedasticity (Wald test), Equations (6) and (6a) are estimated using OLS Panel Corrected Standard Errors (PCSE) correcting for heteroskedasticity and cross-sectional dependence (autocorrelation problems were not found)[4]. The results of the tests are presented in the Appendix (Table A2).

Nonetheless, a main concern in these two equations is that ULC might be endogenous, because they can be explained not only by institutional factors, but also by the evolution of productivity and technological progress, which in turn impacts export price growth. To address this issue, we estimate an additional OLS PCSE model with ULC lagged one period. Additionally, we also compute a difference generalized method of moments (diff-GMM) model (Arellano and Bond, 1991) as a robustness check. We are aware that this estimator performs better with "large N and small T" (Roodman, 2009), but it is the best way to control that the results are neither biased nor inconsistent, given that no other instruments are available.

Regarding Equation (7), the employed estimation strategy is two-stage least squares (2SLS). We have a triangular system, in which export prices are endogenous and the rest of variables exogenous. Endogeneity arises because of potential problems of reverse causality, i.e. it might be the case that an increase in exports demand would drive export prices up. To avoid such a problem, we take advantage of Equation (6) and instrument relative prices with ULC and import prices. A similar strategy is applied by León-Ledesma (2002).

We will report the results of both the first and the second-stage regressions of the 2SLS model. Although first-stage results are not

4 Given the structure of the data (N > T), the FGLS estimator was not considered due to its tendency to produce extremely optimistic standard errors (Beck and Katz, 1995).

typically presented, in this case it is interesting to do so because the specification is quite similar to Equation (6). Furthermore, in a system of simultaneous equations all the exogenous variables are used as instruments for all endogenous variables, otherwise the problem of reverse causation would not be handled properly. The results of both equations are robust to heteroskedasticity and serial correlation.

All the regression models include VIS fixed effects to account for idiosyncratic differences in productive techniques and other factors across sectors which are unlikely to be explained by the other variables. This decision is also supported by the results of the Hausman test, which shows that the null hypothesis of consistency and efficiency of the random effects estimator should be rejected (Table A2, in the Appendix).

5.3 Results

Table 5 reports the results of the export price equation. Columns 1 and 4 show the results of Equation (6), while the outcome of Equation (6a) is presented in columns 3 and 6. Columns 2 and 5 show the results when the effect of wages and productivity is differentiated. In all cases the estimated coefficients are statistically significant and present the expected signs. As can be seen, the results of all the specifications are quite similar. The results of the 2SLS regressions are the ones of the first-stage equation, although the table only presents the variables of interest, i.e. labor costs and import prices.

Our estimations yield a rather small effect of ULC: a decrease of 1pp in this variable drives down export prices between 0.16 pp and 0.18 pp, depending on the model. This outcome reinforces the argument that, usually, there is not a complete pass-through of labor costs onto prices. Furthermore, taking into account that labor cost are a small proportion of total costs (around 25%, according to Storm and Naastepad, 2015: pp. 15, table 2), the residual role of this variable in competitiveness can be better understood. Reported in the Appendix are the results of the model with lagged ULC and the diff-GMM model, in which ULC are treated as endogenous (Table A3 in the Appendix). As can be appreciated, the coefficients are similar and significant.

Widening the analysis, when the ULC is separated into its components (productivity and mean wage), both of them present a similar effect size. Therefore, they are equally important for the evolution of prices and exports. On the other hand, the two parts of the manufacturing subsystem present different effects on prices. The evolution of labor costs in service industries is, in fact, the driving factor behind the coefficient of total ULC; while the effect of ULC of the rest of the VIS (which mainly comprises manufacturing activities) is close to zero and non-significant in some specifications. When introducing both variables separately, the effect of ULC in the rest of the VIS became statistically significant and its effect is slightly larger (see Table A3 in the Appendix). This suggests that wage restraint policies in services were functional to reduce manufacturing prices, despite their weak effect. Moreover, it also fits with the argument that the regained cost-competitiveness was due to wage compression in service suppliers, allowing manufacturing core workers to enjoy higher wage increases without damaging competitiveness.

Finally, the coefficient of import prices is the strongest one. This might be reflecting that imported input prices are important for the cost structure of German exporters. As pointed out by Horn et al (2017), Germany is highly dependent on raw materials and energy imports. At the same time, this result may be a sign of pricing-to-market behavior.

Table 6 presents the results of Equation 7, estimated by 2SLS. The three columns of the table show the results obtained when relative prices are instrumented with either ULC or wages and productivity or ULC in services and the rest of the subsystem. As mentioned above, the other instrument included is the price of imports. The validity of the instruments is confirmed by the Sargan-Hansen test. The null hypothesis that the instruments are uncorrelated with the error term is rejected, therefore they can be considered exogenous. Additionally, the outcomes of the Cragg-Donald test allow us to conclude that the instruments are not weak (they all exceed the 5% threshold value).

Table. 5 Exports price equation results

	(1) OLS PCSE	(2) OLS PCSE W/L & P	(3) OLS PCSE Serv. & rest	(4) 2SLS	(5) 2SLS W/L & P	(6) 2SLS Serv. & rest
ULC'	0.155***			0.184***		
	(0.030)			(0.043)		
ULC (rest)'			0.035			0.044
			(0.031)			(0.056)
ULC (services)'			0.165***			0.156**
			(0.034)			(0.066)
W/L'		0.137*			0.158**	
		(0.077)			(0.081)	
P'		-0.157***			-0.187***	
		(0.029)			(0.046)	
Import prices	0.511***	0.511***	0.477***	0.525***	-0.523***	-0.525***
	(0.042)	(0.042)	(0.046)	(0.101)	(0.102)	(0.101)
Constant	-1.621***	-1.605***	-1.993			
	(0.437)	(0.441)	(0.423)			
Observations	252	252	252	252	252	252
R-squared	0.956	0.956	0.958	0.755	0.756	0.762
Number of VIS	18	18	18	18	18	18
VIS FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

2SLS models are the result of the first stage of the triangular system
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Exports equation results

	(1) Total ULC	(2) W/L & P	(3) ULC Serv. & rest
(pX-pM)	-0.719***	-0.732***	-0.679***
	(0.218)	(0.218)	(0.211)
wY	2.517***	2.506***	2.553***
	(0.348)	(0.346)	(0.359)
KIBS'	0.560***	0.558***	0.564***
	(0.151)	(0.151)	(0.148)
Observations	252	252	252
R-squared	0.567	0.566	0.568
N	18	18	18
VIS FE	YES	YES	YES
Sargan-Hansen test	$\chi^2(13)$: 15.63 p = 0.270	$\chi^2(14)$:17.77 p = 0.217	$\chi^2(14)$: 16.07 p = 0.309
Cragg-Donald Wald F	32.434	30.171	31.113

All models are estimated by 2SLS
Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Regarding the results of the model, the coefficient estimates have the expected sign and are statistically significant. It should be noted that the three types of instruments produce analogous results, and the obtained price coefficient is around -0.7 in the three cases. Hence, a 1pp drop in prices raises export growth by 0.7pp. This result is coherent with the existing literature on German exports (see Table 1 in Section 2).

As usual, the size of the world income coefficient is the highest one, and shows a strong response of German exports to the evolution of world demand. Lastly, the coefficient of KIBS is quite interesting. A 1pp raise in KIBS employment share in manufacturing subsystems is associated with an increase of 0.55pp of manufacturing exports. According to our theoretical proposal, this indicates that high quality production standards introduced by the cooperation between these advanced services and industrial firms have been quite positive to reinforce competitiveness.

All in all, price factors did play a role in the explanation of the German export success. Nonetheless, non-price variables, such as the ability of exporters to meet world demand evolution and their traditional high-quality production strategies –complemented with the participation of advanced services-, have led the exporting performance of the country.

We can now confirm the four hypotheses presented in the previous section:

- We obtained empirical support for *HI*, which state that the German export success was driven by non-price factors and that labor costs dynamics were of secondary importance.
- *HII* and *HIII* on the relevant but weak effect of wage moderation in services that satisfy the final demand of manufacturing goods were also verified.
- Lastly, *HIV* that KIBS vertical integration into manufacturing contributed positively to export growth has been confirmed as well.

5.4 Contributions to export growth over the period 2000-2014

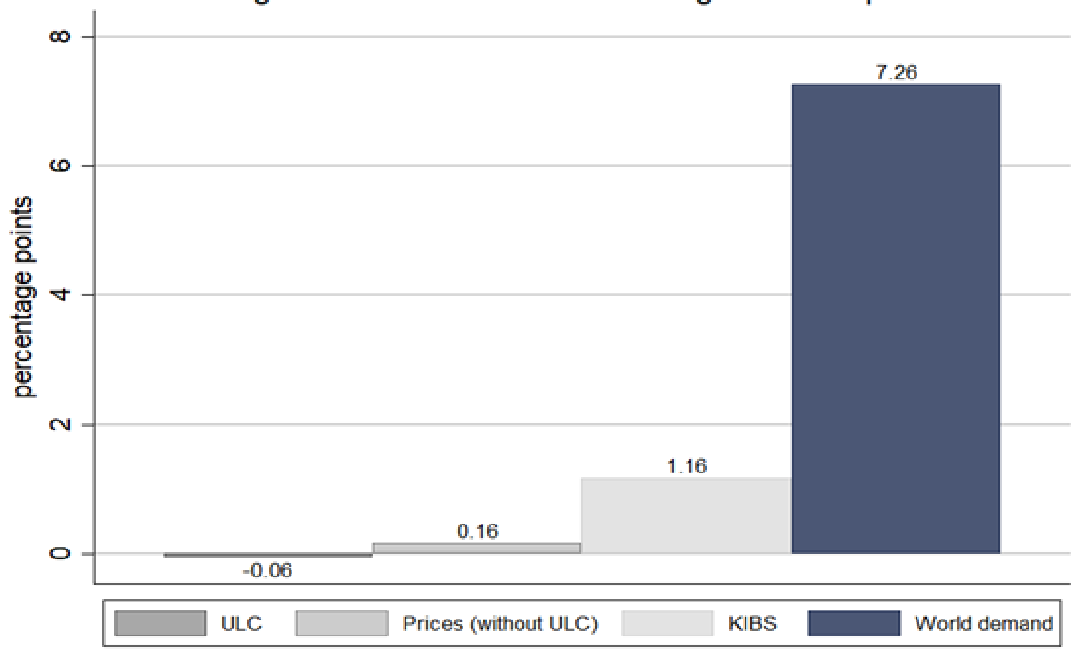
We can inquire further into the role of the variables interest on the commercial success. With the estimated coefficients it is now possible to compute their contribution to export growth by the following calculation:

$$\Delta X = \left[\left(\epsilon_{ULC}^{pX} * \epsilon_{pX}^{X}\right) * \Delta ULC\right] + \\ + \left[\left(\epsilon_{(pX-pM)}^{X} * \Delta(pX - pM)\right) - \left(\left(\epsilon_{ULC}^{pX} * \epsilon_{pX}^{X}\right) * \Delta ULC\right)\right] + \\ + \left[\epsilon_{KIBS}^{X} * \Delta KIBS\right] + \left[\epsilon_{wY}^{X} * \Delta wY\right] \quad (8)$$

The equation illustrates the total effect of a change in the explanatory variables on exports. For instance, regarding ULC and assuming that import prices have been constant throughout the period. We see that the annual growth of exports thanks to ULC is equal to the yearly growth of the latter variable multiplied by its effect on export prices (ϵ_{ULC}^{pX}) and by the effect of the latter on export volumes (ϵ_{pX}^{X}). We used coefficients from specifications 4 (Table 5) and 1 (Table 6), and the obtained growth rate elasticity ($\epsilon_{ULC}^{X} = \epsilon_{ULC}^{pX} * \epsilon_{pX}^{X}$) is -0.134. Furthermore, due to the coefficient of the service part of the VIS being nearly as large as ϵ_{pX}^{X}, the contribution can be almost entirely attributed to it. In second place, we subtract the total effect of ULC from the contribution of relative prices and obtain the effect of price factors non-related with labor costs.

We calculated the weighted average for the whole manufacturing sector (each VIS is weighted by its share in total exports). The figure shows that labor cost competitiveness did not impact significantly on export growth. On the contrary, on average, its contribution was negative. Prices, excluding ULC, present a positive but small impact on exports. It is interesting to note that KIBS integration into manufacturing productive strategies have boosted exports 1.16% each year. Lastly, the expansion of world demand has been the main driver of German commercial success, proving the relevance of non-price factors.

Figure 5. Contributions to annual growth of exports



Source: WIOD, own calculations

Looked at together, the evidence presented in this section suggests that the role played by labor cost competitiveness was of minor importance. This is due to two factors: the incomplete pass-through of ULC onto export prices and the fact that non-price factors (i.e. world demand and the participation of KIBS in manufacturing production processes) are better predictors of export growth than relative prices. This is not to say that price-competitiveness is not an issue for the German industry (certainly, a price growth-rate elasticity of 0.7 indicates the contrary), but that variables other than labor costs must be considered in the analysis of prices, such as the cost of imported inputs or the firms' profit mark-up.

6. Concluding remarks

The question of which were the drivers of the German exporting success has been addressed numerous times without consensus in the literature. Several events occurred at the same time in the country during the last thirty years. On the one hand, exports started to grow rapidly and became the first source of growth. On the other hand, labor costs were reduced against other competitors thanks to a process of institutional reforms concentrated in the service sector, and the restructuring of the manufacturing production processes. In a nutshell, while some authors establish a causal link between these events and highlight the importance of labor costs competitiveness (Dieppe et al., 2011; Thorbecke and Kato, 2012; Baccaro and Benassi, 2017), others claim that the exporting success has nothing to do with wages, but with the advanced productive strategies of German manufacturers (Danninger and Joutz, 2008; Felipe and Kumar, 2014; Storm and Naastepad, 2015).

This article sought to contribute to this debate by applying a novel methodology that combines the subsystem approach to the input-output and panel data regressions. The use of a subsystem approach allowed us to consider the productive interlinkages that exist in the German dual model between manufacturing producers and service suppliers. Moreover, we showed that the traditional approach to the economic analysis underestimates the size of manufacturing by around 10pp regarding value added and employment, so the unit of analysis is considerably different.

The application of a subsystem approach is particularly important for the study of German manufacturing competitiveness for two reasons. First of all, because the process of wage devaluation was much more intensive in services than in manufacturing, so the latter could obtain cheaper inputs from the former and improve its labor cost-competitiveness. Second, because German manufacturers outsourced certain service activities for cost-saving reasons, and increased their demand of KIBS, which currently constitute an important piece for their high quality production, and contributed to enhance their non-price competitiveness.

We found that non-price factors were the main drivers of manufacturing exports. Although a high price coefficient was captured (-0.7), the effect of labor costs on price formation and export volumes is negligible (-around 0.13). Moreover, our estimations report an average yearly contribution of ULC to export growth of -0.06%. In addition, when separating the service part and the rest of the VIS, we found that the impact of ULC on prices is due to the wage restraint in the former, although its effect has been rather low.

Lastly, our results suggest that the relationship between manufacturing and services is not only a matter of saving costs. On the contrary, the interlinkages with KIBS have driven export volumes up over the period. These high-level services are innovation drivers and help manufacturing firms to compete in the international markets through differentiation strategies (Ciriaci et al, 2016).

All in all, our analysis challenges the view that policies of wage devaluation were useful to regain competitiveness and cast doubts on the functionality between the two segments of the dual model. Interestingly enough, the predominant productive linkage between manufacturing and service reinforce the typical high-quality production of coordinated models. We therefore detect a source of continuity in German exporting strategies, which is based on a productive restructuring undertaken to gain competitiveness through differentiation.

Some policy implications follow these findings. To begin with, it seems worthwhile for policy-makers to invest in the development of domestics KIBS. These advanced services proved to be helpful to improve international competitiveness and are also labor intensive industries, so they can also play a role in reducing the unemployment rate without deteriorating aggregate productivity. Thus, they can be part of a "high road" strategy for economic growth.

In addition, we have detected that the fall in labor costs was not fully passed onto prices. Future research might explore the effects of that. For instance, a logical consequence of this is the increase in the profit share. Some authors have found a low sensitiveness of corporate investment to higher profits (Stockhammer et al, 2011; Braun and Deeg, 2019). This, in combination with the lower propensity to consume out of wages, has resulted in low rates of economic growth. It seems that, if wages had grown at a faster pace, the economic growth would have been more balanced, with higher increases in domestic demand without damaging export growth.

Appendix

For space reasons, the Appendix is available upon request.

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