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STRUCTURAL CHANGE, TECHNOLOGY AND INCOME DISTRIBUTION

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SUMMARY

As highlighted by Pasinetti (1981, 1993), the process of structural change of the capitalist economies follows "out-of-equilibrium" paths marked by the complex interaction of supply- and demand-side factors. The driving role of effective demand is intertwined with the patterns of technological change, whose "push effect" on new investments and labour productivity growth has major impact on employment dynamics and income distribution between capital and labour (Bogliacino and Pianta, 2010, 2011; Crespi and Pianta, 2008a, 2008b; Lucchese and Pianta, 2012; Pianta 2005). At the same time, the evolution of economic systems is fundamentally shaped by the opportunities and constraints given by the institutional setting and the socio-economic environment in which different economic actors are embedded (Freeman and Louca, 2001; Perez, 1983). It follows that economies are affected by a "relative inertia", insofar as their different components do not change at the same speed and with the same timing (Landesmann and Scazzieri, 1990, 1996). The investigation of structural economic dynamics thus asks for the adoption of the proper level of aggregation according to the objectives of the analysis that one intends to pursue (Andreoni and Scazzieri, 2014).

Our dissertation proposes an integrated approach to structural change and distributional dynamics combining a Neo-Schumpeterian perspective on technological change and a Post-Keynesian view on demand and income distribution. On the empirical ground, we develop a set of empirical models using industry-level data for major European countries over the period 1994-2014.

We build on evolutionary literature conceiving technological change as a path-dependent, cumulative and radically uncertain process having heterogeneous effects according to the different kinds of innovation pursued by industries (Schumpeter, 1934; Dosi, 1982, 1988; Nelson and Winter, 1982). In particular, we distinguish between the input and output of innovation, i.e. between the innovative efforts carried out by industries (such as the expenditure in R&D and in new machinery and equipment) and the outcome of those efforts (in terms of introduction of new products and new production processes). Most important, we cross the aforementioned dimension of heterogeneity emphasizing the distinction between product and process innovation, proxying a technology-driven and cost-based competitiveness strategy, respectively (Pianta, 2001). While the former is associated with the search for quality improvements and a propensity to innovate for opening new markets, the latter focuses on high machinery expenditures, with a propensity to introduce labour-saving technologies and search for increased flexibility (Bogliacino and Pianta, 2011; Bogliacino et al., 2017; Cirillo, 2017). Whether these competitiveness strategies may coexist at firm level, such a distinction allows to identify the dominant strategy pursued by industries according to their technological regime and related trajectories (Breschi et al., 2000; Dosi, 1982; Malerba and Orsenigo, 1997).

In line with Post-Keynesian theory, we recognize the key role of demand in "pulling" economic growth while shaping the structural change dynamics of the economies (Leon, 1967; Kaldor, 1989; Pasinetti, 1981). In this context, we account for the specific demand structures of industries, distinguishing between the domestic and foreign component of demand flows (Guarascio and Pianta, 2016; Guarascio et al., 2016). We follow the Kaldorian and evolutionary literature emphasizing the linkages between technology, international competitiveness and demand growth, stressing the

technological features of production as crucial elements in order to capture the changing composition of demand – especially exports – over time (Fagerberg, 1988, 1996; Kaldor, 1978). This perspective allows to assess the relative importance of domestic and foreign markets for the growth performance of industries characterized by different technological regimes and competitiveness strategies (Gurascio and Pianta, 2016). Moreover, in line with the Post-Keynesian theoretical framework, we acknowledge the crucial role played by the distributional dynamics in determining the patterns of effective demand (Kalecki, 1935 [1933]; Keynes, 1936). Consistently, we recognize the conflictual nature of income distribution and investigate the structural and institutional factors which shape the balance of power between capital and labour and therefore the dynamics of wages and profits.

In addition, our analysis accounts for the modern process of globalization, inquiring its connection with the production specialization of the economies and consequences in terms of power relations among social actors (Rodrik, 1997). The worldwide liberalization of trade and capital markets occurred in the last four decades and the strong reductions of communication and transport costs resulted in major processes of global fragmentation of production (Feenstra and Hanson, 1996; Hummels et al., 2001). The introduction of new organizational strategies related to the localization of production and the choices with respect to the sources of supply for intermediate goods (namely offshoring practices) spurred the emergence of hierarchical global values chains, marked by power and technological asymmetries and fundamentally shaped by the institutional framework they are embedded in (Milberg and Winkler, 2013; Simonazzi et al., 2013; Timmer et al., 2014). Accordingly, we investigate the relationships between offshoring strategies of industries and their growth performance and inquire the impact that the former have on the wage and profit dynamics. We exploit Input-Output tables to compute different offshoring indicators developed by Feenstra and Hanson (1996, 1999) and, following Guarascio et al. (2015), we also distinguish between high- and low-tech offshoring according to the technological intensity of foreign industries which source the imported intermediates inputs. This enable us to assess the heterogeneity emerging from the linkages among the low- and high-tech offshoring strategies of industries, their structural features and economic and distributional dynamics.

As for the chosen level of aggregation, the industry level allows to properly investigate the changing composition of the economies, permitting to account for both the demand- and supply-side factors which shape their structural dynamics. Effectively, industry-level analyses allow to consider the demand constraint (understood as a limit to production growth) and give the possibility to assess the role of industry-specific demand structure. As regards the supply-side, whether firm-level studies account for high degrees of heterogeneity (Bogliacino, 2014; Bogliacino et al., 2017; Guarascio and Tamagni, 2016), industry-level analyses highlight changes in the structure of the economies and allow to link those changes to the macroeconomic performances; nonetheless, the industry level approach is very suitable to conduct integrated investigations about the structural transformations related to the internationalization of production. Moreover, our analysis properly accounts for the role of sectoral systems of innovation (Malerba, 2002). As suggested by the evolutionary literature, the innovative behaviour of firms is fundamentally affected by the technological regime of the industry they belong to, essentially defined in terms of the appropriability and cumulativeness of technological advances, as well as the technological opportunities and knowledge base of firms' innovative efforts (Breschi et al., 2000; Malerba and Orsenigo, 1997). This perspective also allows to assess the dominant competitiveness strategy pursued by industries, shedding light on their different distributive outcomes.

On the empirical ground, we use the Sectoral Innovation Database (SID), which has been developed at the University of Urbino and including data for 21 manufacturing and 17 service sectors for six major European countries (France, Germany, Italy, Netherlands, Spain and the United Kindgom) from 1994 to 2014. This dataset provides a comprehensive view of industries' dynamics, encompassing information on their technological, distributional, organizational and economic performance.

The structure of the dissertation is the following.

Chapter 1 provides a review of the literature on structural change stressing the different prominence that various theoretical streams of research assigned to technological change and demand dynamics. Moreover, we propose an integrated approach to structural economic dynamics which combines a Neo-Schumpeterian perspective on innovation – emphasizing the different competitive strategies pursued by industries – with a Post-Keynesian view on the driving role of effective demand, explicitly accounting for the modern process of global fragmentation of production. In the last section of the chapter we present a general overview of the Sectoral Innovation Database (SID), which will be exploited for the empirical analysis performed in the second chapter of the dissertation.

Chapter 2 provides an empirical analysis of the patterns of structural change which have interested the European economy in the last twenty years. In particular, we investigate the relationships between the innovative efforts pursued by industries, the offshoring strategies which shape their competitiveness, the industry-specific dynamics of different demand flows and the growth patterns of industries. Notably, we stress that such relationships are not constant in time and uniform in space (Scazzieri, 2009; Landesmann, 2018); accordingly, we identify and discuss four key sources of heterogeneity (related to the nature of production of industries, their technological intensity, their belonging to a core or peripheral country and the upswing and downswing of business cycle) and propose a simple empirical model checking how they affect the strength and direction of structural relationships under investigation. While the relevance of both supply- and demand-side factors in shaping the process of structural change seems confirmed, the results show the importance of breking down the analysis along the detected structural dimensions.

Chapter 3 contributes to the analysis of the determinants of functional income distribution identifying technological change, offshoring strategies and union density at industry level as key factors shaping the power relations between capital and labour. After presenting a theoretical and empirical literature review on the drivers of wage and profit dynamics, we perform an empirical analysis extending the simultaneous model proposed by Pianta and Tancioni (2008). Main results show that labour productivity growth and product innovation have a positive impact on both distributive components, while a rather negative effect of process innovation on wages is detected. Offshoring processes generally emerge as profit-enhancing while represent a reliable firms' weapon to reduce labour costs, although a remarkable heterogeneity arises when the technological nature of offshoring strategies is accounted for; finally, union density tends to be positively associated with wage dynamics, although it loses significance when country-specific institutional characters of labour market are accounted for.

Chapter 4 proposes an extension of the empirical analysis presented in the previous chapter developing a sequential model of income distribution. Taking inspiration from Bogliacino, Guarascio and Cirillo (2018), we investigate the determinants of distributional dynamics within a theoretical framework according to which the wage and profit setting is the result of a two-step bargaining process. Wages are set out in the labour market as a result of workers' bargaining power, which is shaped by employment dynamics, the technological and offshoring strategies pursued by industries and union density. Profits are then realized as a residual and their dynamics depends on the level of previously determined wages, productivity patterns, innovation performance and offshoring trajectories of industries. Main results show a strongly negative relationship between wage and profit dynamics, while the growth of employment positively affects the dynamics of labour compensation (suggesting that industries which drive the structural change process tend to pay higher wages while increasing labour market tightness improves workers' negotiation position). Product innovation is positively associated with both wage and profit growth, while the introduction of new production processes tends to reduce wages (albeit not in all specifications). Offshoring strategies are confirmed as drivers of profits while tend to reduce labour compensation, especially the ones aimed at acquiring low-tech intermediate inputs. Finally, industries in which union density is higher tend to pay higher wages, suggesting the relevance of labour market institutions in conditioning the patterns of income distribution.

Chapter 1

Structural Change: Theory and Data

1. Introduction

With the advent of the first Industrial revolution the historical dynamics of capitalist economies has been marked by the continuous transformation of production structures and socio-institutional arrangements, resulting in major economic processes of structural change. Since the pioneering contributions of Classical political economy, several different approaches to structural change theory have been offered by the economic literature, according to the theoretical background of the scholars, the demand- or supply-side factors they considered from time to time most relevant and the social and economic problems they had to face in different social contexts and/or historical periods. Although summarizing such a huge amount of literature is well beyond the goal of the present work, we propose a theoretical overview aimed at showing how different strands of research have addressed structural change, understood as the changing composition over time of economic aggregates.[1]

After a sketch on the insightful reflections of Classical economists, Marx and Schumpeter on the driving forces lying at the basis of the structural evolution of capitalist economies, we emphasize the striking difference which holds between the former and the 'equilibrium approach' supported by Neoclassical economic theory. Such approach is fundamentally grounded in a static competition framework in which the maximizing behavior of representative agents determines the Pareto-optimal allocation of "production factors". Nonetheless, following the works of Baumol and Kuznetz, modern developments in this field have revised some of the standard theoretical assumptions of general equilibrium framework to address structural change. However, these attempts strive to account for the pivotal role of demand and radically uncertain nature of technological change.

We move then to the Post-Keynesian tradition and account for the key contributions in the field of structural change theory provided by Joan Robinson, Nicholas Kaldor, Paolo Leon, Luigi L. Pasinetti and Richard Goodwin. Contrary to Neoclassical theorists, these scholars stress the intrinsic instability of the capitalistic mode of production. On the one hand, they address the investigation of structural economic dynamics building disaggregated models able to account for the driving role of effective demand (whose dynamics is conceived strictly linked to the conflictual determination of capital and labour income). On the other hand, they recognize the cyclical nature of the capitalistic accumulation process, deepening the mechanisms which govern both the changing production composition and the macro-dynamics of economic systems.

Finally, Neo-Schumpeterian scholars conceive capitalism as an evolutionary process of continuous transformation, whose fundamental engine of growth is not static but dynamic competition, namely the innovative efforts of economic agents aimed at introducing radical innovations which spur technological change and allow the profit-seeking innovators to gain (temporary) monopoly profits. The long-run development of economic systems is not conceived in terms of equilibrium patterns of balanced growth, but as an open-ended process of structural change subject to historical contingencies and fundamentally characterized by cyclical phases of expansion and contraction.

Albeit there are some considerable differences among the aforementioned theoretical approaches, we argue that a step ahead in the analysis of structural economic dynamics might come from the combination of a Post-Keynesian perspective on the driving role of effective demand with a Neo-Schumpeterian approach to technological change. Nonetheless, a modern investigation about the dynamic transformation of production structures cannot disregard the role of globalization in shaping

[1] For a comprehensive literature review on structural change theory see Kruger (2008). Antonelli and De Liso (1997) focus on the role played by technological change in shaping the processes of structural change from an evolutionary perspective. Silva and Teixeira (2008) document the growing importance that has been assigned in the economic literature to the analysis of structural change, especially since the late 1980s, and provide a bibliometric meta-analysis by which they detect trends that literature on this topic has followed in the last decades. In this context, they account for the growing attention various scholars have dedicated to technological change and technology-driven growth patterns, while the role of demand has often been underestimated.

the competitiveness strategies and development trajectories of industries and countries. We thus propose an integrated approach to structural change that combines Post-Keynesian and Neo-Schumpeterian insights, accounting at the same time for the process of global fragmentation of production due to the offshoring strategies pursued by firms belonging to different industries. In this context, structural economic dynamics is conceived as the dynamic outcome of the uneven growth patterns of sectors, whose development paths are fundamentally shaped by technological change, growth patterns of demand and offshoring activities. Furthermore, we stress that the relationships linking the latter with the economic performance of industries are not established once for all; conversely, they change over time and space according to different structural dimensions.

Finally, the necessity to provide and empirical investigation along the lines described requires the matching of different sources of data that account for several aspects of structural change. For this purpose, we employ the Sectoral Innovation Database (SID) that, merging information from various database, provides a comprehensive view of industries' dynamics as well as an assessment of their technological, structural and economic performance.

2. Investigating structural change: a review

2.1 The foundations

Since the second half of the Seventeenth century, the advent of the first Industrial Revolution led to a major structural transformation of the European economy. This turning point in the evolution of economic system is characterized by two main distinctive features: on the one hand a great leap forward in technological progress, thanks to the practical application of considerable scientific and technical discoveries; on the other, an ever-increasing division and specialization of work. These two phenomena were associated with a huge increase in the wealth of the countries that first hosted the industrialization process and the consequent exponential growth of population.

Such great economic transformations went in parallel with theoretical developments regarding the mechanisms which govern the functioning of capitalistic mode of production. In particular, the fundamental link connecting the dynamics of economic growth with the introduction and diffusion of technological and organizational innovations was already recognized by Classical economists. According to Adam Smith (1776), the historical process of industrialization which fostered huge labour productivity increases was linked to technical change fundamentally conceived as growing division of labour. The latter promoted work specialization and encouraged learning-by-doing mechanisms, triggering increasing returns; these, in turn, were limited by the extension of the market and therefore by the division of labour itself. In this sense Smith proposed an endogenous conception of technical change in capitalist economies, according to which the process of structural change due to the division of labour relies fundamentally on the previous patterns of returns to scale, whose dynamics depends on the reached level of market extension.

Ricardo (1951 [1821]) investigated the mechanisms by which technological change affects employment dynamics. If on the one hand the increase in labor productivity resulting from the mechanization of production reduces the labor time needed to produce given amounts of commodities, on the other hand the decrease in prices due to technical progress and labour productivity gains allows an increase in demand, while new markets are created in industries producing new machineries. This leads to potential unbalances between sectors, asymmetric effects on the productive structure and the possibility of rising technological unemployment. Indeed, the compensation mechanisms at work – such as an increase in demand induced by the introduction of new products and made possible by real income increases due to price reductions of mature goods – may not be sufficient to counteract the labor-saving character of new technologies and conduce to employment shifts and production composition changes.

Marx (1976 [1867]) is the XIX century economist who put most attention on the revolutionary attitude of capitalist mode of production and thus on innovation and technological change dynamics.

In the *Manifesto* of 1848, Marx and Engels already recognized the disruptive role of the bourgeoisie, which is spurred to continually introduce technological innovations in the form of new and more efficient production techniques by the inter-capitalist conflict, with the ultimate goal of overcoming competitors, conquering new markets and speed up the rate of accumulation. This process simultaneously modifies the very structure of the markets, which tend to be increasingly concentrated (i.e. they tend towards oligopolistic or even monopolistic market forms) and dominated by large-scale, ever-growing capital-intensive companies introducing mainly process and organizational innovations.

Schumpeter (1934) largely built on the Marxian notion of technological competition to develop an evolutionary theory according to which the introduction of new production technologies represents the engine of capitalist development (Fagerberg, 2003, 2005). Most important, he introduced a broader definition of innovation, stressing that technological change is not limited to process innovations but encompasses also the introduction of new products, new sources of supply (e.g. new sources of intermediate inputs) and new organizational arrangements for production.

In Schumpeterian theory of business cycle (Schumpeter, 1939) major emphasis is assigned to investment in technological innovation as the element that governs the succession of development stages of capitalism. According to Schumpeter's vision, the ability and the rent-seeking attitude of entrepreneurs led them to introduce disruptive innovations which kick off great investment opportunities and lay the foundations for a new phase of development. The introduction of innovations makes it possible to obtain extra-profits which, in turn, are the engine that triggers economic growth as well as further investments by the mass of potential imitators. Once the previously introduced technological innovation has become pervasive reaching an advanced stage of diffusion, the most intense competition (due to the high number of imitators and the emergence of diminishing returns) tends to reduce monopolistic profits, while the sectors producing innovative products tend to become saturated, thus discouraging further investments. It follows a collapse of demand growth, mainly of capital investments, that first generates a slowdown and then a recession, which may turn into a phase of depression before the growth starts again because of a new wave of innovations, bringing about investments as well as new institutional and social challenges.

The Schumpeterian conception of economic development is therefore very far from any steady-state growth in equilibrium conditions. On the contrary, according to Schumpeter, technological innovation triggering the development phase is intrinsically unbalancing as it tends to concentrate in time and space. On the one hand the development of innovative technologies by some companies is followed by irregular processes of imitation, diffusion and adaptation, which in turn tend to generate waves of development that translate into a process of disharmonic and cyclical growth. This means that the changes fostered by innovation are such as to break the equilibrium, unbalance the existing structure of the economic system and give rise to phenomena of cyclical evolution. On the other hand, technological innovation tends to concentrate in some key sectors depending on their knowledge base and on the degree of development of the productive forces determined by the historical phase; this dynamics process generates structural asymmetries that result in different growth rates of sectors, leading to the expansion of certain industries to the detriment of others, which instead experience phases of decline.

In this context, economic growth is configured as a process of structural change that promotes emerging sectors that can meet new needs, while reducing the weight of mature sectors. This results in an unbalanced growth process, mainly due to the different rates of technological change experienced by the various industries. In other words, according to Schumpeter's approach, the birth of new industries – and the development by these of new products and production processes – represents a key factor which triggers growth paths, such that without the former there would not be the latter.

2.2 The Neoclassical approach

Neoclassical theory conceives the object of "economics" as the optimal allocation of scarce resources and is fundamentally grounded in a static competition framework in which market price adjustments steer the allocation of "production factors" towards the most remunerative investments. In standard neoclassical models, representative agents equipped with full information and rational expectations operate in complete markets with a selfishness attitude to maximize their well-behaved utility functions, while firms maximize profits perfectly substituting capital and labour according to their relative marginal productivity. This ensures the economic system to growth along an equilibrium path, characterized by full employment and full utilization of resources and thus guaranteeing the maximization of social welfare and the elimination of the so-called "extra profits". Exogenous supply-side (e.g. technological) "shocks" might give rise to business cycle of expansion and contraction of production as well as unemployment and under-utilization of productive capacity in the short run, while effective demand has no role except when various forms of market imperfections and market failures (such as price- and wage-stickiness, information asymmetries, coordination failures, Marshallian externalities arising out of localized knowledge spillovers, increasing returns to scale) occur (Colander, 2006).

According to this view, the government should intervene only to ensure the smooth functioning of the markets; whether market failures are detected or the unfolding of the development process gives rise to structural and power asymmetries among the different components or actors making up the economic system, the government should support the private sector through a variety of supply-side measures without distorting the market mechanism, since incentives must remain in line with the static comparative advantages determined by the relative abundance of production factors (i.e. the relative scarcity of natural resources, capital and skilled and unskilled labour) (Storm, 2015).

In this context, neoclassical theory of growth generally describes the evolution of economic systems as if their "proportions" remain constant over time. Therefore, it does not properly account for the structural change dynamics of the economies and its implications on the aggregate growth process. This is fundamentally due to the fact that in the neoclassical literature long-term dynamic relationships are generally dealt with by referring to the balanced growth category. Along the balanced growth path magnitudes grow at the same constant rate over time and the system does not therefore vary in its sectoral composition.

Notable exceptions are represented by Baumol (1967) and Kuznets (1971, 1973), who recognized the industry-specific character of technological change and the different income elasticities of demand among products as key factors to understand the evolution of the sectoral composition of the economies. Baumol (1967) developed a two-sector model characterized by different productivity growth rates of industries with the aim of explaining the employment growth in the service sector and the subsequent potential slowdown in the aggregate output growth. Assuming a low price elasticity of demand or an income elasticity of demand higher than one for the stagnant sector, the productivity differential between the two sectors involves a continuous increase in the share of employees in the sector with low productivity growth and a progressive decline in the aggregate growth rate.[2]

More recently, a number of Neoclassical scholars revised some standard assumptions of general equilibrium approach to growth theory to account for structural changes undergone by the economies. For example, Kongsamut, Rebelo and Xie (2001) proposed a three-sector model in which utility function with non-homothetic preferences is introduced to account for the reallocation of labour from agriculture to manufacturing and service industry. Foellmi and Zweimueller (2002) built a model in which consumption goods show different income elasticity of demand according to non-linear Engel curves; this leads to demand saturation and continuous structural changes which modify the

[2] Nonetheless, Baumol et al. (1985) recognized that some service sectors, e.g. telecommunication, computer programming and information activities, may experience rates of productivity growth as high as manufacturing industry, while Oulton (2001) demonstrated that Baumol (1967)'s results do not hold whether stagnant service sectors produce services as intermediate inputs for the manufacturing production process, as it often happens.

employment shares among sectors, while the endogenous introduction of product innovations (although presenting identical labor requirements) might lead to multiple equilibria. Ngai and Pissarides (2007) presented a multi-sector growth model in which industries produce with the same production function and the process of structural change is driven by their different rate of technological progress, assumed exogenous; in this context, as in Baumol (1967), employment is shifted from the sectors with the highest to the ones with the lowest technological progress, while the economy grows along a balanced growth path. Finally, Acemoglu and Guerrieri (2008) proposed a two-sector general equilibrium growth model according to which demand has no role and structural change is fundamentally conceived as technology-driven. Assuming certain conditions hold, capital deepening at the aggregate level increases the relative output in the more capital-intensive sector but at the same time triggers a reallocation of capital and labor away from that sector. In this way, they demonstrate that a nonbalanced pattern of economic growth at sectoral level is consistent with Kaldor's stylized facts at aggregate level.[3]

In general, neoclassical multi-sector growth models, although demonstrating that a changing sectoral composition of the economy is consistent with equilibrium growth paths, are affected by a fundamental lack of generality and fall short in presenting a realistic explanation of structural macro-dynamics of the economies, since the theoretical pillars of marginalist approach prevent integrating the role of demand and income distribution within a consistent framework which recognizes the path-dependent and radically uncertain nature of technological change.

2.3 The Post-Keynesian approach

Post-Keynesian economists argue that growth is fundamentally a demand-driven process and the rejection of the so-called Say's law is the main pillar on which the Post-Keynesian theoretical framework is built. According to this view, capital accumulation is essentially determined by effective demand in the goods market, which in turn has a strong connection with income distribution, expectations («animal spirits») of entrepreneurs, credit-financial conditions and international competitiveness (Keynes, 1936; Kalecki, 1971). More precisely, Post-Keynesian theory holds that demand dynamics crucially depends on the patterns of functional income distribution due to the different propensity of saving out of wage and profit income; in turn, a fast-paced economic growth fosters capital investments and affects employment and inflation dynamics, with major feedback effects on functional income distribution, giving rise to an unbalanced development path subject to periodic realization crisis. Consistently, Post-Keynesian economics stresses the relevance of wages and profits dynamics in determining the evolution of the main components of demand and is mainly focused on aggregate analyses concerning growth and distribution as well as monetary economics (Lavoie, 2006, 2014).[4]

Although Post-Keynesian scholars put particular effort in developing a theory of long term growth with Keynesian features, research on structural economic dynamics is not a core topic in the early

[3] It is worth mentioning the neoclassical literature on the so-called "new" growth theory and "new" trade theory, which sought to include Kaldorian and Schumpeterian features by developing formal models which endogenize technological change and allow for potential divergent patterns of development among countries and regions (Lucas, 1988; Romer, 1986, 1990; Krugman, 1991, 1998). Models such as the ones proposed by Aghion and Howitt (1992) and Grossman and Helpman (1991, 1994) draw from Schumpeterian theory to develop multi-sector growth models in which the economy produces both intermediate and final goods which change in terms of quantity and quality as consequence of innovative efforts, conducing to a higher total factor productivity at the aggregate level. Aghion and Howitt (1998) proposed a model of endogenous growth according to which the growth rate of the whole economy is triggered by a "creative destruction" mechanism driven by capital accumulation and technological spillover effects which, in turn, increase the overall productivity level. However, this model does not provide a proper explanation of structural change since the assumption of symmetry among sectors precludes changes in the sectoral composition of the economic system. For critical assessments of this kind of literature see, among the others, Cesaratto (1999, 2010), Fine (2000), Guarini (2011) and Setterfield (2013).

[4] Post-Keynesian theory of growth and distribution has developed several theoretical and empirical models starting from the three following model families: Classical / (Neo-) Keynesian models (Robinson, Kaldor, Pasinetti); Kaleckian models (Kalecki, Steindl) and Post-Kaleckian models (Bhaduri & Marglin, 1990; Kurz, 1990). See Lavoie (2014).

Keynesian theory: neither Keynes nor those belonging to his "circle" at Cambridge University (UK) have explicitly devoted major attention to the process of structural dynamics defined as a process of change in the proportions between the different components of the economic system (Pasinetti, 2007). Nonetheless, some of the contributions of the pioneers of Post-Keynesian economics have provided fundamental insights to the structural analysis. In this regard, Harrod (1939) was the first that, along Keynesian lines, faced the problem of the evolution of the economy in the long term. However, neoclassical features of Harrod's approach leads him to consider the problem of growth in conditions of equilibrium and full employment, under the assumption that the natural growth rate which ensures full employment is given exogenously by the growth rate of population and technical progress. Moreover, the dynamic analysis of Harrod is carried out exclusively in aggregate terms, so that it cannot account for changes in the structure of the economic system.

Joan Robinson

Joan Robinson (1956, 1962) directed her research towards the study of the long run economic growth through the employment of some theoretical tools that allow her to deal with the pervasive, radical uncertainty under which investment decisions are taken according to a Keynesian theoretical framework. First, she replaced the concept of "equilibrium" with the one of "tranquility": being very critical of neoclassical economics, Robinson was careful not to confuse the study of the growth paths with neoclassical equilibrium models and the concept of tranquility – which refers to an economic configuration whereby the expectations on all the relevant economic variables (price level, sales, costs, profits, etc.) are realized – is introduced by her in order to carry out an analysis of the growth in the long run without having to adopt a series of hypotheses that she considered extremely reductive and unrealistic, such as full employment and balanced growth at a uniform "natural" rate. Second (and complementary), Robinson introduced a sharp distinction between "historical time" and "logical time". The former is regarded as «crucial to the understanding of economics because it allows the organization of the flow of events from an irreversible past to an unknown future» (Pasinetti, 2005, p. 843); the latter is instead a central conceptual pillar of the neoclassical analytic method, which culminates in equilibrium analysis. In this regard, it is worth noting that the concept of "historical time" represents an analytic tool which allows to properly account for the path-dependent nature of long run growth patterns and non-ergodic character of the economic systems, while "logical time" «may often become a misleading concept precisely because human history is crucially far away from the idea or the analogy of an hydraulic system, that can be run forwards or backwards, indifferently» (*ivi*).[5]

In line with Kalecki, Robinson (1962)'s theory of growth moved substantially from a Marxian reproduction scheme to highlight the causal process that emerges from the relationships between accumulation rate, business expectations, expected profits and investments. This causal sequence is conceived as fundamentally intertwined with functional income distribution dynamics, resulting in different paths of growth (Kerr and Scazzieri, 2013). However, the analyses proposed by Robinson cannot be defined as properly addressing the investigation of structural economic dynamics, since the results she reached show the factors on which each state of tranquility is based in a particular historical moment, but not the explanation about the movement from one state of tranquility to another, resulting in an essentially static analysis (Pasinetti, 2007). Moreover, the progressive approaching to Kalecki's conception of economic dynamics definitely moved her away from the study of non-proportional growth processes and long-term dynamics.[6]

[5] A system is called "ergodic" (a concept drawn from physics) when, once the premises are known, the future is perfectly determined and therefore predictable; a "non-ergodic" system is open to unpredictable outcomes since the future is not predetermined at all (see Pasinetti, 2005, pp. 842, 843).

[6] Kalecki (1971) considered the long run as a series of short periods, while the economic development as a succession of cycles, guided by investment decisions, in which the institutional set-up of the economy represents a central element with respect to the dynamics of the system.

Nicholas Kaldor
The analysis of the historical developments Kaldor (1966, 1981, 1996) focused on led him to put the intersectoral dynamics at the center of his studies. According to his vision, the development process of the economies is characterized by path-dependent patterns of cumulative growth centered on the manufacturing sector. In this regard, Kaldor (1966, 1967) built a disaggregated model that envisage the division of the economic system into two sectors: the manufacturing sector, characterized by increasing returns to scale, and the agricultural sector, featured by decreasing returns to scale. The former was conceived by Kaldor as crucial for the development path of the economies, since it is featured by higher income elasticity of demand of its products (compared to goods produced by the agriculture sector) and both static (due to the scale of production) and dynamic (due to learning process, i.e. learning-by-doing) increasing returns to scale, whose spillovers to the other sectors accelerate the labour productivity pace of the whole economic system.

On the other hand, the role of demand (exports of manufactured products in particular) was regarded by him as the driver of economic growth, able to foster a deeper division of labour that, in turn – as already stressed by Smith (1776) –, grows with the very extension of the markets. In other words, Kaldor brought forward a «marriage of the Smith-Young doctrine on increasing returns with the Keynesian doctrine of effective demand» (Kaldor, 1972, p. 1251), resulting in the well-known Kaldor-Verdoorn's law, also known as Kaldor's second growth law (Kaldor, 1966; Verdoorn, 1949, Young, 1928). According to this causation mechanism, increases in demand foster embodied technical change and spur a higher labour productivity dynamics, triggering a circular and cumulative growth process as the one already described by Myrdal (1957).[7]

Furthermore, Kaldor (1989) stressed the diverging patterns of development that increasing returns to scale and endogenous technical change may entail, potentially resulting in phenomena of economic and industrial polarization among countries and regions (a topic that is all the more relevant nowadays in the European Union). In other words, Kaldor provided key insights about the economic consequences of cumulative causation mechanisms, demonstrating that an increasing gap in terms of growth rates may occur between regions that specialize in technologically more advanced productions (which face an increasing foreign demand) and laggard ones that result technologically backward.[8]

Paolo Leon
Another author in the Post-Keynesian tradition who addressed the long-run macro-dynamics of economic system is Paolo Leon. The fundamental contribution of this scholar in this field is represented by the book *Structural Change and Growth in Capitalism*, published in 1967. In this work, Leon focused on the long-term relationship between the accumulation of capital and technological progress, while accounting at the same time for the structural dynamics of consumption. In this framework the growth patterns of economies are driven by investments which embody technical change and increase labour productivity allowing in this way for higher real wages. On the demand side, continuous increases of per capita income drive the evolution of consumption patterns as result of Engel's law. The intertwining of these dynamic factors in historical time generates in the long run changes in the relative proportions of produced goods, being capital or consumption ones. The consumption dynamics thus triggers the production of some goods at a higher rate than others – notably, some of these become obsolete and cease to be produced while new variety of products enter into the market – leading to the emergence of a set of different profit rates. Leon argued that this differentiation of rates of profit, strictly interlinked with the changing composition of production,

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[7] See Argyrous (1996) for an evolutionary reading of Kaldor's theory of cumulative causation and a discussion concerning how properly reconcile it with Myrdal's institutionalist framework.

[8] The distinction between the technological and demand-related peculiarities of manufacturing sector compared to the agriculture sector has also been proposed by Kaldor on a global scale to explain the different growth path experienced by poor countries, in which the agricultural sector is predominant, and modern advanced economies, whose development is mainly based on manufacturing and service industries. See Kaldor (1967, 1989, 1996).

engenders or lays down the basis for monopolistic market forms which, in turn, contribute to maintain this differentiation.

Once that the above structural dynamics has been assessed, the issue at stake concerns the coordination mechanism which allows to generate effective demand flows – whose composition changes over time as consequence of the Engel's law – such as to meet the macroeconomic needs of the system; in other terms, effective demand patterns which allow the system to reproduce over time without generating realization crises. According to Leon, for this purpose both monopolistic market forms and technological progress were necessary. While the latter plays a pivotal role in allowing a continuous increase of real wages – which feed effective demand growth –, the former would allow an increase in the degree of self-awareness of the entrepreneurial class. In other words, insofar as the monopolistic class assumes a long-term point of view such that monopolies end up to rising to the role of regulators of the accumulation process, capitalistic economic system would be able to reproduce itself by adapting its evolution over time to its structural internal dynamics.

As it should be clear, this last aspect of Leon's exposition is crucial for warranting that the evolution of consumption and production structures being adequate for the dynamic reproduction of the economy, since builds on the hypothesis that monopolistic market forms «provide entrepreneurs with that foresight which permits them to know, more or less approximately, the effect of their actions on the economy as a whole» (Leon, 1967, p. 115). What is at stake is thus whether the establishment of monopolies is actually a sufficient condition for capitalists to assume that macroeconomic perspective which would allow the system to generate a demand flow adequate for its stable reproduction. Leon's most recent contributions seem to negatively answer to this question (see Leon, 1981). On the contrary, he pointed out that market agents, and capitalists in particular, «have no knowledge (or interest) of the effects of their [market] exchange on the other participants and therefore on the effective demand and the economy as a whole» (Leon, 2012, p. 10, my translation). In other terms, he maintained that capitalists can only have a "microeconomic vision" about their role and actions in the system, and this prevents the structural coordination the economic system needs for reproducing without crisis.

It follows that, according to Leon, capitalism is an intrinsically conflictual system, not only with regards to the relationships between social classes, but especially with regards to the existing contradictions between individual behaviors and their macroeconomic outcomes (Leon, 1981). Contrary to neoclassical economists, whose theoretical framework is grounded in micro-founded intertemporal equilibrium theory according to which the economic development process unfolds in the sequence "Equilibrium–Disequilibrium–Equilibrium", Leon (1967, 1981) drawn mainly from Keynes to propose a conception of economic growth as a process of structural change based on the sequence "Disequilibrium–Equilibrium–Disequilibrium"; in this sense, he put in evidence the structurally unstable nature of capitalistic system that will then be formally detected by Pasinetti.

Luigi L. Pasinetti

Pasinetti (1981, 1993) provided a theory of structural economic dynamics developing a formal model which merges the Keynesian principle of effective demand with Leontief's input-output approach (Leontief, 1941, 1966) within a Classical theoretical framework (see Sraffa, 1960). In his model, the two main forces which drive the long-term process of structural transformation of the economies are the changing composition of demand and the heterogeneous process of technical change experienced by industries. Both these factors are fundamentally shaped by human learning process which invests the production technologies as well as the consumption patterns.

In Pasinetti's model, the structure of production and consumption is described by two linear and homogenous systems of equations (expressed in matrix notation), i.e. the quantity system and the price system. The fundamental components of the systems are represented by the technical coefficients of labour and consumption, which outline the production technology used by each sector and the relative per capita consumption, respectively.[9]

[9] A simplified presentation of the model can be found in Pasinetti (2007, Part III).

Technological change is conceived as a general human learning activity on the production side which mainly results in the introduction of process innovations. The pace of technical progress is represented by an exogenous non-uniform process of reduction of the technical labour coefficients of sectors, fundamentally driven by the different growth rates of labour productivity experienced by sectors over time. Labour productivity improvements support the growth of real per capita income which, in turn, triggers learning effects on the demand side: indeed, Pasinetti places at the center of its long-term analysis of the dynamics of demand the evolution of consumption as dictated by the Engel's law, according to which the changing composition of demand is essentially governed by the increase in income.[10]

More specifically, the growth in per capita income changes over time the sectors' coefficients of consumption and thus the composition of the consumption structure; changes in the level and composition of demand then trigger a process of structural change in the productive structure of the economy. In this sense, in Pasinetti's theoretical framework the technological change on the supply side – although considered as an exogenous "natural" force that shapes the labor productivity dynamics of industries – and the changing patterns of consumption on the demand side are two sides of the same coin. The resulting structural economic dynamics – namely the different growth rates experienced by the sectors and the employment dynamics of the economy – is therefore the product of the interaction of the unbalanced growth patterns of technical progress and the changing structure of demand.

The necessary condition for the two systems to provide meaningful solutions is the same for both and is substantiated in what Pasinetti defines the "fundamental macroeconomic condition". When this macroeconomic condition holds, the model assures at once full employment and price stability.[11] It should be noted that this condition emerges not from the simple aggregation of the sectors composing the economy, but from the simultaneous combination at any moment of time of the non-uniform demand and productivity dynamics of sectors, where interdependence is generated by the endogenous dynamics of demand. This reveals the truly macro-economic nature of the fundamental condition and highlights that the model incorporates the Keynesian principle of effective demand.[12]

It is worth noting that there is no automatic (i.e. endogenous) adjustment between these two opposite tendencies, so that nothing entails an automatic and even less definitive and systematic satisfaction of the fundamental macroeconomic condition. In other words, the evolution of the economic system does not ensure the conditions necessary to avoid involuntary unemployment and massive waste of resources. It follows that the model provides a coherent and fully-dynamic

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[10] Note that the structural dynamics of demand, i.e. the evolution of consumption coefficients, is endogenous since it crucially depends on income (via Engel's law), which grows over time as consequence of the technological progress. In particular, the incorporation of Engel's law in Pasinetti's model implies that, as income increases, consumers do not increase the demand for goods proportionately, but change the composition of consumption due to a changing hierarchy of needs and demand-side learning processes.

[11] More precisely, the fundamental macroeconomic condition ensures that effective demand is equal to the full employment output while prices are such that fully cover production costs, without generating inflationary or deflationary pressures. For this purpose, the determinant of the two matrices (i.e. of the quantity and price system) must be equal to zero. If the macroeconomic condition is less than fulfilled, unemployment situations are combined with a reduction in prices (deflation). If the macroeconomic condition is more than fulfilled, this indicates production constraints on the production side and related inflationary phenomena.

[12] It means that prices and wages are relevant in their macroeconomic function with respect to aggregate purchasing power rather than as instruments for the efficient reallocation of resources. For example, if productivity increases tend to always occur in the same sectors, demand will be significantly responding to price signals, reaching the saturation threshold more quickly. The achievement of a level of demand saturation for a given sector's products is all the more probable as technological progress continuously leads to price reductions in that sector. It follows that demand does not respond to changes in prices only, but it is partly independent from them. In other words, demand does not necessarily increase in sectors where the greatest increases in productivity occur (i.e. in sectors whose products' prices are relatively lower), nor does it necessarily reduce where relative prices rise as result of a negative productivity differential. The continuous change in the composition of aggregate demand and the non-uniform technological progress between sectors thus generates a non-proportional growth process that makes the study about the dynamics of disequilibrium particularly relevant, to the detriment of the models that identify paths of balanced growth.

representation of the structural instability of the economy – accounting for the process of human learning and the crucial role played by effective demand dynamics – far from any balanced growth path.[13]

Richard Goodwin

Although Richard Goodwin cannot be labeled under the heading of "Post-Keynesian", his belonging to the Cambridge tradition induces us to briefly discuss here his own contribution.[14] Goodwin (1983, 1987), together with Pasinetti (1981), was the first to direct his research towards the analysis of structural economic dynamics. Building mainly on Marx and Schumpeter (of whom Goodwin had been a student at Harvard University), Goodwin identified the instability of the economic system as the main problem of economic development, so that «the relationship between the constraints (and opportunities) of sectoral interdependencies and the unevenness of technical change across productive sectors is central to his attempt to outline a general explanation of the long-run structural dynamics of a capitalist economy» (Kerr and Scazzieri, 2013, p. 274).

The Schumpeterian background of Goodwin led him to focus – rather than on the analytical configuration of the economic structure – on the analytical representation of the dynamic process and therefore on the time-varying factors that influence its trend. For this purpose, he adopted a multi-sector approach to investigate the role that the various components of the economic system play in determining the fluctuations of the aggregated variables of the system, proposing a disaggregated model composed of *n* sectors producing *n* homogeneous goods (Goodwin, 1987).[15] His studies are thus part of the tradition of research on structural business cycles: according to his view, the study of the cycle and therefore of the dynamics is *per se* essential to carry out an adequate investigation of the historical evolution of economic structure (see also Goodwin and Landesmann, 1996).

Goodwin (1989) regarded the introduction of major technological innovations – able to stimulate productivity and therefore investments in those sectors in which they are first exploited – as not dictated by the unfolding of the economic process only, but as result of a wider evolution of science over time. It follows that in his vision an analytical representation of historical and social processes cannot but be fundamental to the investigation of long-term dynamics. More precisely, he argued that to deepen the analysis about the width of business cycles the investigation regarding the different

[13] In a more recent contribution, Pasinetti (2007) brought forward an analytical-methodological tool, preparatory to the analysis of the structural economic dynamics, which he calls the "separation theorem". Through such a theorem he proposes to distinguish «those investigations that concern the foundational bases of economic relations to be detected at a strictly essential level of basic economic analysis – from those investigations that must be carried out at the level of the actual economic institutions, which at any time any economic system is landed with» (Pasinetti, 2007, p. 275). In other terms, the distinction proposed is between the pre-institutional (that Pasinetti calls "natural") and the institutional level of investigation. The former would be exclusive domain of the economists and allows the identification of the structural conditions – defined in terms of labour and consumption coefficients – necessary for achieving a full employment growth path. The latter concerns the individual and social behavioral relationships which account for the effective functioning of real economic systems according to a specific institutional context, and hence the study of policies suitable for the dynamic realization of the fundamental macroeconomic condition (and thus of full employment). In this context, the "natural" stage of investigation has a normative character, as it helps to understand the institutions whose introduction should be encouraged, rather than hindered, as well as those which – having become obsolete with respect to the historical evolution of structural dynamics – should be radically changed or abolished. Finally, it should be stressed that, contrary to the Classical economists for whom the capitalist system was regarded as "natural", for Pasinetti such a term has to be understood in the sense of "fundamental" or "permanent", since in his analysis the natural economic system is independent from any historical-institutional configuration and therefore also from the capitalist one (from this point of view, Pasinetti's theoretical conception deviates from the one of Paolo Leon and Richard Goodwin, whose structural analyses refer to a specific institutional setting, namely the capitalistic mode of production).

[14] See Pasinetti (2007, Part II).

[15] It is worth noting that the different sectors of the economy are identified by Goodwin and Pasinetti according to different criteria. Goodwin distinguished sectors on the basis of their dynamics, so that sectors which share the same current or potential growth rate over time are represented as being part of a single aggregate sector; Pasinetti (1981), on the other hand, Pasinetti identified the different sectors on the basis of what they produce.

timing and patterns with which innovations pervade progressively each sector must be connected to the behavioral norms and institutional structures that have "embraced" those great innovations.

From this perspective, Goodwin (1989) identified two main factors on which the long-term dynamics of a capitalist economy is grafted: on the one hand a long run fundamental tendency of the system, on the other the modalities with which capitalism "reacts" to the technological upheavals that it generates in a medium-term time horizon. These two forces operate simultaneously: on the one side the evolution of production techniques and the interdependencies that this creates among the sectors induce long-term trends that take place independently from the fluctuations of the system in the short and medium term; on the other side, it is the pattern of medium-term reaction of the system to the technological shocks that allows to identify the level of penetration and diffusion among sectors of those technological innovations at a certain point of time. In other terms, major technical improvements or major innovative investments – whose nature greatly influences the intensity according to which a dynamic and pervasive process will be generated – trigger clusters of similar investments which foster demand and output growth while stimulate an uneven and sequential process of diffusion of the new technologies among sectors. In this context, as underlined by Kerr and Scazzieri (2013), the historically-determined institutional set up of the economic system plays a crucial role in shaping the timing and paths of the generated non-uniform structural process of change, which results in short- and medium-run fluctuations of the economy along a smoother technological development of the whole system.

2.4 The Neo-Schumpeterian approach

Neo-Schumpeterian scholars address the problem of long-run structural transformation of the economic and institutional environment with a special attention to the characteristics, role and consequences of technological change.[16] The authors belonging to this stream of research adopted population dynamics – mainly borrowed from biology – as conceptual tool to deal with the evolutionary character of economic development (Nelson and Winter, 1982). The latter is not conceived in terms of equilibrium patterns of balanced growth, but as an open-ended process subject to historical contingencies and fundamentally characterized by the radically uncertain, cumulative and irreversible nature of technological change (Dosi, 1988; Dosi and Nelson, 2010; Nelson, 1995). As Metcalfe (1995, p. 29) has written, «there is nothing further from the evolutionary argument than the belief that technological progress can be understood as if it were an aggregate process of balanced growth».

Neo-Schumpeterian theory fundamentally builds on the Schumpeterian concept of «creative destruction» (Schumpeter, 1934, 1939), according to which capitalism is an evolutionary process of continuous innovation, whose dynamics triggers major changes in productive techniques, organizational patterns and structure of the markets. According to this Marxian conception of capitalist competition, the fundamental driver of growth in capitalist economies is not static but dynamic competition, i.e. the introduction of radical innovations which spur technological change and allow the profit-seeking innovator to greatly overcome competitors and gain (temporary) monopoly profits. This conception shed light on the role of "rent" in capitalist economies, no longer conceived as deadweight welfare loss but as the economic outcome of dynamic competition, which turns out to be the real engine of technological progress aimed at capital accumulation.

According to an evolutionary theoretical framework, technology is thus as a rent-seeking collective process of research and learning, i.e. of knowledge generation, where the key role of past experiences is due to the cumulative character related to the acquisition of problem-solving capabilities. In this sense, the diffusion of the innovations in the economic system is not conceived as

[16] The emphasis put on the innovation dynamics led this stream of research to strongly reject the neoclassical microeconomic assumptions regarding the "representative agent" following a perfectly rational behavior; on the contrary, they model the economy as a collection of heterogenous agents – equipped with "bounded rationality" (Simon, 1955) – which follow path-dependent behavioral rules and routines to reach satisfying goals (the so-called satisficing behavior) (Nelson and Winter, 1982).

a process of linear and passive adoption of new technologies as long as several constraints and drawbacks related to technological indivisibilities and lock-in mechanisms have to be overcome through incremental improvements and adaptation procedures (Nelson and Winter, 1982; Dosi, 1984; Freeman and Louca, 2001).[17]

The occurrence of disruptive innovations might give rise to new emerging technological paradigms (or "techno-economic paradigms"), consisting in novel specific patterns of solution to selected techno-economic problems that shape the rate and direction of further incremental technological change and create the conditions for long waves of development (Dosi, 1982, 1988). Nonetheless, a "mismatch" between the emerging technological paradigm and the socio-institutional system is likely to rise, asking for major institutional changes to govern their coevolution (Freeman, Clark and Soete, 1982; Freeman and Louca, 2001; Perez, 1983). The rate and direction of technological change is the fundamental driver of this historical process of paradigm shifts, which relies on the continuous creation of variety and the subsequent selection mechanisms – due to the economic and institutional environment in which technological novelties are inserted – which tends to reduce it (Dosi et al., 1990; Metcalfe, 1995).

It follows that, from an evolutionary point of view, the development patterns of the economies are strictly connected with major processes of structural change which continually transform the qualitative composition of production as well as the consumers' preferences, progressively saturating some consumption needs while creating new ones. The unfolding of this process radically changes the share of sectors in output and employment, leading to the fast grow of industries able to introduce major technological innovation (allowing them to gain major productivity increases and attract a growing demand) and the decline of the ones which rely on old technological content.

Moving from an evolutionary perspective, Metcalfe (1994, 1998) builds a model which embeds a replicator dynamics mechanism according to which firms with below-average unit costs gain an increasing market share while firms producing with higher unit costs see their market shares progressively reduced. In Metcalfe (1999), technological progress is expressed in terms of sectoral and aggregate productivity growth rate and is made endogenous by selection processes, fostered by intra- and inter-sectoral competition, and sorting processes; the latter is triggered by income elasticities of demand and increasing returns differentiated among sectors.

Metcalfe, Foster and Ramlogan (2006) provide an evolutionary theory of "adaptive growth" conceived as a result of an endogenous process of structural change in which dynamic increasing returns play a key role. They build a model able to explain the macroeconomic productivity growth on the basis of different income elasticities of demand as well as heterogeneous technical progress functions of industries, while the coordination among the different productivity and employment patterns of sectors is reached through the market coordination of demand and production capacity.

Montobbio (2002) proposes a model in which the process of structural change among industries is driven by the technological heterogeneity of firms, while the macroeconomic growth rate is given and unit costs at firm level are constant (meaning that technological change is absent). Two mechanisms are at work: on the demand-side, a sorting mechanism based on industries' income elasticities of demand; on the supply-side, a selection mechanism based on the average unit costs of firms of a given industry with respect to the average unit costs of the whole economy. Long-run productivity growth thus crucially depends on the generation of variety at firm level.

Saviotti and Pyka (2004) propose a model of endogenous qualitative development of the economic system according to which a process of demand saturation of the mature sectors and creation of new industries as result of radical innovations interact promoting structural change and economic growth. Larger technological opportunities spur the process of qualitative transformation of the economy, although demand has substantially no role. Saviotti and Pyka (2013a) investigate the role of innovation and structural change on long-run development (from the industrial revolution to

[17] For a comprehensive overview of the evolutionary literature on innovation procedures and related mechanisms of imitation, adoption and diffusion, see Fagerberg et al. (2005).

nowadays), focusing on increasing productive efficiency, increasing output variety, and increasing output quality and differentiation. The latter require higher education levels and higher wages, which in turn raise consumers' income. The dynamic interaction of these factors together with the emergence of new sectors results in higher disposable income which allows consumers to buy the new products generated by innovation (see also Saviotti and Pyka, 2013b). Saviotti and Pyka (2017) draw from Pasinetti's structural change theory to improve the exploration of the interactions between income distribution dynamics, the evolution of demand patterns and the process of differentiation of economic system. The role of income distribution is introduced distinguishing two social classes within the population presenting different level and quality of education and thus different wages. They conclude that innovation alone is not able to account for economic development, since the latter comes out from the co-evolution between the former and demand dynamics. In this regard, a crucial role in determining the qualitative character of growth paths is played by the shape of the Engel curves, which depend on the interaction between demand and a number of other features of the socio-economic system (see also Saviotti et al., 2016).

Overall, Neo-Schumpeterian theory puts major emphasis on the supply-side determinants of structural change, stressing the learning process, uncertain and path-dependent nature of innovation and the different technological advances it triggers. From this theoretical point of view, technological change represents the key driver of economic development – closely linked to the unbalanced process of structural transformation of the economies.

3. Combining structural change and evolutionary perspectives

Although there are considerable differences among the theoretical approaches reviewed in the previous section, we argue that a step ahead in the analysis of structural change might come from the combination of a Post-Keynesian approach to structural economic dynamics (Pasinetti, 1981, 1993) with a Neo-Schumpeterian approach to technological change (Fagerberg, 2003, 2005; Nelson and Winter, 1982; Verspagen, 2005).[18] Nonetheless, we hold that a modern investigation on structural dynamics cannot disregard the role of globalization in shaping the competitiveness strategies and development trajectories of industries and countries.

In this context, our contribution aims to propose an integrated analysis that combines Post-Keynesian and Neo-Schumpeterian insights, accounting at the same time for the process of global fragmentation of production fostered by the offshoring strategies pursued by firms belonging to different industries. This perspective leads us to jointly consider technological change, demand dynamics and global restructuring through production offshoring as the driving forces of structural change, where the latter is conceived as the dynamic process resulting from the uneven growth patterns of industries.[19]

We hold that our approach is consistent with the principle of "relative structural invariance" proposed by Landesmann and Scazzieri (1990, 1996). Effectively, such principle represents an analytical tool able to provide a unifying framework for investigating the structural economic dynamics of economic systems. In particular, this conceptual device stresses that economic systems work out in historical time according to the non-proportional evolution of its different components. In other words, the long-run transformation of economic systems is featured by a "relative inertia", according to which its components (or "sub-systems") do not change at the same time and at the same

[18] Scazzieri (2018) provides a thorough theoretical analysis concerning the structural and evolutionary approach and discusses potential prospects of integration of the two.

[19] A recent stream of research has tried to build bridges between Schumpeterian and Keynesian economic theory constructing agent-based models which simultaneously account for the role of technological innovation (conceived as the "engine" of economic development), income distribution dynamics and mechanisms of demand generation in shaping the process of structural change of the economies. See, among the others, Ciarli et al. (2010), Dosi et al. (2010), Lorentz et al. (2015), Ciarli and Valente (2016), Caiani et al. (2018). From a theoretical point of view, the evolutionary simulation model developed by Verspagen (2002) might be considered a forerunner of this kind of models. See also Lucchese (2011).

speed because of path-dependent constraints. It follows that «the resulting pattern of structural change is the outcome of interaction between fixed or slowly changing components (…) and components (…) that are changing at a higher speed» (Scazzieri, 2009, p. 551), so that the aggregate magnitudes experience processes of change according to different timing (see also Hagemann et al., 2003). In other terms, the principle of relative structural invariance allows to focus on the internal motion of the aggregate and «to investigate the role of structural change for the dynamics of the overall economic system» (Landesmann, 2018, p. 709). This is fully consistent with our framework, since we conceive structural change as the dynamic outcome of an uneven process of structural transformation of the economies which manifests itself in the continuous change of production composition.

Furthermore, and most important for our goals, this approach permits to deepen the analysis of the "forces of change" – representing «variables (such as technical progress and demographic changes) that impact an economic system in a continuous manner (although often with varying strengths) over a longer period» (Landesmann, 2018, p. 706 n.1) – which shape the structural evolution of the economies. Consistently, the analytical perspective that we propose focus on the industry level as the most proper level of investigation to deepen the structural changes undergone by the economies, while detects technological change, demand dynamics and international fragmentation of production as crucial 'forces of change' which mold the long-term structural change process of the economies.

In the rest of this section we present the reasons which induced us to set up the analysis focusing on the industry level and discuss in detail the three building blocks that, in the proposed framework, are put at the center of the investigation of the structural economic dynamics.

An industry-level analysis

We have chosen to focus the analysis on the industry level as it allows to properly investigate the changing composition of the economies, permitting to account for both the demand- and supply-side factors which shape the process of structural change.

As regards the demand-side, industry-level analyses allow to consider the demand constraint (understood as a limit to production growth), since demand that an industry faces has a downward slope and consists in the part of the aggregate demand directed to the products of that industry. In other terms, in the absence of a simultaneous expansion of demand, the growth of industries is constrained and this gives the possibility to assess the role of industry-specific demand structure and its relationship with production growth.[20]

As regards the supply-side, whether firm-level studies account for high degrees of heterogeneity (Bogliacino, 2014; Bogliacino et al., 2017; Guarascio and Tamagni, 2016), industry-level analyses show the dynamics of industries highlighting changes in the structure of the economies and allowing to link those changes to the macroeconomic performances. Furthermore, whether increasing vertical disintegration of firms and their disparate positions along value chains risk to exacerbate heterogeneity, an industry-level approach permits to conduct a more integrated investigation of structural transformations related to production organization.

Nevertheless, industry-level analysis allows to properly account for the wide Neo-Schumpeterian literature on sectoral systems of innovation, which stressed that the innovative behaviour of firms is fundamentally affected by the technological regime of the industry they belong to (Malerba, 2002, 2004a, 2004b). More precisely, technological regimes – defined in terms of appropriability of innovations, cumulativeness of technological advances, technological opportunities and knowledge nature of firms' innovative efforts – shape the trajectories of innovation and thus determine the

[20] It follows that, in the absence of a simultaneous expansion of demand, the relationship between innovation and demand is harder to be identified at industrial-level rather than at firm-level. Indeed, demand is not constraint for the individual firms, since "business stealing" allows firm to gain increasing market share and grow at the expense of competitors (it faces a perfectly elastic demand curve).

structure of the markets as well as the rate and direction of technological change of industries (Breschi et al., 2000; Malerba, 2006; Malerba and Orsenigo, 1997).

Consistently with this framework, evolutionary approaches developed meaningful classification of industries, framing them within a limited number of classes according to the technological paradigm they share (Dosi, 1982, 1988). Such a framework led to the construction of taxonomies of industries, identified on the basis of their common technological trajectories, competitiveness patterns and economic performance. In this regard, Pavitt (1984) focused on the structure of the markets and on the nature, sources and appropriability of innovation to conceptualize the existence of four different technology-based classes, according to which classify manufacturing industries. Bogliacino and Pianta (2010, 2016) investigated the relationships between innovation patterns and economic performance of service industries and provided a Revised Pavitt Taxonomy which extends the original Pavitt classification to the latter sectors. We hold that these classifications may result very useful for the analysis of structural change, since they provide the possibility to reduce the heterogeneity and, focusing on the growth patterns of industries belonging to different technological classes, shed light on the overall process of structural change of the economies.[21]

The role of technological change

Schumpeter (1934) identified different kinds of innovation that can foster a potential variety of technological and economic performances of firms and industries. We take up this insight moving beyond the notion of an undifferentiated technological change – usually proxied by R&D expenditure or patents – and introduce a key distinction between product and process innovation, meant as the outcomes of different innovative strategies, i.e. a technology-driven and a cost-based competitiveness strategy, respectively (Pianta, 2001). The former is associated with the search for quality improvements, high internal innovative efforts and a propensity to innovate for opening new markets consistently with the evolution of demand. The latter focuses on high machinery expenditures, with a propensity to acquire new technologies from suppliers, augment the mechanization degree of production processes, introduce labour-saving technologies and search for increased flexibility.

Whether these competitiveness strategies may coexist at firm level, such a distinction results insightful when applied in industry-level studies, since allows to identify the dominant strategy followed by the sectors. Industries whose firms show the highest propensity to introduce product innovations are those expected to get the greatest growth potential since should be characterized by strong innovative efforts which favor employees' cumulative knowledge and result in high-value added productions that permit them to continuously intercept demand flows (whose composition changes over time). On the other side, industries whose firms tend to pursue mainly a cost competitiveness strategy put major effort to introduce new production techniques – aimed at reducing costs and fostering industrial restructuring processes – having efficiency increases and price reductions as main results.

Overall, although providing a rather stylized picture of the potential competitiveness strategies pursued by firms, we argue that the distinction between the relatively higher propensity of industries to search for quality improvements or cost efficiency allows to shed light on the asymmetric technological opportunities they face. Effectively, such distinction has proved to be a powerful tool to investigate the performances of firms and industries in terms of output, employment and productivity growth over time (Bogliacino and Pianta, 2011; Bogliacino et al., 2017; Cirillo, 2017; Crespi and Pianta, 2007, 2008a, 2008b; for a review on the different impact of innovation on employment dynamics see Pianta, 2005; Vivarelli, 2014).

The dynamics of demand

According to an evolutionary approach, technological change is conceived as the main driver of structural change. However, Neo-Schumpeterian scholars often neglects the key role played by

[21] A detailed description of the Revised Pavitt classes according to which we classify sectors is provided in the final Appendix on the SID database.

demand as driver of long-run growth. In other words, the great attention devoted to the supply-side factors usually leads evolutionary scholars to underestimate the complementary role of demand in "pulling" economic growth, while shaping at the same time the structural change dynamics of the economies.

Whether it is trivial that a higher growth rate of demand leads to higher output growth rates, it is worth stressing that industries are characterized by specific demand structures. Within the Keynesian tradition, Kaldor (1978) emphasized exports as the most dynamic component of demand, able to trigger increasing returns to scale and growing rate of output growth. Most important, he stressed that the dynamics of exports is not a matter of price, but mainly depends on the technological features of production and thus on the quality of products (see also Fagerberg, 1988, 1996). Starting from the insights provided by Kaldorian and Neo-Schumpeterian literature on the relationships among technology, international competitiveness and growth dynamics of sectors (Guarascio and Pianta, 2016; Guarascio et al., 2016), we unpack the demand that is addressed to a given industry in two main components, i.e. domestic final demand and exports. This allows to assess the relative importance of domestic and foreign markets for the growth performance of industries characterized by different technological regimes and competitiveness strategies.

The role of offshoring

Modern analyses of structural change dynamics cannot disregard the prominent role played by the growing process of international fragmentation of production (Feenstra, 1998; Hummels et al., 2001). Since the Eighties an increasing integration of production systems – boosted by trade liberalization policies together with a collapse of transport and communication costs – led to an intensification of trade flows of intermediate inputs (Feenstra and Hanson, 1996). Firms started to strategically localize specific stages of production abroad with the aim of reducing labour costs, taking advantage of international technological spillovers and finding new sources of intermediate goods supply (Grossman and Rossi-Hansberg, 2008; Malerba et al., 2013; Pöschl et al., 2016; Tajoli and Felice, 2018; Timmer et al., 2014). On the one hand, the linkages due to the growing foreign acquisition of intermediate inputs by firms, namely offshoring practices, gave rise to transnational supply chains marked by power and technological asymmetries and fundamentally shaped by the institutional framework they are embedded in (Milberg and Winkler, 2013). On the other hand, the technological regime and competitive environment of industries in which firms operate and the hierarchical positioning of the firm, industry and even country along global value chains influences the impact that offshoring strategies have on the overall process of structural change.

We thus include the internationalization of production among the factors which might show a connection with the growth performance of industries. For this purpose, we use different offshoring indicators developed by Feenstra and Hanson (1996, 1999), distinguishing between domestically produced and foreign imported intermediate inputs. Nonetheless, we argue that technological capabilities of industries represent a crucial component defining their positioning in modern global value chains. Hence, we also distinguish between high- and low-tech offshoring according to the knowledge base foreign industries which source the intermediate inputs (Guarascio et al., 2015). This enables us to describe the relationships between the growth rate of industries and the low- and high-tech offshoring strategies they pursue.

On the one hand, high-tech offshoring might be a symptom of a more technology-oriented competitive strategy, entailing a general knowledge-based upgrading of firms' productive system and showing a positive relationship with industries' growth rate (Guarascio et al., 2015); offshoring-intensive industries might reduce their products' prices through the acquisition of cheap foreign intermediate inputs, allowing them to gain a competitive advantage which could be associate with higher growth rate; the localization of productive units abroad may give indirect access to foreign final markets, conducing to an increase in sales; the involvement in global production clusters might allow firms taking advantage of international technological spillovers which foster skill and organizational upgrading and dynamics returns to scale (Campa and Goldberg, 1997; Colantone and

Crinò, 2014; Pöschl et al., 2016; Tajoli and Felice, 2018; Stollinger, 2017). On the other side, a growing share of intermediate inputs acquired from abroad might be the result of major processes of production externalization that can lead to a contraction of the industry with consequent job losses (Bramucci et al., 2017; Stollinger 2016); moreover, industries which pursue intensively low-tech offshoring strategies might be less stimulated in introducing innovations and technological upgrading, leading to phenomena of technological lock-in (industries stuck in low-value added productions) and market shares reductions.

4. Data: the Sectoral Innovation Database

The challenge of turning the approach proposed in the previous section into an empirical analysis required major efforts in building up a database able to account for the factors linked to the process of structural change and for the several sources of heterogeneity which shape the structural economic dynamics of the economies. In this section we thus present a general overview of the Sectoral Innovation Database that we exploit to perform our empirical analysis.

4.1. The SID

The Sectoral Innovation Database (SID) has been developed at the University of Urbino (Pianta et al., 2018) and merges five different sources of industry-level data coming from various publicly available international datasets.[22]

The database includes industry-level data for six major European countries – France (FR), Germany (DE), Italy (IT), the Netherlands (NL), Spain (ES) and the United Kingdom (UK) –, which represent a very large part of the European economy (75% of the entire EU28's GDP). The time span covered by the dataset is 1994-2014.

Data are available for the two-digit NACE Rev. 1 classification for 21 manufacturing and 17 service sectors, listed in the final Appendix on the SID database. To fulfill the requisite conditions for comparability, all the data from 2008 onwards have been converted into NACE Rev. 1 using the conversion matrix provided by Perani and Cirillo (2015).

Notably, all data refer to total activities of industries, while all the monetary variables are in euros and constant prices (base year 2000).

4.2 Data for structural analysis: the variables

Innovation variables

Data concerning the innovative efforts of industries represent the core of the SID database, since the wealth of information that it provides allows to account for several dimensions of technological change. On the one hand, it permits to distinguish between product and process innovation, assessing the dominant competitiveness strategies pursue by different industries. On the other hand, it allows to distinguish between the "input" and "output" of innovative efforts; in other words, our database enables to introduce a distinction between the innovative efforts pursued by industries with the aim of introducing innovations (e.g. R&D expenditure per employee) and the outcome of innovative procedures (e.g. share of turnover due to new or improved products at industry-level).

All data concerning the innovation variables are drawn from the following five European Community Innovation Surveys (CIS) collected by Eurostat: CIS 2 (1994-1996), CIS 3 (1998-2000), CIS 4 (2002-2004), CIS 7 (2008-2010) and CIS 9 (2012-2014). As shown below, the latter five survey waves are therefore matched with economic, productive structure and labour market data at industrial level.[23]

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[22] Further information on the database are provided in the final Appendix on the SID database.

[23] We do not use ANBERD or EU KLEMS as data source for innovation variables because they do not encompass any kind of data concerning embodied technical change (contrary to data from the CIS waves, which include data on expenditure in machinery and equipment) and we do not want to 'mix' different sources of data for building up the

Economic variables
The SID database includes a series of variables related to the economic performance of industries, such as gross output, value added, labour productivity and employment at industry-level. Data are drawn from the Structural Analysis Database (STAN) provided by the OECD and from the Socio Economic Accounts (SEA) released by the World Input-Output Database (WIOD).

Distributive variables
Concerning the distributive dynamics of sectors, the SID includes data on the growth pattern of wages (both per employee and per worked hour) and profits, where the latter is computer as gross operating surplus at industry level. Data are drawn from the Structural Analysis Database (STAN) provided by the OECD and from the Socio Economic Accounts (SEA) released by the World Input-Output Database (WIOD).

Demand variables
We exploited the World Input-Output Tables (WIOT) provided by the World Input-Output Database (WIOD) (Timmer et al., 2015, 2016) to compute industry-specific flows of domestic final demand and exports for each country included in the database. The former has been computed in the following way: for each industry of a given country we computed the sum of four sources of final demand coming from that country, namely final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households (NPISH), final consumption expenditure by government and gross fixed capital formation. As regards exports, for each industry of a given country we computed the sum of both intermediate and final flows of goods (expressed in monetary terms) produced by that industry and directed abroad, i.e. bought by any other industry of any other country in the world.

Offshoring variables
The need to deal with the emerging features of globalization of production leads us to exploit the World Input-Output Tables (WIOT) provided by WIOD (Timmer et al., 2015, 2016) to construct offshoring variables. In this way the SID database is able to properly accounts for the increasing role of international trade of intermediate inputs among industries (Yamano and Ahmad, 2006).

The offshoring indicators that we built measuring global production fragmentation are computed as the ratio between the sum of the expenditure devoted by each industry to the acquisition of different types of inputs over the expenditure for the total (domestically produced and foreign) intermediate inputs devoted by each user sector (Feenstra and Hanson, 1996).

We use the "narrow" indicator of international offshoring proposed by Feenstra and Hanson (1999), which is computed as the ratio between the expenditure of a given industry for the intermediate inputs imported from foreign industries of the same type (corresponding to the diagonal terms of the import-use matrix) and the expenditure for the total intermediate inputs used by that industry.[24]

Furthermore, we relate the international fragmentation of production with its technological dimension, arguing that the kind of technology embedded in imported intermediate inputs is crucial for determining the position that industries occupy along global value chains and thus to investigate the relationship between the technological orientation of industries' offshoring strategies and their economic performance (Guarascio et al. 2015).[25] Accounting explicitly for this technological distinction, we can write the formal expression of our high-tech and low-tech offshoring indicator as follows:

innovation variables. Nonetheless, the conversion from CIS firm-level data into industry-level data is performed so as to ensure consistency with other industry-level indicators in the dataset (Bogliacino and Pianta, 2013a).

[24] It is worth noting that Feenstra and Hanson (1999) stress the reliability of narrow offshoring indicator since it is conceived to capture better the definition of production fragmentation, an event which mostly occurs within industries.

[25] A table presenting the correlation matrix of offshoring indicators' variations is reported in the final Appendix on the SID database.

$$OFFSH_{i,j,t}^{k} = \frac{Imported\ intermediate\ inputs_{i,j,t}^{k}}{Total\ intermediate\ \ inputs_{i,j,t}}$$

$$k \in \{HT\ foreign\ industries; LT\ foreign\ industries\}$$

The subscript i stands for the industry, j for country and t for time, whilst "HT" and "LT" stand respectively for high- and low-tech industries distinguished according to the Pavitt's taxonomy as revised by Bogliacino and Pianta (2010, 2016). More precisely, we follow Guarascio et al. (2015)'s revision of Feenstra and Hanson (1996)'s offshoring indicator discriminating intermediate inputs according to their origin (domestic or imported) and their technological content. With regard to this second aspect, the criterion adopted has been the following: Science based or Specialized suppliers industries are classified as high-tech industries (HT) and the imported intermediate inputs coming from these industries represent the numerator of the high-tech offshoring indicator, while Scale and information intensive industries are classified as low-tech industries (LT) and the imported intermediate inputs coming from these industries represent the numerator of the low-tech offshoring indicator (a detailed description of the Revised Pavitt Taxonomy is presented in the final Appendix on the SID database).[26]

Labour market variables

The SID provides information on the labour market dynamics of industries including a set of indicators which capture the design of labour market institutions, their evolution over time as well as task-related occupational trends.

Exploiting the ICTWSS database (Visser, 2016) we built an industry-level indicator of union density to assess the role of trade unions, conceived as key actors which are expected to shape the distributive dynamics of sectors. Furthermore, the SID accounts for the broad process of flexibilization of labour markets occurred in the last three decades; in this regard, it includes an industry-level measure of workers "precariousness" – i.e. the share of workers who have a part time job and/or a fixed term employment contract at sectoral level –, that we built on data from the Labour Force Survey (LFS) provided by Eurostat. Finally, the SID includes data on the occupational structure of industries over time, reporting data on employment dynamics for four task-related groups – Managers, Clerks, Craft and Manual workers – which result from a grouping procedure of the nine professional categories of the International Standard Classification of Occupations (ISCO).

4.3 The time structure of the database

The dataset is a panel over five periods covering a time span from 1994 to 2014. The time structure of the panel is the following:

- *Economic, demand and offshoring variables* are computed for the periods 1996-2000, 2000-2003, 2003-2008, 2008-2012 and 2012-2014. For economic, distributive and demand variables we compute the compound annual growth rate that approximates the difference in logarithmic terms, while for the offshoring indicators we take the simple difference.
- *Innovation variables* are taken from five waves of innovation survey: the first wave (CIS 2) refers to 1994-1996 and is linked to the first period of economic variables; the second wave (CIS 3) spans 1998-2000 and is linked to the second period of economic variables; the third wave (CIS 4) refers to 2002-2004 and is linked to the third period of economic variables); the fourth wave (CIS 7) spans 2008-2010 and is linked to the fourth period of

[26] Some studies questioned the reliability of offshoring indicators. For example, Castellani, De Benedictis, and Horgos (2013) argue that the offshoring indices usually used may not capture international fragmentation of production but structural change in the economy. Horgos (2009) assesses the design of several offshoring indicators used in analyses targeted to evaluate outsourcing processes' effects on labour market and argues that empirical results making use of these indicators broadly depend on the particular offshoring index employed.

economic variables; the fifth wave (CIS 9) refers to 2012-2014 and is linked to the fifth period of economic variables.[27]

In conclusion, the wealth of information included in the SID database provides a comprehensive view of industries' dynamics and allows an assessment of their structural dynamics as defined by their technological, distributional and economic performance. In the next chapter we exploit the SID database to perform an empirical analysis on the processes of structural change in Europe as shaped by the technological change, demand dynamics and offshoring activities.

[27] The temporal structure of the database is firstly due to the frequency according to which Eurostat collects the innovation surveys and makes them available. Secondly, the surveys' innovation-related questions are partially changed over the time, forcing us to select consistently the CIS containing the variables of our interest. Finally, we matched the economic and innovation variables so that the latter are lagged relative to the former, bearing in mind the time needed by technological efforts to display their effects. For more details, see the final Appendix on the SID database.

Chapter 2

The Determinants of Structural Change: Demand, Technology and Offshoring

1. Introduction

In this chapter we build on a theoretical framework which combines Post-Keynesian and Neo-Schumpeterian insights to provide an empirical analysis of the patterns of structural change which have interested the European economy in the last twenty years.

As theoretically discussed in the previous chapter, the patterns of structural change of the advanced economies are shaped by a number of supply-side and demand-side factors which interact each other giving rise to a complex dynamics of economic and institutional transformation. In this sense, the process of technological change is fundamentally intertwined with the growth patterns of demand and their dynamic combination results in major shifts in the sectoral composition of the economies. Nonetheless, in the last decades the process of production globalization has come to the fore, reshaping the industrial landscape of Europe and giving rise to new potential sources of power and production asymmetries among geographical areas of the continent.

Therefore, we propose an empirical assessment of the relationships between the innovative efforts pursued by industries, the offshoring strategies which shape their competitiveness, the industry-specific dynamics of different demand flows and the growth patterns of industries. Our aim is to provide an overview about the way in which the heterogeneous rates and directions of technological progress intertwined with the uneven growth paths of demand – as well as with the internationalization of production – give rise to a structural economic evolution of the economies.

However, the relationships holding between the structural factors considered and the uneven growth patterns of industries are not constant in time and uniform in space. In other terms, a better understanding about the process of structural change may come from the detection of those dimensions which allow to provide a deeper investigation about the relationships between the “forces of change” and the growth patterns of industries (Landesmann, 2018). For this purpose, we identify four key sources of heterogeneity which exert a potential influence on the strength and direction of relationships investigated.

1.1 Manufacturing vs. Service industries

The first source of heterogeneity consists in the potential diverging patterns of development between manufacturing and service industries (Bogliacino et al., 2013; Bramucci et al., 2017; Marconi et al., 2016; Storm, 2015).

Landesmann et al. (2013) stressed that the manufacturing sector represents the main source of innovation and technological progress, showing that resources devoted to research and development are far much higher than in the service industries and that countries with a dynamic manufacturing industry are those experimenting a more sustainable fast-growing economic path. Andreoni and Chang (2016) summarized in a few points the reasons why the manufacturing industries are crucial to set the economies on a virtuous trajectory of structural change. First, manufacturing industry experiments the higher productivity growth rates thanks to the technological advancements that is generates over time, while the potentialities of agriculture and service industries are nature-constrained or related to a quality worsening of the products, respectively. Second, manufacturing sector constitutes the ‘learning centre’ of capitalism in technological terms and its technical advances spill over spurring productivity growth of the other sectors (Andreoni and Chang, 2016, p. 495; see also Andreoni and Gregory, 2013). Third, manufacturing represents the main source of organizational innovation and the techniques that develops are foten adopted by other industries. Fourth, services with the highest labour productivity (e.g. logistics) are producer services whose main source of demand comes from the manufacturing industry, from which depends the growth of the former (Andreoni and Gregory, 2013; Guerrieri and Meliciani, 2005). Finally, manufacturing goods have a far higher tradability than agriculture and, in particular, service sectors, with main consequences with regard to the export performance of countries and their international competitiveness (Chang, 2010). Furthermore, manufacturing industry is at the center of the modern process of global production disintegration with asymmetric consequences on the productive matrix and specialization patterns of countries (Celi et al., 2018; Landesmann and Stollinger, 2018; Simonazzi et al., 2013; Stollinger, 2016).

Given this rationale, we adopt the interaction terms technique to get different estimated coefficients for manufacturing and service industries, assessing in this way the potential dichotomies in terms of growth patterns of industries along this dimension.

1.2 High-tech vs. Low-tech industries

The second source of heterogeneity that we detect refers to the technological trajectories of industries. Neo-Schumpeterian literature stressed that the economic performance of sectors is fundamentally shaped by the rate and direction of innovative efforts they pursue; in turn, evolutionary literature on sectoral systems of innovation highlighted that such innovative efforts and the technological improvements they are able to get depend crucially by the technological regime of industries defined in terms of market structure, nature of knowledge and cumulativeness and appropriability of innovation (Breschi et al., 2000; Dosi, 1982, 1988; Malerba and Orsenigo, 1997). On this ground we follow the strategy adopted by previous empirical works in the evolutionary field (Bramucci et al., 2017; Bogliacino and Pianta, 2011; Cirillo, 2017; Pianta and Tancioni, 2008) and group industries in "high-tech" and "low-tech" clusters. In particular, we exploit the Revised Pavitt Taxonomy provided by Bogliacino and Pianta (2010, 2016) to perform separate estimations for the cluster including Science based and Specialized suppliers industries, namely the high-tech cluster, and the one including Scale and information intensive and Supplier dominated industries, namely the low-tech cluster.[28] This distinction, empirically carried out using the interaction terms technique, allows to assess the potential heterogeneity about the role of different components of demand – namely domestic final demand and exports – and offshoring for the growth rate of industries.

Moreover, building on Neo-Schumpeterian literature, we consider the heterogeneity involving the process of technological change accounting for different kinds of innovation, with the aim of assessing their relationships with the uneven growth patterns of different industry clusters. In particular, we perform our analysis constantly distinguishing between process and product innovation. The former allow for uneven patterns of productivity increases among firms and industries leading to changes in relative prices and market structures; the latter entails a qualitative improvement of existing products, the introduction of new products or the emergence of new sectors, giving rise to saturation phenomena of mature productions while providing opportunities to satisfy new needs (Pianta, 2001).

Finally, we hold that the radically uncertain nature of technological progress and the differentiated degree of appropriability of innovative efforts introduce another potential source of heterogeneity in the relationship which links innovation to the economic performance of industries (Dosi, 1988; Nelson and Winter, 1982). For this purpose, we perform our analysis using indicators which proxy both the "input" and "output" of innovation, assessing in this way potential dichotomies between industry group sharing different technological trajectories. As described below, we regard the Research and Development (R&D) expenditure per employee and the expenditure in the acquisition of new machinery and equipment per employee as proper proxies of innovation input, while the share of turnover due to new or improved products and the share of firms introducing process innovations are eligible proxies of innovation output.

1.3 Core vs. Peripheral countries

The third source of heterogeneity that we detect as pivotal to understand modern patterns of structural change in Europe is related to the divergent growth patterns of industries belonging to core and peripheral countries. We regard the Core-Periphery dimension as one of the most interesting for

[28] See the final Appendix on the SID database for further details on the Revised Pavitt Taxonomy and the list of sectors classified accordingly.

investigating the process of structural polarization among European economies, since it allows to draw some considerations on the productive specialization of countries and their ability to develop a productive matrix suitable to govern successfully the process of structural change (Botta, 2014; Celi et al., 2018; Cirillo and Guarascio, 2015; Guarascio and Pianta, 2016; Guarascio and Simonazzi, 2016; Guarascio et al., 2016; Landesmann, 2015; Landesmann et al., 2015; Simonazzi et al., 2013; Stehrer and Stöllinger, 2015). For this purpose, we build on huge literature on the process of economic polarization in Europe and divide our sample of European countries in two cluster. The core cluster is composed by France, Germany, the Netherlands and the United Kingdom; the peripheral cluster is composed by Italy and Spain.[29]

Our expectation is that industries belonging to the core countries emerge as the ones pursuing more intensively technological competitiveness strategies based on the search for quality improvement of products and new source of technologically advanced goods supply. In other words, we expect that the growth performance of industries belonging to the core countries result mostly driven by technological competitiveness strategies, which foster product innovations and allow to meet the demand (whose composition changes over time) (Botta, 2014; Celi et al., 2018; Guarascio et al., 2016; Storm and Naastepad, 2015a, 2015b, 2015c).

On the other hand, given the poorer productive matrix of peripheral countries and their lower accumulation of technological capabilities, we expect that technological efforts aimed at cost reductions and productive efficiency (through the introduction of process innovation and low-tech offshoring activities) constitute the dominant strategies which drive the growth performance of their industries. In other words, our expectation is that industries belonging to peripheral countries primarily seek cost reductions – mainly through increasing internal and external flexibility, reducing labor costs and acquiring low quality intermediate inputs from foreign industries – and, accordingly, are more prone to experience demand saturation phenomena and thus a tendential decline in market shares. Furthermore, the specialization in sectors whose technological trajectory is mainly oriented towards cost-based strategies leads these economies to compete with emerging and newly industrialized countries, which however can take advantage of low labor costs, low corporate taxation and poor environmental regulation. In this scenario, market mechanisms lead to race-to-the-bottom phenomena – marked by reducing productive capacity and job losses – which can lock-in industries and countries in a vicious circle featured by low innovation, low competitiveness and low-paid jobs (Celi et al., 2018; Guarascio and Pianta, 2016; Landesmann, 2015; Storm and Naastepad, 2015a, 2015b).

1.4 Upswing vs. Downswing of business cycle

The fourth source of heterogeneity regards the temporal dimension. More precisely, we account for the different phases of business cycle, investigating the way in which the relationships among output rates of growth, innovation regimes, demand dynamics and offshoring strategies change during the upswing and downswing periods (Cirillo et al., 2018; Lucchese and Pianta, 2012; Guarascio et al., 2015). On the one hand, this perspective links our structural analysis to the dynamics of the economic aggregates; on the other hand, we argue that focusing on the role of business cycle at industry level may allow to better assess the different pace of technological and structural change of the economies.

On this ground, Mensch (1979) argued that firms tend to introduce innovations during depressions since periods of low profitability force them to innovate with the aim to capture growing rents; conversely, during upswing they have relatively lower incentive to innovate since can rely on a higher demand for existing products to achieve their profitability targets. On the contrary, Freeman (1974, 1982) and Freeman and Louca (2001) stressed the uncertain nature of technological change and low opportunities due to weak demand dynamics discourage the introduction of product innovation during

[29] The strong divergent dynamics in terms of manufacturing production, technological progress and economic performance between core and peripheral countries included in the SID database, i.e. the database on which we rely to perform the empirical analysis proposed in Section 3, emerges very clearly from the descriptive evidence that we present in Section 2, providing further rationale for the adopted grouping of countries.

downswing, while tend carry out innovative efforts aimed at the introduction of new processes associated to production restructuration; on the other side, during periods of recoveries the expansion of the markets due to a growing demand provides the condition to successfully introduce product innovation to increase market share and gain higher rents.

Moreover, recent literature on global fragmentation of production has shown that offshoring activities, being strongly connected with the dynamics of international trade, are strictly intertwined with business cycles dynamics (Easterly et al., 2000; Burstein et al., 2008; Feenstra, 2010). Di Giovanni and Levchenko (2012) performed an industry-level analysis and found that sectors which show a high degree of openness to both intermediate and final goods trade are relatively more volatile, albeit they result less influenced by the domestic economy dynamics. Feenstra (2010) discussed the potential interaction among demand shocks, offshoring and business cycle, arguing that increases in demand in the home country (i.e. the one pursuing the offshoring activity) may induce increases in wages that, in turn, foster production offshoring as firm's strategy to reduce labour costs; it follows a reduction of the domestic output, which soften the effects of the original demand expansion.

The set of structural relationships we are investigating are thus potentially affected by the business cycle; accordingly, we follow previous empirical literature (Lucchese and Pianta, 2012; Guarascio et al., 2015) and perform our empirical analysis introducing interaction terms to allow slope and intercept coefficients to diverge according to the upswing and downswing phases. Our expectation is that product innovation, together with technology-driven offshoring activities, show a stronger association with the growth rate of industries during upswings, while process innovation and offshoring strategies pursued to reduce production costs characterize more the performance of industries during downswings.

The joint consideration of all these different dimensions of structural change, i.e. of these different sources of variety regarding the relationships between the structural factors considered and the uneven growth patterns of industries, represents the main value added of our empirical analysis. In the next section the database on which we rely on is briefly presented and large descriptive evidence on different aspects of structural change in Europe is reported.

2. Data and descriptive evidence

The database that we use in our analysis is the Sectoral Innovation Database (SID) of which we have given wide description in the last section of the previous chapter. This dataset includes industry-level data in two-digit NACE Rev. 1 classification for 21 manufacturing and 17 service sectors for six major European countries – France (FR), Germany (DE), Italy (IT), the Netherlands (NL), Spain (ES) and the United Kingdom (UK).The time span covered by the dataset is 1994-2014.

The variables employed in the empirical analysis are listed in Table 1.

Table 1. List of variables

Variable	Unit	Source
Rate of growth of value added	Annual rate of growth	SID – (WIOD-SEA)
Rate of growth of domestic final demand	Annual rate of growth	SID – (WIOT)
Rate of growth of exports	Annual rate of growth	SID – (WIOT)
R&D expenditure per employee	Thousands euros/employee	SID – (EUROSTAT-CIS)
New machinery exp. per employee	Thousands euros/employee	SID – (EUROSTAT-CIS)
Turnover due to product innovation	Share	SID – (EUROSTAT-CIS)
Share of firms introducing new processes	Share	SID – (EUROSTAT-CIS)
Rate of growth of narrow offshoring	Simple difference	SID – (WIOT)
Rate of growth of high-tech offshoring	Simple difference	SID – (WIOT)
Rate of growth of low-tech offshoring	Simple difference	SID – (WIOT)

Source: Sectoral Innovation Database.

Note: Rate of growth are compound average annual rate of growth computed over two to five years periods (1996-2000; 2000-2003; 2003-2008; 2008-2012; 2012-2014). Offshoring variables are computed as the simple difference between the value assumed in the last year and the one assumed in the first year of each of the five periods.

We remind that innovation variables are matched with economic variables according to the specific time structure of the SID database. In particular, the former refer to the following five periods: 1994-1996, 1998-2000, 2002-2004, 2008-2010 and 2012-2014, while the variables referring to value added growth and demand growth are computed as average annual compound rate of change over the following five periods: 1996-2000, 2000-2003, 2003-2008, 2008-2012 and 2012-2014; the offshoring variables are computed as simple difference between the last and the first year of each of these last five periods. We refer to the final Appendix on the SID database for further detail.

In the rest of this section we report descriptive evidence concerning the structural evolution of the industries and countries included in our database, presenting graphical and statistic evidence on the growth dynamics of sectors, their technological performance and the degree of integration in global value chains they present. At the same time, main findings will form the basis from which drawing some considerations on structural changes in Europe and their linkages with technological change, international disintegration of production and the dynamics of domestic and foreign demand.

It must be noted that, unless otherwise stated, in the tables and figures that follow values for value added, domestic final demand and exports refer to the compound average annual rate of change over the specified period; all the monetary variables are in euros and in real terms.

Standard descriptive statistics of our main variables are summarized in Table 2, that reports the average unweighted values for the whole sample of industries over the period 1994-2014.[30]

[30] More precisely, given the time structure of our database and the availability of data coming from different sources, Table 2 provides descriptive statistics for the main innovation variables for the period 1994-2014, while the values of all the other variables reported in the table refer to the period 1995-2014.

Table 2. Descriptive statistics of main variables
(whole sample: DE, IT, FR, ES, NL, UK, 1994-2014)

Variable		
Value added (% change)	Mean	1,64
	Std. Dev.	2,80
Domestic final demand (% change)	Mean	1,01
	Std. Dev.	4,45
Exports (% change)	Mean	4,69
	Std. Dev.	5,32
R&D exp. per emp.	Mean	2,89
	Std. Dev.	5,19
New machinery exp. per emp.	Mean	1,26
	Std. Dev.	1,08
Turnover due to product innovation (%)	Mean	13,98
	Std. Dev.	8,64
Share of firms introducing process innovation (%)	Mean	27,95
	Std. Dev.	11,18
Narrow offshoring (% change)	Mean	1,67
	Std. Dev.	5,78
High-tech offshoring (% change)	Mean	1,12
	Std. Dev.	4,30
Low-tech offshoring (% change)	Mean	4,78
	Std. Dev.	6,37

Source: Our elaboration on Sectoral Innovation Database.
Note: Domestic final demand is computed as the sum of final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households, final consumption expenditure by government and gross fixed capital formation. Expenditure in research and development (R&D) and in new machinery and equipment is expressed in thousands of euros for employee and reflects the average value over the period. Turnover due to the introduction of new products is the share of innovative turnover over total turnover of industries, while the share of firms which introduced new process reflects the average share of innovators at sectoral level over the period. Offshoring variables are computed as the average simple difference over the period.

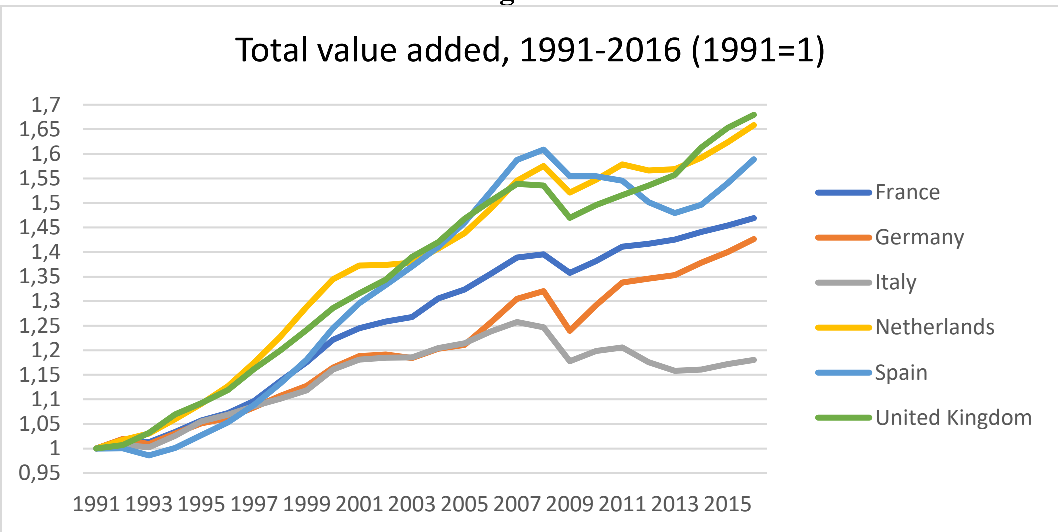
2.1 The economic performance of countries

Figure 1 shows the growth of value added for all the six countries from 1991 to 2016, while in Figure 2 it is broken down in two periods, namely 1990-2008 and 2008-2016, to account for the development paths experienced by countries before and after the global financial crisis. The first thing to note is that Spain, the Netherlands and the United Kingdom are the countries which experienced higher growth rate over the whole period, while France and Germany recorded lower performance; notably, the Italian economy showed the worst economic performance among the countries under investigation.[31]

[31] A large literature addressed the so-called Italian economic decline. Forges Davanzati (2018) argued that Italy's poor performance is fundamentally due to its productive and industrial structure. Italy shows a productive specialization in mature, mainly agri-food and Made in Italy sectors, with an increasingly smaller machinery sector. Its productive fabric is mainly composed of small and very small enterprises, characterized by low level of expenditure in research and development, with a low propensity to introduce innovations and with limited integration in international markets (see also Forges Davanzati et al., 2017; Forges Davanzati and Traficante, 2018). Furthermore, Lucarelli et al. (2013) noted that, since the Nineties, while the productive specialization of the other European economies progressively shifted to innovative sectors with a higher research intensity, the Italian one moved more and more away from the technological frontier. Without the domestic production of innovative goods, the Italian economy has become increasingly dependent

A second aspect which emerges from the Figure 1 is that phases characterized by sustained growth rates of value added have been alternated with phases of slow growth or even recession. After the economic growth phase of the Nineties, the growth rates of countries (with the partial exception of Spain and the United Kingdom) slowed down at the beginning of the 2000s as a consequence of the bursting of the dot-com financial bubble in the United States. From 2003 to 2008 all the economies experienced a phase of growing value added, but the global financial crisis triggered in 2007 and exploded in 2008 in the United States led to a sharp fall in production in 2009, followed by a second recession period in 2012 due to the so-called sovereign debt crisis. Since 2013 a slow recovery started, although Italy and Spain were still experiencing a negative growth rate of value added in that year.

Figure 1.

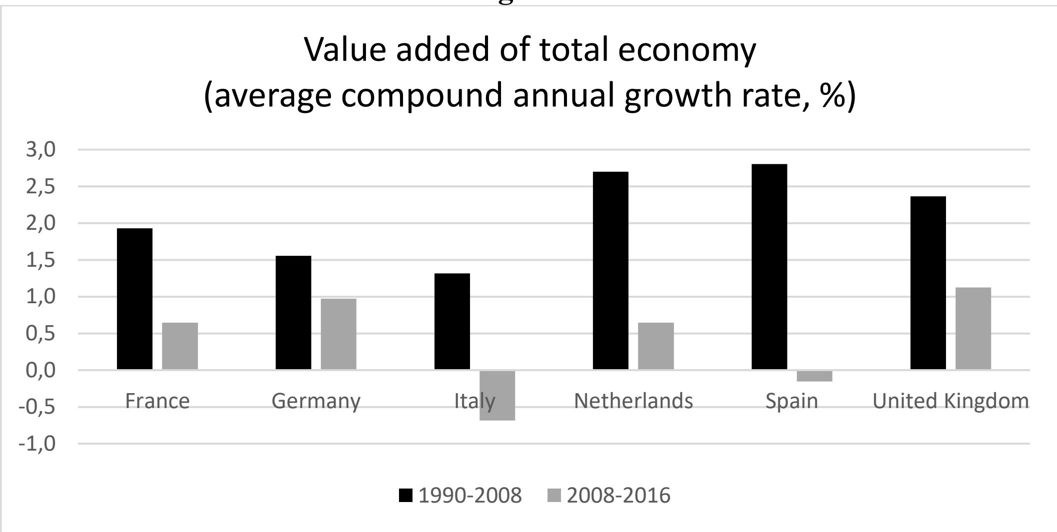


Source: Our elaboration on OECD STAN database.

In general, as Figure 2 shows clearly, between 2008 and 2016 countries belonging to the eurozone periphery, namely Spain and Italy, experienced a negative annual average growth rate, so that in 2016 they had not yet reached the production levels recorded in 2008. On the other side, among the core countries, Germany and the United Kingdom are those having most quickly recovered and then exceeded the production levels of 2008.

on their importation, being victim of a technological constraint that has undermined its development prospects. Before the outbreak of the crisis, Italy has neglected this element and today is faced with both an insufficient level of investment and its inadequate qualitative composition. They argued that to tackle the Italian economic decline it is therefore necessary to govern the qualitative composition of investments. See also Lucarelli and Romano (2016), Lucchese, Nascia and Pianta (2016) and Guarascio and Simonazzi (2016).

Figure 2.



Source: Our elaboration on OECD STAN database.
Note: Data for Germany refer to the period 1991-2016.

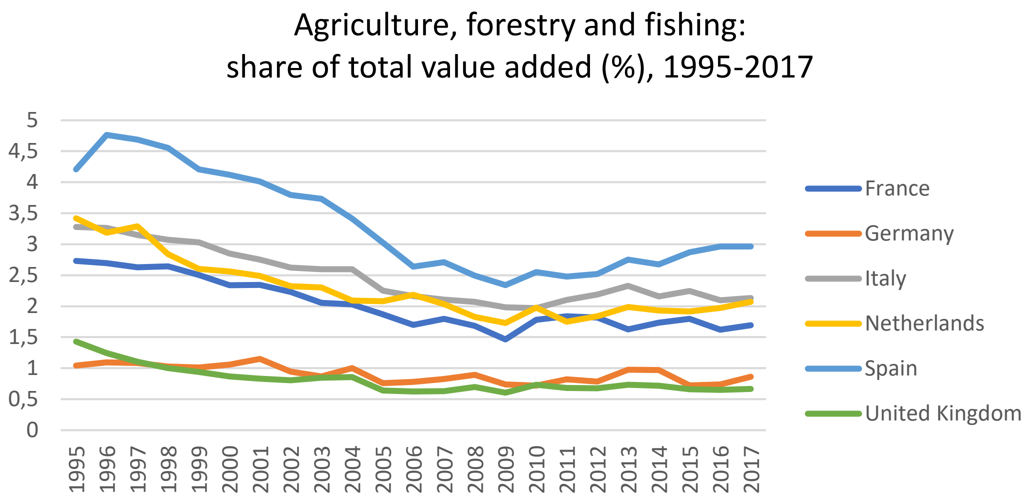
2.2 The sectoral composition of the economies

The development path of advanced countries has been characterized by a first phase of growth of the manufacturing sector together with service sector to the detriment of agriculture (Lewis, 1954; Kaldor, 1966, 1967; Kuznets, 1971), followed by a second phase of growth of services directly to the detriment of manufacturing (the so-called tertiarization of the economy).[32] In this regard, we show the relatively recent trend, i.e. from 1995 to 2017, of the value added shares of agriculture, manufacturing and services sectors over the total added value, allowing a preliminary analysis of the modern production composition of the economies under investigation.

Figure 3 reports the long-term reduction of the industry share related to agriculture, forestry and fishing activities. As known, economic development due to industrialization has fostered exceptional productivity gains together with income growth and changing pattern of consumption, leading to a major reduction of the economic relevance of this sector in advanced countries. Albeit very low, it is interesting to note that peripheral countries (Spain in particular) have the greatest agricultural production share among the countries considered. Germany and the United Kingdom, on the other hand, are those in which this share is lowest (since 2000 it represents less than 1% of total added value).

[32] The tendential increase of the share of tertiary sector is usually referred to as the Clark-Fisher hypothesis (see Montresor and Vittucci Mazzetti (2011) for a recent empirical investigation whose results support the tertiarization hypothesis). A strong debate has raised about the most important determinants of the phenomenon. Some contributions explained the growing importance of the service sector as a result of changes in the demand structure triggered by the increasing level of per capita income (Fisher, 1939; Clark, 1940; Pasinetti, 1993). Other authors acknowledged the differences in the pace of labour productivity growth between the manufacturing and service sector as explanation of the heightened relevance of the latter; according to this view, since manufacturing sector tends to experience higher productivity gains compared to the service sector, the latter absorbs the workers expelled from the former (Kuznets, 1971; Fuchs, 1968; Baumol, 1967, 1985; Kaldor, 1966, 1967). Finally, other contributions suggested that the expansion of demand for services is fundamentally driven by the rising demand for business services (as inputs in the production of goods) expressed by the manufacturing sector, i.e. by the growth of intermediate service demand (Stanback, 1979; Petit and Soete, 1997).

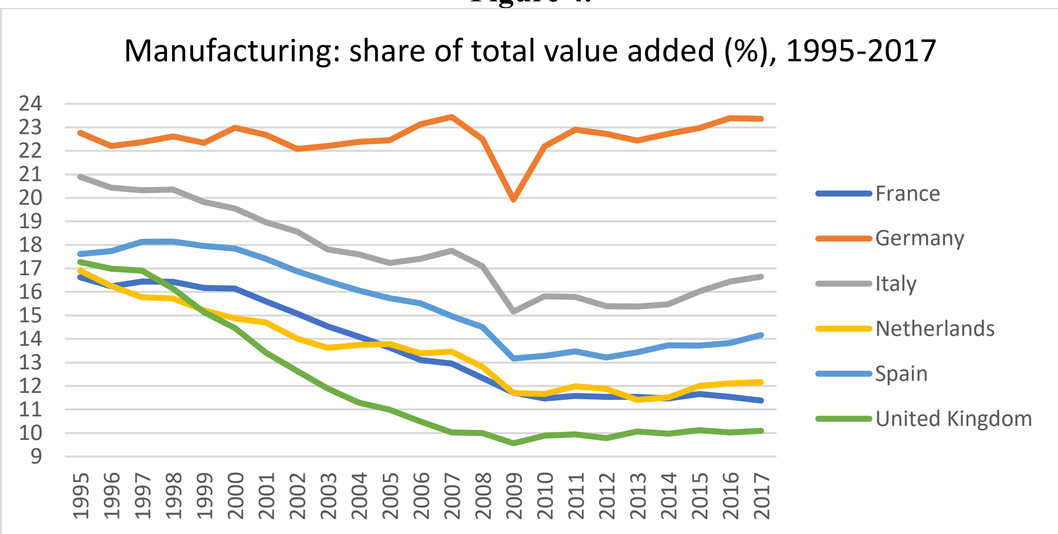
Figure 3.



Source: Our elaboration on OECD data.

Figure 4 focuses on the value added due to the manufacturing production. The first striking thing to note is the very high share of manufacturing value added in Germany, which amounts to almost a quarter of total value added and does not show a falling trend; at the same time, as shown by Figure 5, Germany is the country that shows the lowest share of value added coming from the services sector.

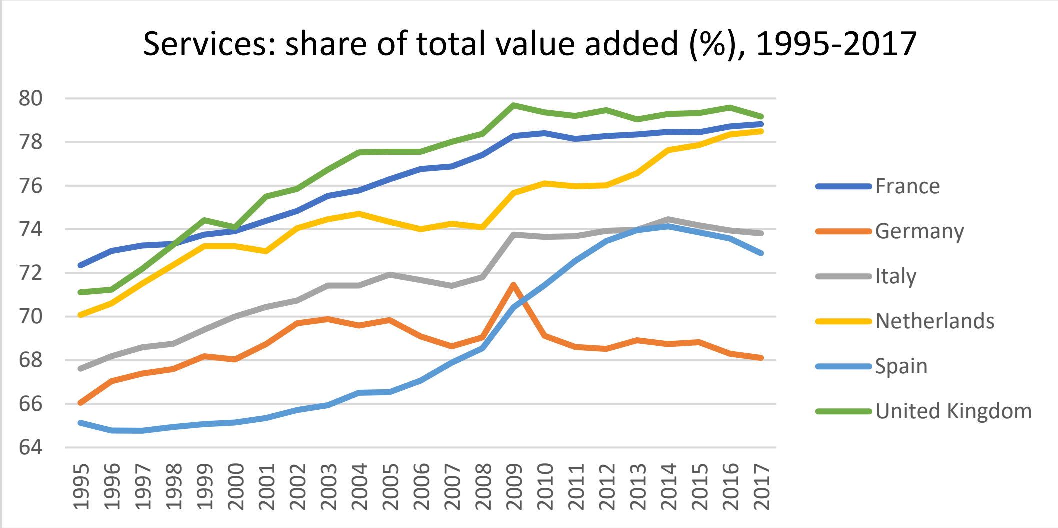
Figure 4.



Source: Our elaboration on OECD data.

Moreover, while Italy emerges as the country with the second larger manufacturing industry (approximately one sixth of total value added), the process of deindustrialization of the United Kingdom makes this country the one with the lowest share of manufacturing value added. As shown by Figure 5, this phenomenon is associated with a share of value added from services close to 80%, largely due to the importance of the United Kingdom's financial sector. Germany aside, an integrated reading of Figure 4 and 5 shows that the explosion of the economic crisis in Europe seems to have partially halted the process of long-term reduction of the manufacturing share, while it lowered the growth rate of services sector.

Figure 5.

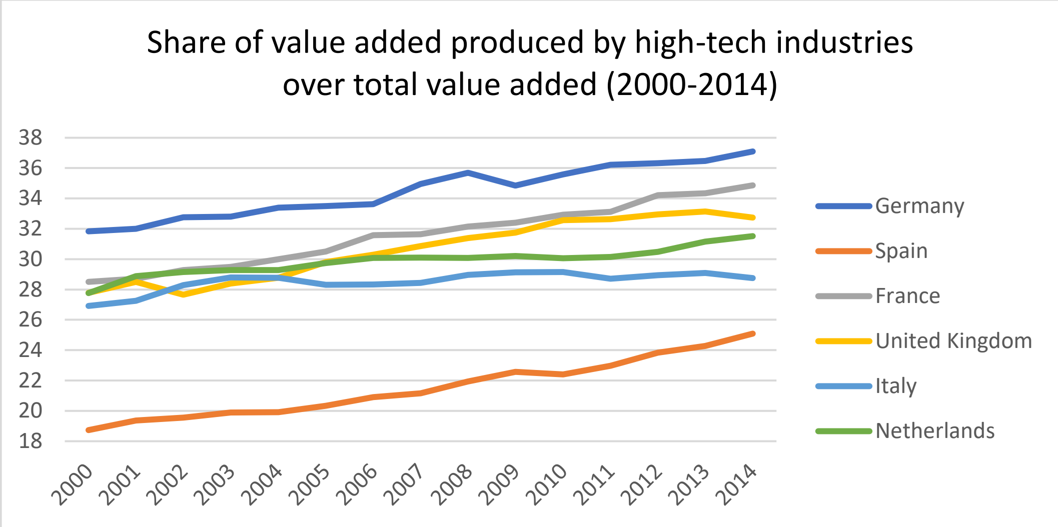


Source: Our elaboration on OECD data.

Figure 6.a and 6.b provide further evidence about the production composition of the economies although stressing the technological dimension. In particular, Figure 6.a exploits the Pavitt classification as revised by Bogliacino and Pianta (2010, 2016) to compute the share of high-tech industries over total production of the economies, i.e. the share of value added coming from Science based and Specialized suppliers industries over total value added, offering insights about the technological capabilities of countries.[33] As expected, Germany shows the highest share of high-tech production, followed by France, the United Kingdom and the Netherlands. At a lower level we find Italy which, differently from the other countries, shows an almost flat line, suggesting that the development of knowledge-based industries represents a major challenge for the technological upgrading of this country. Finally, despite a sustained pattern of growth, Spain still results mostly specialized in low-tech productions and reports the lowest share of value added produced by high-tech industries.

[33] Industries whose Revised Pavitt classification is not available have been excluded. In particular, we excluded from the computation of total value added the following fourteen sectors out of the fifty-six reported by WIOD: crop and animal production and hunting; forestry and logging; fishing and aquaculture; mining and quarrying; electricity and gas; water collection; sewerage and other waste management services; construction; real estate activities; public administration, defence and compulsory social security; education; human health and social work activities; activities of households as employers; activities of extraterritorial organizations. See the final Appendix on the SID database.

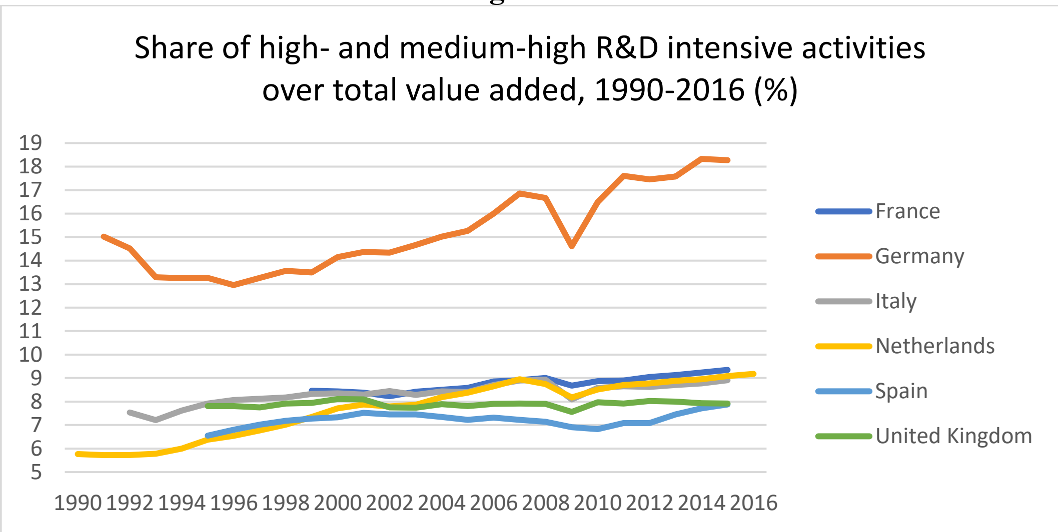
Figure 6.a



Source: Our elaboration on WIOD-SEA database.
Note: High-tech industries include sectors classified as Science based and Specialized supplier by the Revised Pavitt Taxonomy proposed by Bogliacino and Pianta (2010, 2016).

Figure 6.b takes advantage of the OECD taxonomy of economic activities based on R&D Intensity (Galindo-Rueda and Verger, 2016) to compute the share of high- and medium-high R&D intensive activities over total value added from 1990 to 2016. Consistently with the previous figure, Germany emerges even more as the country with the largest share of value added coming from the technologically advanced industries, confirming its technology-driven productive specialization pattern (German share of high- and medium-high R&D intensive industries constantly represents about twice the one recorded by other countries, the former fluctuating between 13% and 18% over total value added, while the share of the other countries is between 6% and 9%). Furthermore, it should be noted that, while the other countries show a slightly increasing trend over the whole period, German high-tech industries share has been constant or even decreasing during the Nineties, probably because of the internal restructuring process which followed the reunification. Nonetheless, at the end of the century Germany consolidated its manufacturing sector and strengthened its high-technology productions, allowing the country to catch-up quickly pre-crisis production levels after the slump of 2009. As regards the other countries, we note that Spain reports the lowest value added share of high- and medium-high technology industries over total value added, while the United Kingdom's relatively low share of value added coming from R&D-intensive industries is likely linked to the deindustrialization process undergone by the country since the end of the 20st century. The Netherlands, France and Italy report the highest share of value added coming from R&D-intensive industries after Germany, although there is a huge gap with respect to the latter; despite this, it is worth noting that Italy is the only one country among the ones investigated which in 2015 has not yet recovered the share of value added produced by high-tech industries recorded before the crisis.

Figure 6.b



Source: Our elaboration on OECD STAN database.
Note: The time period covered by the figure is not the same for all the countries because of the limited availability of data. High- and Medium-high R&D intensive activities include Chemical and pharmaceutical products, Electrical, electronic and optical equipment, Machinery and equipment n.e.c., Transport equipment, Publishing activities, Computer programming, Information service activities and Scientific research and development.

2.3 Innovation patterns and productive specialization

Table 3, 4 and 5 group industries according to four different clusters to investigate their technological performance along a plurality of dimensions.[34] The wealth of information they provide allows to better understand the technological patterns of industries and, together with the analysis of the production composition of the economies, sheds light on the technological capabilities as well as the productive specialization of countries.

Table 3 shows the values assumed by a series of innovation variables grouped by country and clusters of countries highlighting the technological gap that exists between the core and peripheral ones. We note that the values assumed by the innovation variables included in the table are all higher for core countries and, notably, the difference seems to be particularly marked as regards the variables associated with technology-based competitiveness strategies (i.e. share of firms introducing new products and which innovates with the aim of opening new markets); consistently, the technological gap between core and peripheral countries is smaller whether we look at the variables associated with cost-based competitiveness strategies (i.e. the share of firms introducing new processes or the expenditure in new machinery and equipment).

Another aspect that should be emphasized arises from a horizontal reading of Table 3. Looking at the first two columns, it emerges that all the core countries have a higher share of firms introducing product innovations with respect to process innovations (on average, the former is over one third – 35,8% – while the latter is less than one third – 28,6%). On the contrary, peripheral countries (namely Italy and Spain) both present higher share of firms introducing process rather than product innovation (on average, the former is equal to 36,7% while the latter is equal to 24,4%). We argue that such descriptive findings allow to provide important insights regarding the different competitiveness strategies which dominate the development trajectories of core and peripheral countries belonging to the European Union. Nonetheless, the linkage between the technological capabilities and the production composition of countries underlines the structural components which lie at the basis of the process of industrial polarization in Europe.

[34] Table 3, 4 and 5 report the unweighted average values of industries for all the countries included in the SID database (France, Germany, Italy, Spain, the Netherlands, the United Kingdom) over the whole period (1994-2014).

Table 4 groups industries on the basis of the Revised Pavitt Taxonomy offered by Bogliacino and Pianta (2010, 2016) and reports the average values of the innovative variables distinguishing between high-tech and low-tech industries (where the former are Science based and Specialized Suppliers industries while the latter are represented by Scale and Information intensive and Supplier dominated ones).[35] The table clearly shows that high-tech industries are characterized by a higher rate of technological dynamism and that the gap appears wider when looking at the variables associated with technology-based competitiveness strategies (i.e. research and development expenditure per employee and turnover due to product innovation), while it seems smaller with regard to the variables associated with cost-based competitiveness strategies (i.e. the share of firms introducing new processes or expenditure on new machinery and equipment per employee, where the latter is the only one variable for which the two clusters present the same value on average).

Finally, Table 5 distinguishes, on the one hand, between manufacturing and service industries; on the other hand, between upswing and downswing phases of the business cycle, allowing to assess how the rate and direction of technological change vary during periods of growing production and recession. As regards the former dimension, we note that manufacturing sector is confirmed to be the "learning centre" of capitalism in technological terms (Andreoni and Chang, 2016, p. 495), as shows higher values for all the innovation variables included in the table. Whether this finding contributes to underline the prominence of manufacturing sector in determining the rate of technological upgrading and thus international competitiveness of countries, on the other side it supports the need to distinguish between manufacturing and service industries when addressing the study of structural changes of the economies.

Moving to the bottom half of Table 5 we note that the values assumed by the innovative variables do not seem to change radically along the economic cycle, albeit the values assumed by the innovative variables are generally slightly higher during the upswing phases. Most important, we note that the variable related to the expenditure on new machinery and equipment per employee – which proxies the introduction of process innovation – presents higher values during the downswing phase, while the opposite seems slightly to emerge when looking to the expenditure in research and development per employee – a variable which tends to capture a technology-driven competitiveness strategy. This suggests that during periods marked by production slowdown, industries tend to promote production restructuring processes aimed at achieving greater production efficiency and cost reductions (normally associated to job destruction and wage squeeze).

[35] See the final Appendix on the SID database for further details on the Revised Pavitt Taxonomy and the list of sectors classified accordingly.

Table 3. Innovation performance of countries and Core-Periphery clusters. Average values of industries (unweighted measure), 1994-2014.

Country	New products (% share)	New processes (% share)	New products or processes (% share)	R&D exp. per emp.	New machinery exp. per emp.	Innov. to open new markets (% share)	Turnover due to product innovation (% share)
France	30,8	28,7	41,2	4,6	0,9	29,0	11,5
Germany	46,0	35,8	63,0	3,9	2,4	40,7	17,8
Netherlands	36,3	29,8	46,0	2,9	1,0	26,7	(9,4)
United Kingdom	30,0	20,0	40,4	1,9	1,2	42,7	16,0
Core	**35,8**	**28,6**	**47,7**	**3,3**	**1,4**	**34,8**	**15,1 (13,7)**
Italy	27,6	29,2	38,6	1,9	1,4	19,1	13,4
Spain	21,2	24,2	34,7	2,1	0,6	14,9	15,7
Periphery	**24,4**	**26,7**	**36,7**	**2,0**	**1,0**	**17,0**	**14,6**

Source: Our elaboration on Sectoral Innovation Database.

Note: The variables expressed as percentage share reflect the average share of firms at sectoral level for any given country over the period, except for the innovation turnover variable, which reflects the average share of turnover due to new or improved products at sectoral level for any given country over the period. The expenditure in R&D per employee and in new machinery and equipment per employee are expressed in thousands of euros at constant prices and reflect the industries' average value for any given country over the period.

Table 4. Innovation performance of industries classified according to the Revised Pavitt Taxonomy and High/Low-tech clusters. Average values of industries (unweighted measure), whole sample of countries (DE, IT, FR, ES, NL, UK), 1994-2014.

Pavitt class	New products (% share)	New processes (% share)	New products or processes (% share)	R&D exp. per emp.	New machinery exp. per emp.	Innov. to open new markets (% share)	Turnover due to product innovation (% share)
Science based	50,7	35,9	61,4	8,9	1,7	41,8	22,6
Specialized suppliers	31,2	24,6	41,6	3,2	0,9	27,5	15,7
High-tech industries	**40,9**	**30,3**	**51,5**	**6,1**	**1,3**	**34,6**	**19,1**
Scale and Information intensive	34,6	34,1	48,5	1,7	1,6	30,0	13,3
Supplier dominated	21,8	21,5	33,9	0,7	0,9	22,6	9,7
Low-tech industries	**28,2**	**27,8**	**41,2**	**1,2**	**1,3**	**26,3**	**11,5**

Source: Our elaboration on Sectoral Innovation Database.

Note: The variables expressed as percentage share reflect the average share of firms at sectoral level for any given Revised Pavitt Class (RPC) over the period for the whole sample of countries, except for the innovation turnover variable, which reflects the average share of turnover due to new or improved products at sectoral level for any given RPC over the period for the whole sample of countries. The expenditure in R&D per employee and in new machinery and equipment per employee are expressed in thousands of euros at constant prices and reflect the industries' average value for any given RPC over the period for the whole sample of countries.

Table 5. Innovation performance of Manufacturing/Service industries and during Upswing/Downswing phases of business cycle. Average values of industries (unweighted measure), whole sample of countries (DE, IT, FR, ES, NL, UK), 1994-2014.

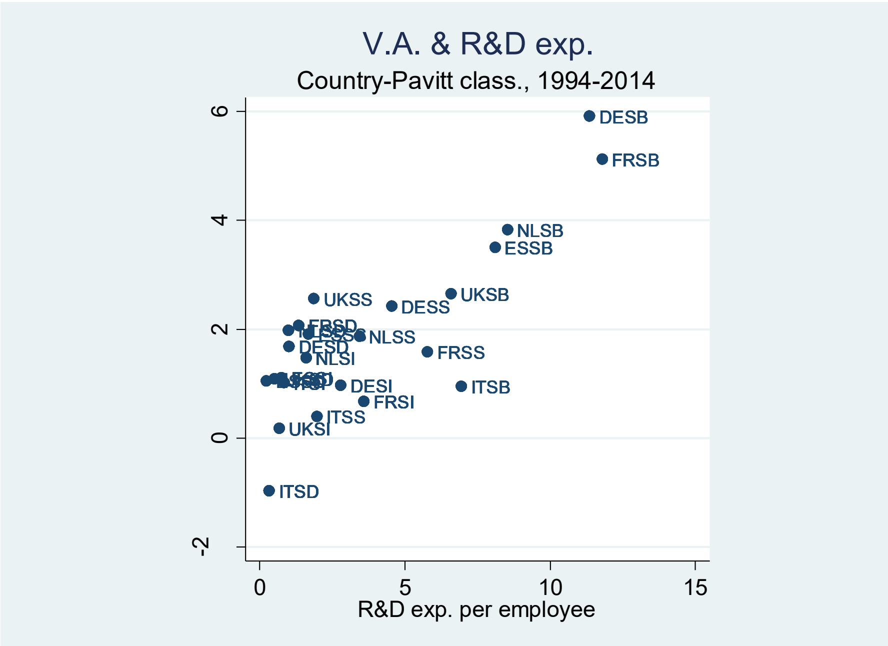
	New products (% share)	New processes (% share)	New products or processes (% share)	R&D exp. per emp.	New machinery exp. per emp.	Innov. to open new markets (% share)	Turnover due to product innovation (% share)
Manufacturing	38,0	32,1	49,8	3,5	1,6	32,8	17,1
Services	24,6	22,8	36,8	2,1	0,9	23,9	10,2
Upswing	34,5	30,8	45,7	2,9	1,2	33,6	16,6
Downswing	31,4	26,1	43,1	2,8	1,4	25,1	12,5

Source: Our elaboration on Sectoral Innovation Database.
Note: With respect to the manufacturing/services clusters, the variables expressed as percentage share reflect the average share of firms in manufacturing/services industries over the period for the whole sample of countries, except for the innovation turnover variable, which reflects the average share of turnover due to new or improved products in manufacturing/services industries over the period for the whole sample of countries; the expenditure in R&D per employee and in new machinery and equipment per employee are expressed in thousands of euros at constant prices and reflect the average value in manufacturing/services industries over the period for the whole sample of countries.
With respect to the upswing/downswing grouping, the variables expressed as percentage share reflect the average share of firms during upswing (1996-2000, 2003-2008, 2012-2014) and downswing (2000-2003, 2008-2012) phases of business cycle for the whole sample of countries, except for the innovation turnover variable, which reflects the average share of turnover due to new or improved products during (the aforementioned) upswing and downswing phases of business cycle for the whole countries; the expenditure in R&D per employee and in new machinery and equipment per employee are expressed in thousands of euros at constant prices and reflect the average value of industries during (the aforementioned) upswing and downswing phases of business cycle for the whole sample of countries.

2.4 Innovation and economic growth

Once provided evidence about the different innovative efforts pursued by industries and countries, we move to the analysis of the relationships holding between such trajectories of technological change and the resulting economic performance in terms of value added growth rate. For this purpose, in the following figures we group industries on the basis of the country and the Revised Pavitt Class they belong (Bogliacino and Pianta, 2010, 2016) computing the unweighted average values for the whole period covered by our database.

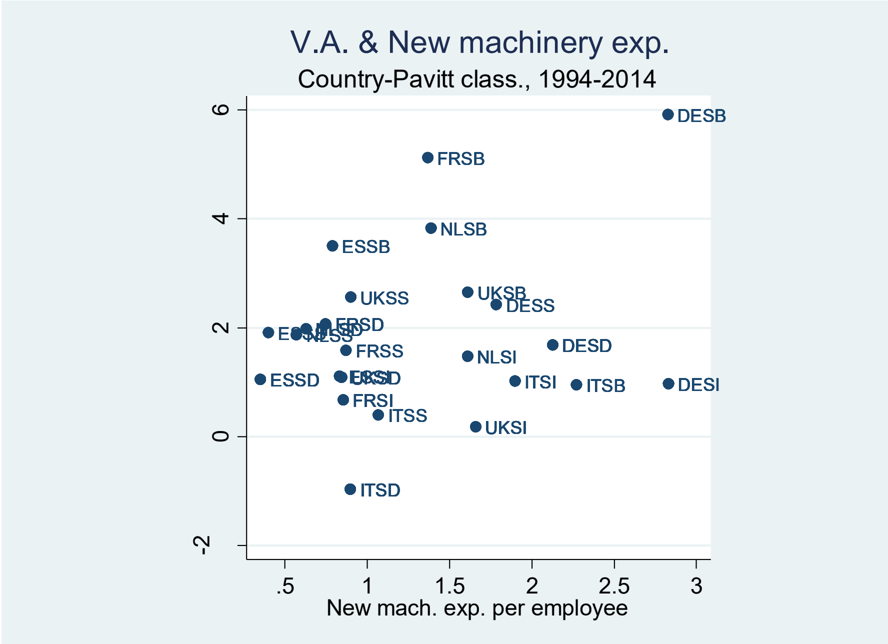
Figure 7.



Source: Our elaboration on Sectoral Innovation Database.

We start focusing on variables capturing the input of innovation, i.e. expenditure in research and development per employee and on new machinery and equipment per employee, that we regard as associated to a technology-based competitiveness strategy and to the efforts to obtain efficiency gains, respectively (Pianta, 2001). While Figure 7 shows a clear positive relationship between R&D expenditure and the growth rate of value added – a growth dynamics driven by the most innovative sectors such as the Science based ones –, Figure 8 does not show a clear association between the new machinery expenditure and the growth of value added. Although the relation which emerges appears to be generally positive, this finding seems to suggest industries whose technological efforts are mostly aimed to achieve productivity gains may not be able to trigger production increases as long as cost reduction strategies are not sufficient to intercept a continuously evolving demand. In this regard, we note the particularly poor technological performance of traditional Italian sectors based on low value-added products and suffering from a stagnant demand.

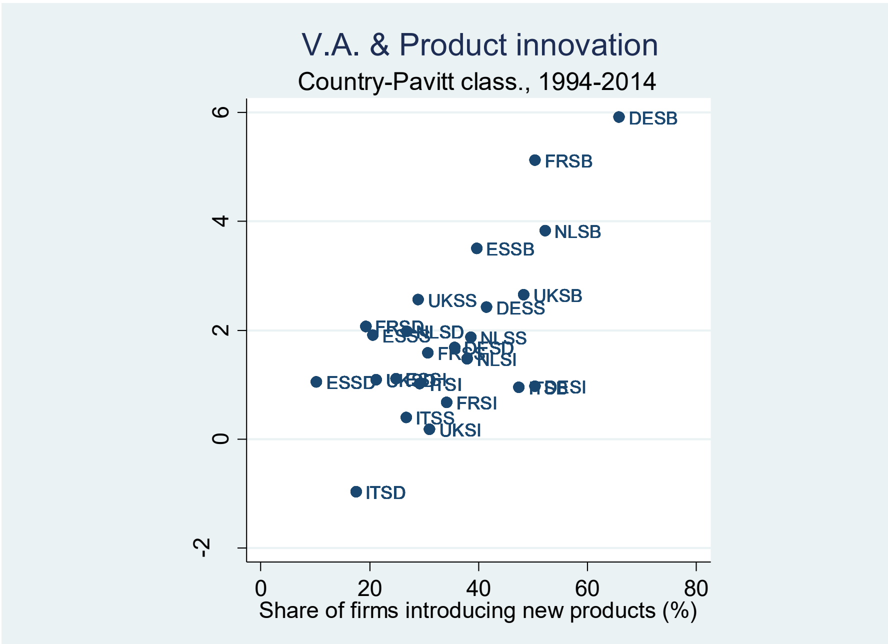
Figure 8.



Source: Our elaboration on Sectoral Innovation Database.

Figure 9 and 10 investigate the relationship between technological capabilities and growth performance of industries using different innovation variables, namely variables which capture the output of innovative industry efforts. In particular, Figure 9 shows the strongly positive association between the share of firms introducing product innovations at sectoral level and the dynamics of sectoral value added, largely confirming the insight already sketched by Figure 7 about the driving role played in the process of structural change by industries which mostly rely on technological improvements and new product development.

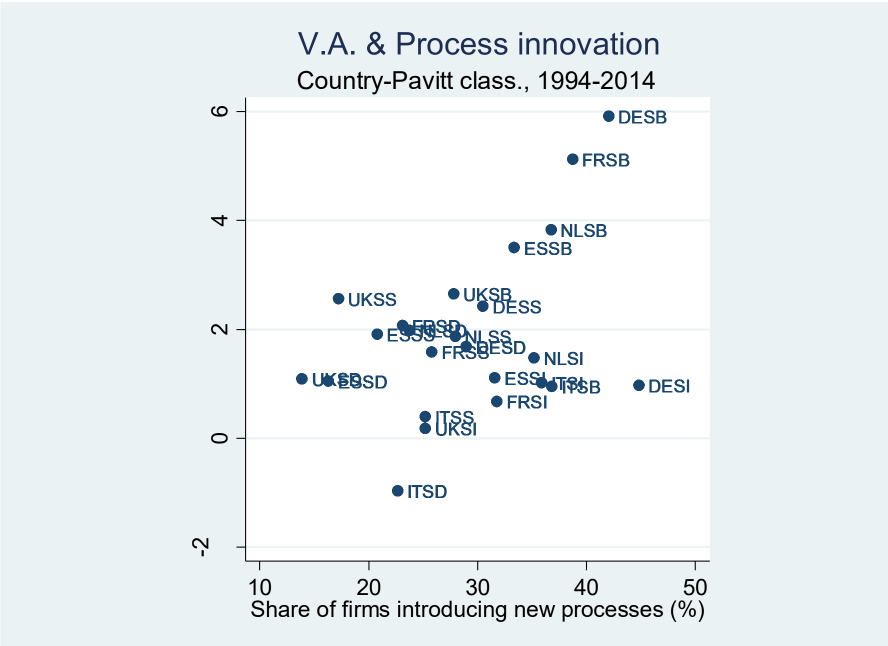
Figure 9.



Source: Our elaboration on Sectoral Innovation Database.

Moreover, Figure 10 reports the relationship between the average share of firms introducing process innovations at sectoral level and the rate of growth of industries' value added. Although the figure shows a positive association between the two variables, the emerged association is less clear than the one reported by the previous figure. Science based industries are confirmed the most technologically advanced ones, being able to combine product quality improvements and great efficiency gains through the simultaneous introduction of process innovations. Scale and information intensive industries, especially the German, Dutch, French and Spanish ones, show strong process innovation performance, consistently with the incremental nature of the knowledge base they build on and their propensity to gain from increasing returns to scale as associated with the cumulative character of their innovation capabilities; nonetheless, the productivity gains they reach do not seem to be sufficient to meet the changing demand over time, preventing them to get high production growth rates.

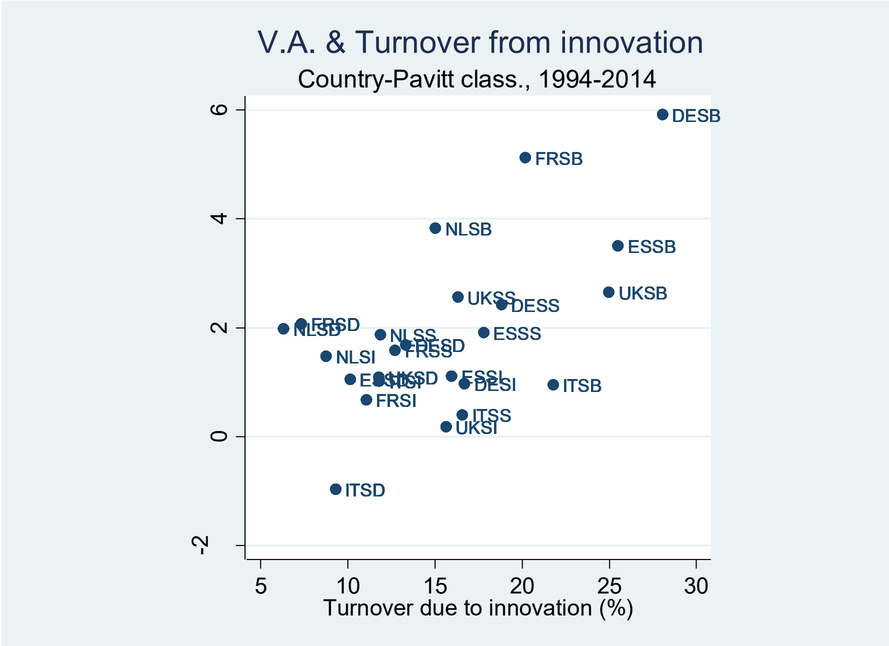
Figure 10.



Source: Our elaboration on Sectoral Innovation Database.

Finally, Figure 11 shows the relationship between industry growth rate and a different proxy of product innovation, i.e. turnover due to new or improved product, since it should capture at best the success due to competitiveness strategies based on technological upgrading and quality improvements. The strong and positive association reported by the figure seems to confirm that pursuing competitiveness strategies aimed at increasing the quality of products and introducing new ones is crucial to intercept new consumer needs and therefore increasing flows of demand.

Figure 11.



Source: Our elaboration on Sectoral Innovation Database.

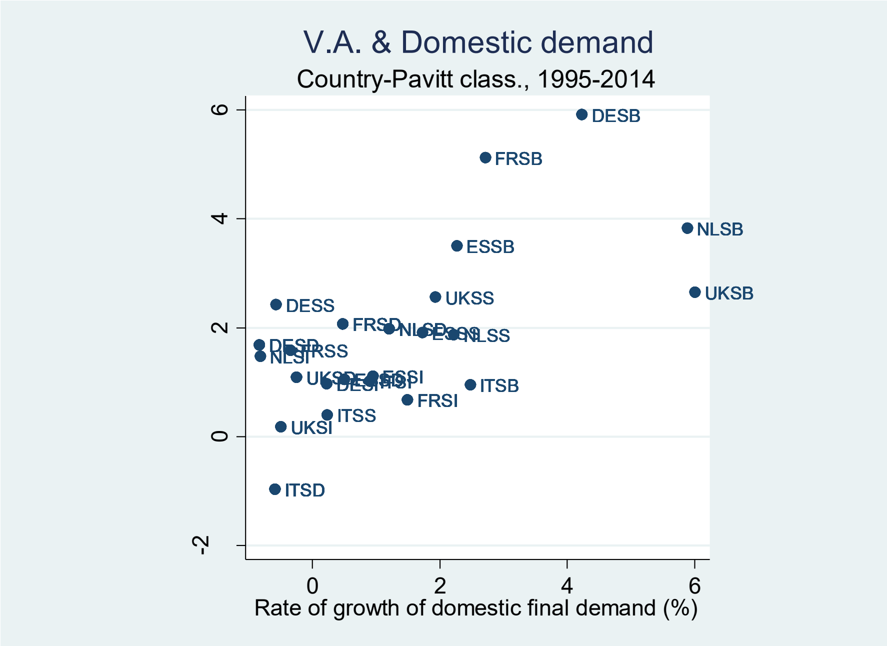
Overall, the heterogeneous relationships emerged from the previous figures tell us that, albeit in a stylized form, the analysis of the different kinds of innovation, as well as the dominant competitiveness strategies defined by the technological trajectories of industries and their related outcome in terms of value added growth rates, provides key insights about the patterns of structural change in Europe and the factors which shape dynamics evolution of the economies. Following this approach, in the next section we will deep further the investigation about the uneven growth of industries' production as related to their technological efforts, but before doing this we propose descriptive evidence regarding other factors we consider as crucial to understand the structural change economic process, i.e. the demand dynamics and the role of global fragmentation of production.

2.5 Demand and economic growth

Figure 12 and 13 show the relationship between the dynamics of domestic and foreign demand and the compound average annual growth rate of value added of industries, respectively. Once again, industries are clustered according to the Revised Pavitt Taxonomy (Bogliacino and Pianta, 2010, 2016) and the country they belong. These figures allow to appreciate the ability of industries to attract over time different demand flows on the basis of their different technological trajectories.

Figure 12 reports the expected positive association between the growth rate of domestic final demand (computed as the sum of final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households, final consumption expenditure by government and gross fixed capital formation) and the dynamics of industries' value added. We note that technologically advanced industries, namely Science based and Specialized suppliers ones, have been the most able to intercept the growing domestic final demand, being the industries which pursue most intensively a strategy aimed at introducing new products which satisfy the changing consumption needs.

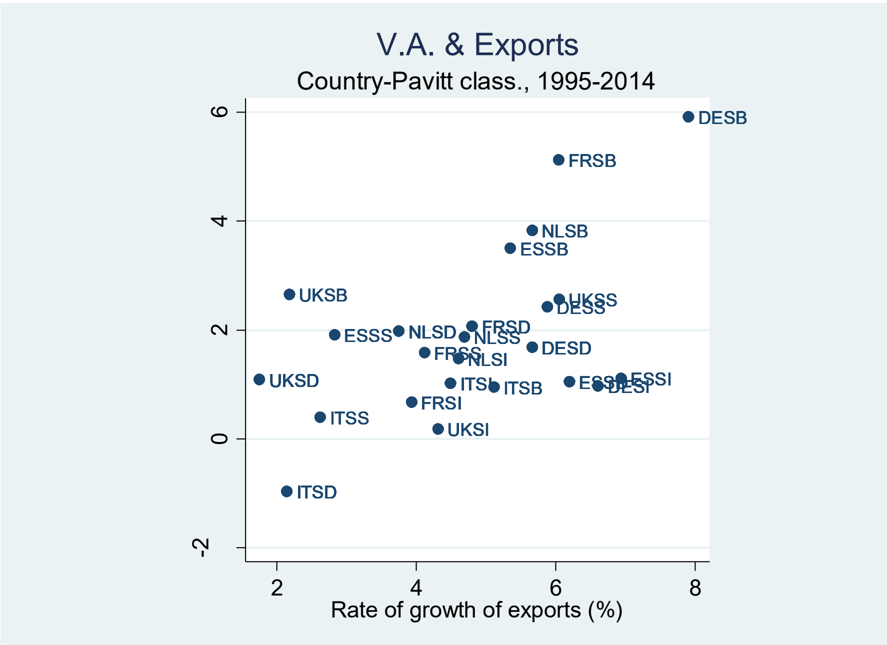
Figure 12.



Source: Our elaboration on Sectoral Innovation Database.

The relationship between exports and growth performance of industries, reported in Figure 13, gives rise to a more heterogeneous picture, marked by German high-tech industries situated in the north-east area of the figure, while Italian traditional industries occupy the south-west position. On the one hand, we find the expected positive association between exports and value added growth, confirming the ability of technologically advanced industries to attract increasing flows of foreign demand; on the other hand, we note that also Scale and Information intensive as well as Supplier dominated sectors of Germany, Spain and France have registered good exports performance over the period.

Figure 13.



Source: Our elaboration on Sectoral Innovation Database.

2.6 The offshoring dynamics

Taking advantage of the Input-Output data provided by WIOD (Timmer et al., 2015), we move now to the analysis of offshoring patterns of countries under investigation, with the aim of accounting for the growing international fragmentation of production and of the transnational value chains in which industries are involved. Although the intensity of this processes and the analytical reconstruction of global networks of production would require deeper research, the following figures allow to appreciate the relevance of the phenomenon and some aspects of its evolution over time. Most important, we also focus on the technological dimension of offshoring, trying to grasp the underlying strategies which drive the involvement of industries and countries in global value chains.[36]

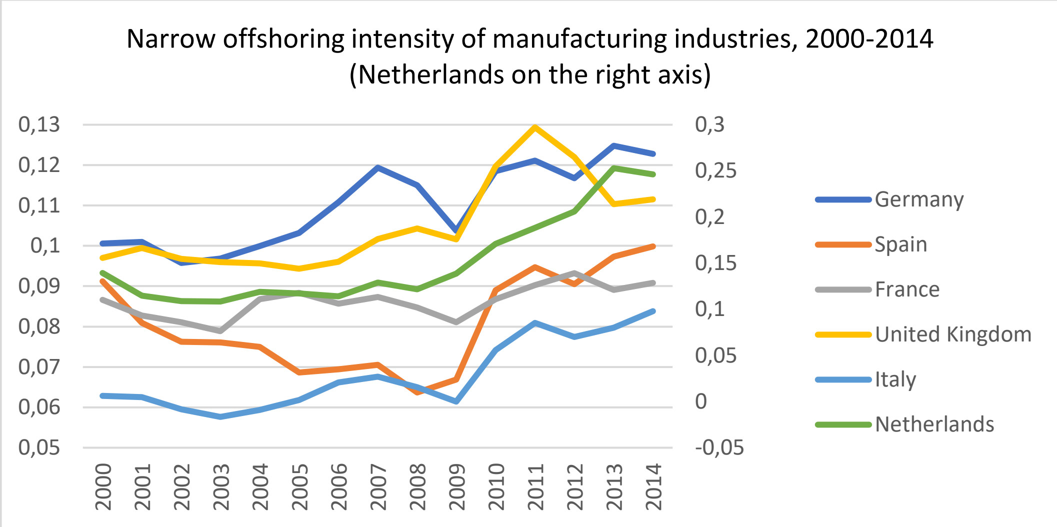
Figure 14 and 15 report the different intensity with which manufacturing and service industries of our six countries pursued offshoring strategies from 2000 to 2014, respectively. For this purpose, the figures provide the evolution of the narrow offshoring indicator (proposed by Feenstra and Hanson, 1999), which accounts for the fragmentation of production within industries as measured by the ratio between the expenditure of manufacturing (service) industries for the intermediate inputs imported from foreign manufacturing (service) industries of the same kind and the expenditure for total intermediate inputs purchased to produce. As expected, the nature of manufacturing production (i.e. the higher tradability of intermediate goods used) leads this kind of industries to be much more concerned with global fragmentation of production than service industries.[37]

Figure 14 shows that there has been a general increase in the disintegration of production in the manufacturing sector over the period as in 2014 the narrow offshoring indicator for such sector registered a value higher than the one recorded in 2000 for all the countries considered. Germany and the United Kingdom emerge as the countries which pursued most intensively offshoring strategies, although the offshoring indicator for the latter country showed a decline in recent years. In any case, given the very different weight of manufacturing sector in these two countries, it is likely that the underlying dynamics that drive their integration in the global network of production are not assimilable. In other words, while Germany is at the centre of the so-called Central European Manufacturing Core (IMF, 2013; Foster-McGregor et al., 2013; Landesmann et al., 2015; Stehrer and Stöllinger, 2015) – mainly constituted by value chains which connect the German production system with Central and Eastern European countries – the highly fragmented manufacturing industry of the United Kingdom is likely the consequence of the process of deindustrialization that has suffered its economy since the end of the Nineties. With regard to the other countries, France has not recorded significant increases in the offshoring indicator over the period, showing an almost flat line; Spain is the only country whose internationalization of production registered a decreasing trend at the beginning of the 21st century, albeit it sharply reversed upward with the outbreak of the economic crisis. The same strong increase of the offshoring indicator since 2009 is common also to the Netherlands and Italy, although the manufacturing industry of the latter appears far less integrated in global value chains than all the other countries.

[36] Industries whose Revised Pavitt classification is not available have been excluded. In particular, we excluded the following thirteen sectors over the fifty-six ones reported by WIOD: crop and animal production and hunting; forestry and logging; fishing and aquaculture; mining and quarrying; electricity and gas; water collection; sewerage and other waste management services; construction; public administration, defence and compulsory social security; education; human health and social work activities; activities of households as employers; activities of extraterritorial organizations. See the final Appendix on the SID database.

[37] Note that in all the four following figures, i.e. Figure 14, 15, 16 and 17, the offshoring indicator values for the Netherlands are reported on the right axis, since the small dimension of Dutch economy is such that it shows a much greater share of imported intermediate inputs over the total intermediate inputs used for production.

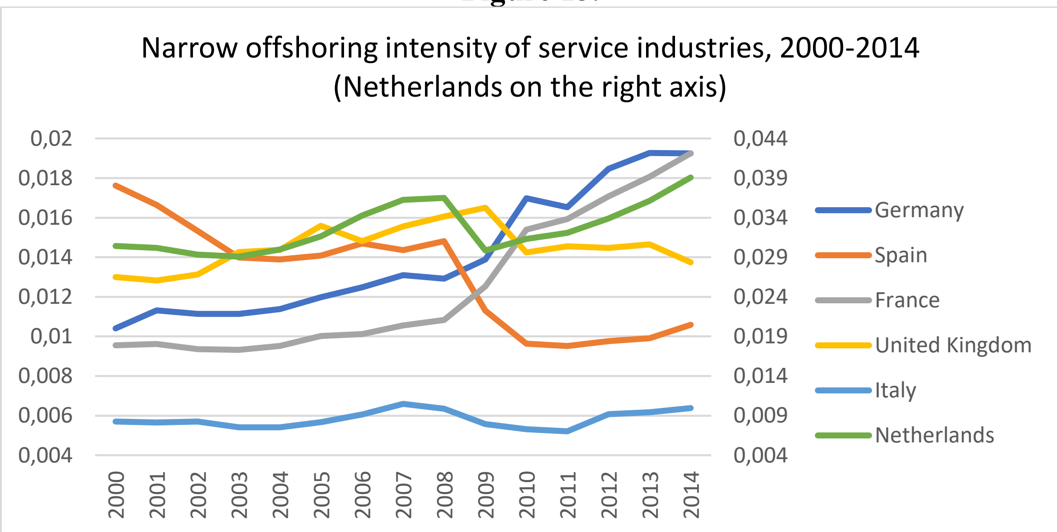
Figure 14.



Source: Our elaboration on WIOD database.

Figure 15, which reports the dynamics of fragmentation of service industries, provides a more complex picture. Germany and France showed a slightly growing trend which strongly increases after the burst of the crisis, while the United Kingdom service sector registered the opposite, with a slightly growing trend from 2000 to 2009 and a sharp decrease from 2010 to 2014. The Netherlands experienced a reduction of the offshoring indicator in 2009, but since 2010 it initiated a new sudden rise. As regards Spain, the sharp increase of international fragmentation of manufacturing production documented above has been partly counterbalanced by the fall registered in the share of foreign sourced intermediate inputs used in service production since 2009. Finally, as was for the manufacturing sector, Italy's service sector shows the lowest offshoring values, with a flat trend over the whole period.

Figure 15.

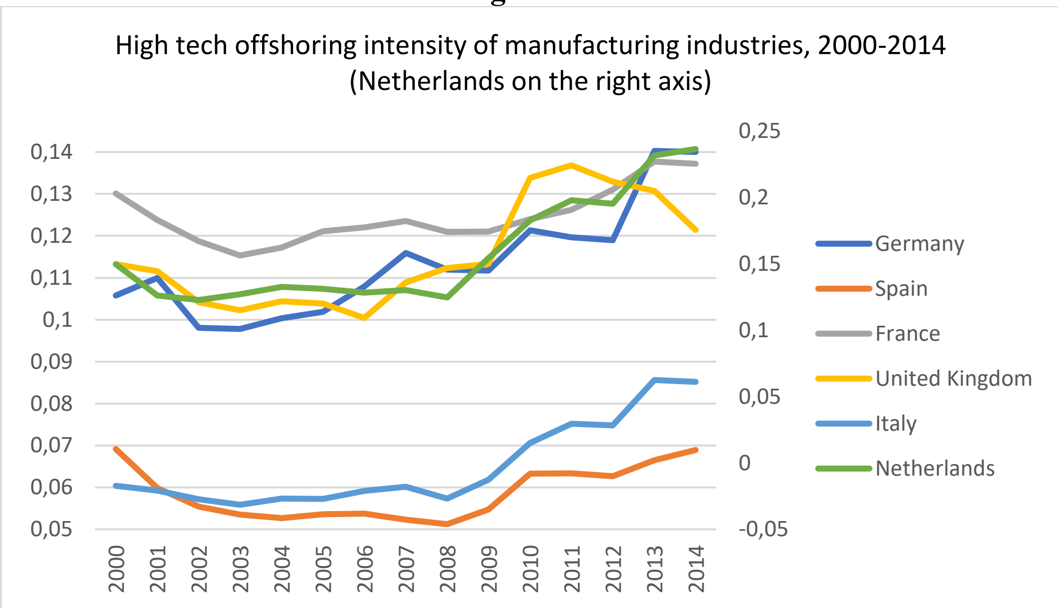


Source: Our elaboration on WIOD database.

Figure 16 and 17 allow us to focus on the technological dimension of internationalization of production, shedding light on the technological content of intermediate inputs sourced from foreign industries as well as on offshoring trajectories of countries. Given the complex and rather marginal offshoring patterns of service sector, these figures report the evolution of high- and low-tech offshoring indicator (Guarascio et al., 2015) for manufacturing industries only.[38]

Figure 16 shows the striking gap between the high-tech offshoring intensity of manufacturing sector of European core countries (i.e. Germany, France, United Kingdom and the Netherlands) and the one of peripheral countries (i.e. Italy and Spain). Although both showed an increasing pattern since the start of the global crisis (Germany reported the sharpest increase), the foreign acquisition of technologically advanced intermediate inputs registered by core countries is about twice the one of the countries belonging to the periphery of European Union. This finding suggests that, on the one hand, the productive specialization of countries has a major role in determining the direction of offshoring strategies of industries and thus the nature of the global production fragmentation patterns; on the other hand, it underlines the limited ability of peripheral countries to gain competitiveness thanks to the technological spillovers stimulated by international trade in knowledge-intensive products.

Figure 16.

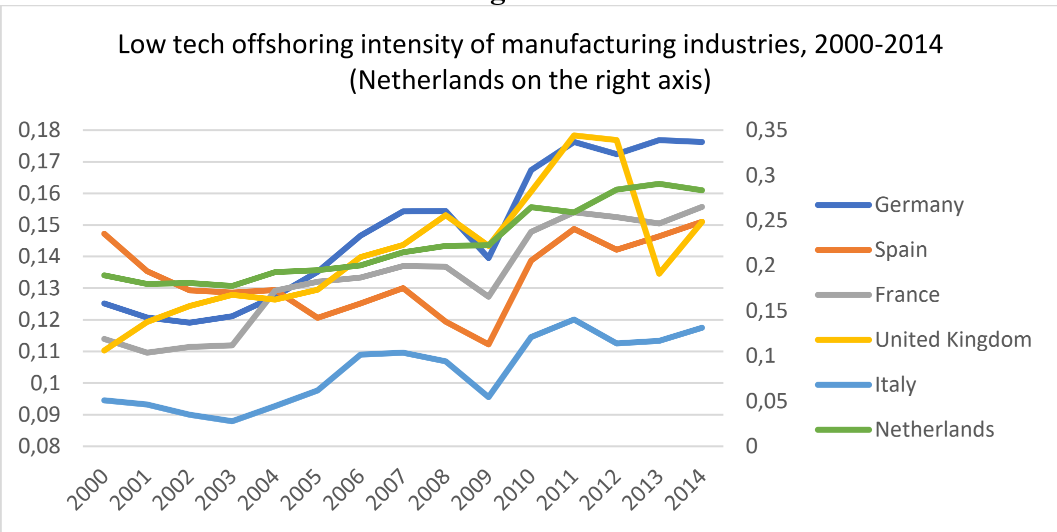


Source: Our elaboration on WIOD database.

The first general result which emerges from Figure 17 is that European manufacturing industries are relatively higher intensive in low-tech offshoring strategies than in high-tech ones; this emerges clear since for all the countries the values of the low-tech offshoring indicator are higher than the ones reported by Figure 16 over the whole period. This finding is consistent with the idea that the internationalization of production processes is pursued by firms mainly to obtain cheaper intermediate inputs and reduce labour costs with the aim of improving efficiency and overcoming production rigidities. The figure shows an increasing trend for all the countries, especially Germany and – albeit with lower absolute values – Spain, United Kingdom being the only one country which seems having experienced a fall in the low-tech offshoring indicator in 2013. Finally, Italian manufacturing industries report growing but constantly lower values of the low-tech offshoring indicator with respect to the other countries, confirming its more modest integration in global supply chains of intermediate inputs.

[38] We remind that the high-tech (low-tech) offshoring indicator is computed as the ratio between the expenditure for imports of intermediate inputs from foreign Science based and Specialized suppliers (Scale and Information intensive and Supplier dominated) industries (Bogliacino and Pianta, 2010, 2016) and the expenditure for total intermediate inputs used for production (Guarascio et al., 2015).

Figure 17.



Source: Our elaboration on WIOD database.

2.7 Offshoring and economic growth

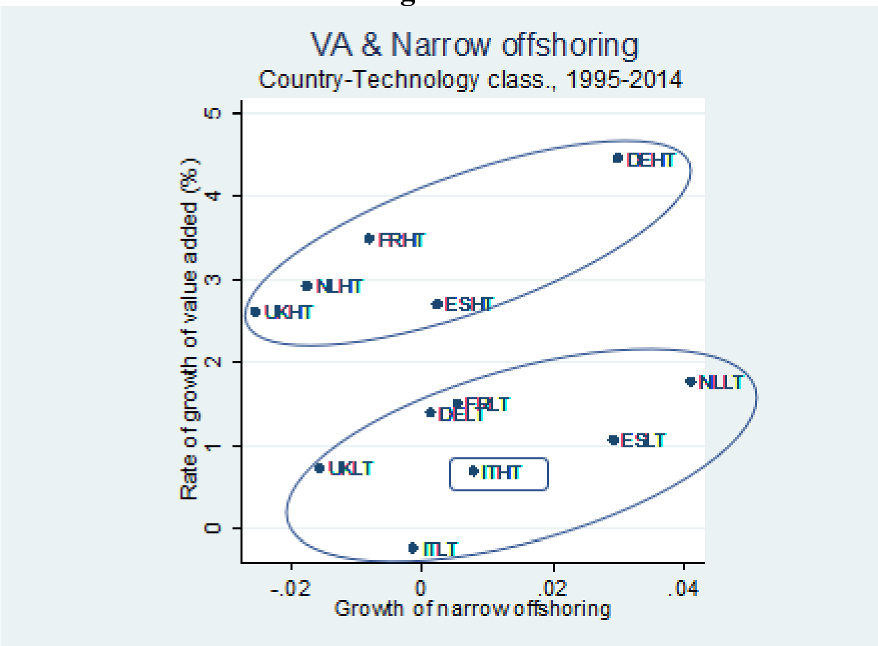
Previous figures allowed to investigate the offshoring intensity of manufacturing and service industries as well as the role played by technology in shaping the trajectories of internationalization of production. The following three figures combine the long-period offshoring dynamics of industries with their economic performance in terms of growth of value added. For this purpose, we follow the procedure already described above and distinguish between high- and low-tech industries cluster on the basis of the Revised Pavitt Taxonomy proposed by Bogliacino and Pianta (2010, 2016), assigning Science based and Specialized Suppliers industries to the former group and Scale and Information intensive and Supplier dominated ones to the latter group.[39] Then, we group industries according to the country and technological cluster they belong and compute the corresponding unweighted average values for the whole period covered by our database.

Figure 18 shows the relationship between the average growth of narrow offshoring indicator and the growth rate of industries. Although high-tech industries registered value added growth rates higher than the low-tech ones, a positive association for both class of industries emerges between the intensity with which sectors pursued strategies of internationalization of production and their growth performance. This result suggests that offshoring activities may be an important factor for the whole economic performance of industries as they may trigger organizational improvements of firms, provide them with cheaper intermediate inputs and allow agglomeration effects which foster increasing returns to scale and accumulation of knowledge, leading to competitiveness increases and quality improvement of products.

Moreover, it is interesting to note that while high-tech German industries are situated in the top-right corner of figure (being the cluster which is grown the most, as well as the most integrated in global value chains), the poor growth performance of Italy is such that not even its high-tech cluster overcomes the low-tech industries of the other countries in terms of value added variation.

[39] See the final Appendix on the SID database for further details on the Revised Pavitt Taxonomy and the list of sectors classified accordingly.

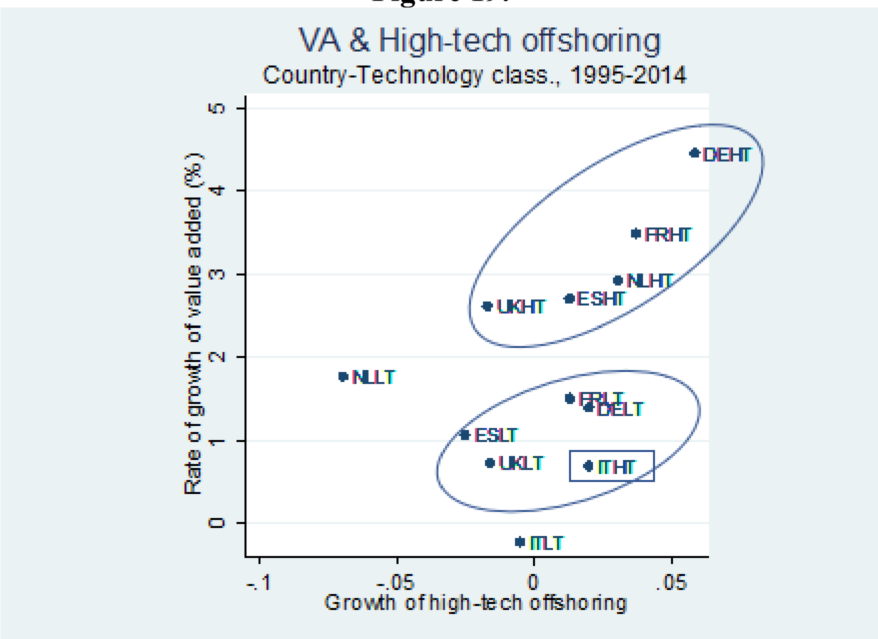
Figure 18.



Source: Our elaboration on Sectoral Innovation Database.

Figure 19 and 20 report respectively the association between technology-driven and cost-based offshoring strategies and high- and low-tech industries' value added growth rate. As expected, two specular findings seem to emerge. As Figure 19 shows, there is a positive association between the intensity with which high-tech industries acquire intermediate inputs from technologically advanced foreign industries and their growth rate, while this relationship is much weaker for low-tech industries.

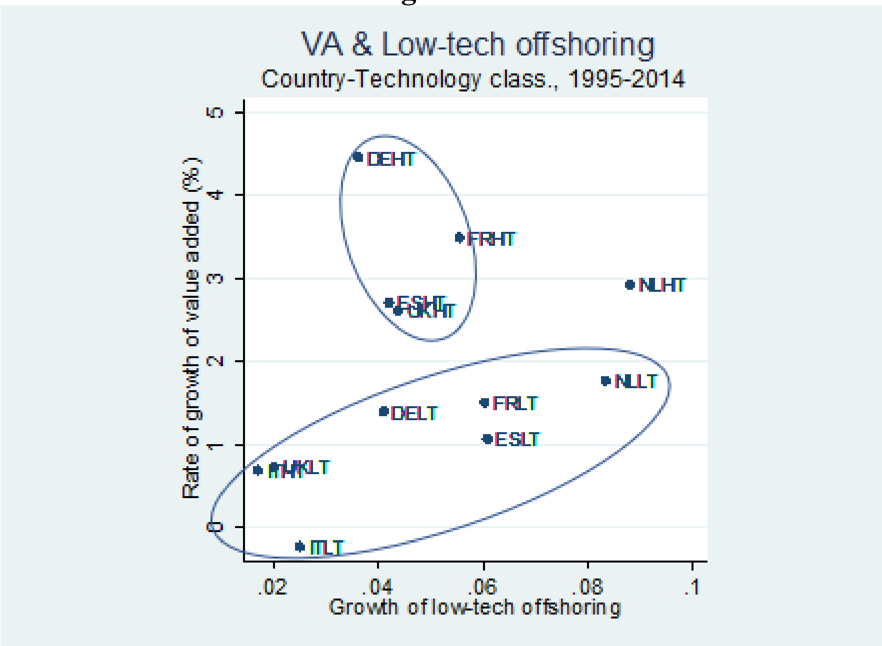
Figure 19.



Source: Our elaboration on Sectoral Innovation Database.

On the contrary, Figure 20 provides evidence about the strongly positive relationship between the increasing purchasing of intermediate inputs from foreign low-tech industries and the growth rate of low-technology clusters of industries; on the other side, albeit also high-tech industries show having pursued intensively the search for cost reduction and efficiency gains through the acquisition of cheap intermediate inputs and foreign sectors, no clear association appears to emerge in relation to their growth performance.

Figure 20.



Source: Our elaboration on Sectoral Innovation Database.

Overall, these findings suggest that the technological regimes of industries fundamentally determine their offshoring strategies as well as the trajectories along which they build international supply chains. While growing internationalization of production may improve competitiveness of industries fostering dynamic economies of scale and opening up new sources of intermediate inputs supply, the increasing import of goods from firms localized abroad (especially whether these are firms belonging to the same industry to which belong the buyer firms, as captured by narrow offshoring indicator) might reduce the domestic value added of industries, resulting in lower patterns of growth.

In the next section the relationships among offshoring dynamics of industries, the technology-push impact of innovations and the evolution of demand are investigated with the help of econometric techniques. Albeit without identifying causal relationships, we try to address the complexity entailed by the uneven process of structural change accounting for both supply- and demand-side factors. In this regard, the several dimensions along which we study the relationships holding among our key variables offer important insights about the structural evolution of the economies over time.

3. The model

3.1 The structural change equation

According to our framework, the process of structural change stems from the uneven growth patterns of industries, whose output dynamics results from the interaction between their technological trajectories and the different growth patterns of demand components. Moreover, as stressed in the final part of previous section, we argue that the increasing fragmentation of production might play a role in shaping the growth performance of industries.

In this section we propose an empirical model to assess the development paths of industries as linked to the rate and direction of technological change, the changing structure and growth rate of domestic and foreign demand and the growing international fragmentation of production.

Building on the theoretical considerations provided in previous sections, we try to describe the growth rates of industries' value added setting up the following log-linear equation:

$$log\left(VA_{ijt}\right) = \alpha_1 log\left(PROD_{ijt}\right) + \alpha_2 log\left(PROC_{ijt}\right) + \alpha_3\, log\left(DOMDEM_{ijt}\right) + \alpha_4 log\left(EXP_{ijt}\right) + \alpha_5 log(OFFSH_{ijt}) + u_{ij} + \varepsilon_{ijt}$$

where i, j and t identify, respectively, industry at two-digit level according to NACE (Rev. 1) classification, country and time.

Although the variation of the share of each sector in the whole economy would be a more proper measure of structural change, growth rates of value added – indicated by VA – allow a better representation of the heterogeneity of sectors.

$PROD$ indicates the share of turnover due to product innovation or the R&D expenditure per employee and captures the industries' efforts in pursuing a technology-driven competitiveness strategy. $PROC$ stands for the share of firms introducing process innovation at industry level or the expenditure in new machinery and equipment per employee and captures the industries' efforts in pursuing a cost-based competitiveness strategy (Pianta, 2001).

As regards demand variables, $DOMDEM$ indicates the flow of domestic final demand while EXP captures the flow of exports of industries.

Finally, $OFFSH$ stands for the offshoring indicator, capturing the role of international fragmentation of production.[40] The measures of offshoring process that we implement in our model include both a narrow offshoring indicator (Feenstra and Hanson, 1999) and a technology-based offshoring proxy introduced by Guarascio et al. (2015). The latter enables to distinguish between high-tech and low-tech offshoring strategies according to the nature of knowledge, patterns of innovation and market structure of foreign industries from which the inflow of imported intermediate inputs origins – as described above, this distinction relies on the Revised Pavitt taxonomy developed by Bogliacino and Pianta (2010, 2016).

By taking the first difference of the equation we get rid of the time-invariant components, reducing the endogeneity bias. Hence the final formulation of the value added dynamics is the following:

$$\Delta log\left(VA_{ijt}\right) = \alpha_1 \Delta log\left(PROD_{ijt}\right) + \alpha_2 \Delta \log\left(PROC_{ijt}\right) + \alpha_3 \Delta\, log\left(DOMDEM_{ijt}\right) + \alpha_4 \Delta log\left(EXP_{ijt}\right) + \alpha_5 \Delta log(OFFSH_{ijt}) + \Delta\varepsilon_{ijt}$$

As it has already been stated, the variables regarding value added and demand components are computed as compound annual average rate of change which proxies the difference in logarithmic terms. Overall, our expectation is that the growth of value added be strongly associated with the

[40] Values of all the offshoring variables have been multiplied by 100.

variables capturing the innovative efforts aimed at pursuing a technology-driven strategy and, on the other side, a general weaker positive association with the process-innovation intensity of industries.

We expect that industries characterized by a high rate of technological change driven by R&D expenditures, product innovations and a deeper integration into high-technology global value chains to be those with the greatest growth potential, as their technological trajectory leads them to compete on high-value added productions that allow them to intercept a growing demand. Since the demand is never equal to itself but changes over time as a result of income growth and human learning processes, this means that the most dynamic industries are expected to be those with a higher income elasticity of demand, i.e. those able to develop new high-quality products stemming from high research efforts and technology-driven offshoring strategies. Moreover, the inclusion of demand variables has to be interpreted as an effort to account for the key role that the structure and growth rate of demand plays in driving the growth paths of industries. Although our model simplifies the complexity of this relation, the challenge consists in assessing the general relationships which link the technological and growth performance of industries to the demand dynamics.

3.2 Econometric strategy

Although we do not pretend to identify causal relationships among the variables under investigation, we make use of a series of precautions to better assess the associations that might subsist between the growth rate of industries and the innovation, demand and offshoring dynamics. Hence, the econometric strategy adopted relies on panel data techniques suitable for dealing with datasets marked by a large cross sectional and relatively reduced temporal dimension.

First, the estimation procedure is performed after having differentiated the equations to get rid of any time-invariant individual effects. Considering that the latter may have a simultaneous impact on both the dependent variable and the regressors – leading to biased estimates –, first-differencing removes this source of endogeneity. Furthermore, we calculate long differences with two- to five-years lags, softening considerably the autoregressive character of variables. As already mentioned, offshoring indicators are computed as simple difference while value added, final domestic demand and exports are computed as compound average annual rate of variation over the following periods: 1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014.

Second, the temporal structure of the panel is designed to harmonize the different sources of data we exploit and, remarkably, to account for the time needed by innovation to unfold its economic effects. Except for the last period (for which the timing of the CIS waves does not allow us to account for a time lag), innovation variables – i.e. $PROD$ and $PROC$ – refer to a lagged period as compared to dependent economic variable (i.e. value added growth rate). Indeed, the former refer to the following periods: 1994-1996, 1998-2000, 2002-2004, 2008-2010, 2012-2014. This allows us to reduce the presence of simultaneity-related endogeneity and to account, at once, for the time required by our innovation proxies to impact on growth patterns of industries.

Third, we include a set of time, country and Pavitt dummies as additional control, with the aim of reducing the endogeneity bias which may stem from other sources of observable heterogeneity. Primarily, time dummies are conceived as essential to control for the business cycle; otherwise, time-specific effects – that likely impact on all variables under observations – would be captured by the error term worsening specification problems. Nevertheless, from a theoretical point of view, country and sectoral dummies are fundamental tools to control for, respectively, national and sectoral systems of innovation (Freeman, 1995; Lundvall, 1992; Malerba, 2002, 2004a). Regarding the former, the complex institutional features of countries represent a source of heterogeneity which is likely to have an effect on the development paths of industries and degree of uncertainty regarding the outcome of innovation efforts. On the other hand, Pavitt dummies account explicitly for the technological and structural patterns of industries avoiding the risk of multicollinearity that would be induced by the inclusion of a great number of sector-specific dummies; moreover, too many dummy variables may prevent the model to get a sufficient number of degrees of freedom for adequately powerful statistical tests.

Fourth, we adopt an interaction terms technique to assess the heterogeneity which emerges when industries are grouped in clusters according to specific structural dimensions (i.e. the four key sources of heterogeneity detected in Section 1 of the present chapter). In particular, the interaction technique permits to address, without any loss of observations, potential "breaks" in the relationships under investigation allowing heterogeneity of model's slope and intercept when specific dichotomies are explicitly accounted for.

Fifth, estimations are performed using the weighted least squares (WLS) estimator. The reason lies in the fact that industry data are grouped data of unequal size, thus their contribution in terms of information is asymmetric, affecting the consistency of the estimator (Wooldridge, 2002). Following Guarascio and Pianta (2016), we achieve consistency using the number of employees in the sectors (as observed in the first year of each economic period) as weights.

Sixth, it is well known that industry-level data are usually affected by heteroskedasticity and, not unexpectedly, the results of the Breusch-Pagan test performed on baseline WLS regressions confirms that the variance of the error term differ across observations. Therefore, we carry out all the estimations applying heteroskedasticity- and autocorrelation-robust standard errors.[41]

Finally, we perform our investigation using two sets of innovation variables; as discussed above, we employ proxies of both the innovative efforts of industries aimed at introduction innovation (innovation input variables) and proxies of the outcome of those innovation efforts (innovation output variables), accounting for the potential heterogenous role that they may have on the industry performance.

4. Results

As discussed in previous section, we conceive structural change as the dynamic outcome of the uneven growth patterns of industries. In this section we report the empirical results of the performed estimations of our structural change equation, having the growth of value added of industries as dependent variable. Notably, we estimated the equation exploiting the interaction terms technique to account for all the sources of heterogeneity – described in Section 1 of the present chapter – which are supposed to shape the set of relationships under investigation and thus providing a better assessment of the dimensions of the process of structural change.

Table 6 reports the results of the estimation of the baseline equation. The first three columns present the estimations performed using input-innovation variables – i.e. R&D and new machinery expenditure per employee –, while the last three columns the ones using output-innovation variables – i.e. turnover due to product innovation and share of firms introducing process innovation. Starting from the first three specifications, we note that both the expenditure in R&D and new machinery and equipment show a positive association with the growth rate of industries; nonetheless, the former turns out more significant than the latter, suggesting a link between the search for high-technology advancements and the industries' rate of growth. As expected, both domestic and foreign demand present a positive correlation with the performance of industries, while the role of offshoring emerges more differentiated. When controlling for the indicator of narrow offshoring (column 2) – which proper captures the industry-specific disintegration of production, as accounts for the share of intermediate inputs bought from foreign industries of the same kind of the buyer industry over the total intermediate inputs used for production – we find that it shows a strongly positive association with the growth rate of industries' value added. Most interesting, when we split the indicator to account for the technological content of offshoring activities, we find that the positive role they seem to exert on the performance of industries is driven by the high-tech offshoring, while the low-tech one shows a nonsignificant negative coefficient. These finding highlights that the technological dimension of offshoring has a role with respect to the structural change process, since the

[41] See the Appendix of the present chapter for further robustness tests about the estimated equations.

internationalization of production is not indistinctly associated with a better performance of industries.

When we move our attention to the last three columns of Table 6, we find that the results are significantly consistent with the ones already discussed. Nonetheless, it may be of interest focusing on the differences to grasp potential insights. First, we note that our process innovation proxy is as significant as the product innovation variable, suggesting that industries which have success in introducing efficiency-enhancing innovations get rewards in terms of value added growth. Second, the coefficients of demand components still show that the ones related to the dynamics of domestic final demand are higher than the ones of exports, may be suggesting the importance for the European economies of a sustained dynamics of domestic consumptions with respect to the more volatile international trade. Third, we note that narrow and high-tech offshoring lose significance, albeit maintaining a positive sign, while the negative association between the low-tech strategies of offshoring and the value added growth rate of industries turns out reinforced, confirming that sectors which pursue most intensively a cost-based policy of competitiveness tend to get lower growth rates.

Table 7 reports estimation results distinguishing between manufacturing and service industries and accounting for input-innovation variables. The first striking difference that we note concern the role of technological change. As expected, manufacturing industries are confirmed as the main source of technological progress, showing that their growth dynamics mainly relies on R&D expenditure. On the contrary, service industries present a positive and significant relation with the expenditure in new machinery and equipment, confirming their nature of "producer users" of manufacturing industries. As regards the role of demand components, the export vocation of manufacturing industries is confirmed, as the positive and strongly significant exports coefficients for these industries show. Conversely, service industries present final domestic demand coefficients more significant and higher than exports ones. Notably, these findings are broadly unchanged when we move to Table 8, which reports the estimations using output-innovation inputs. Consistently, when we account for these latter proxies of innovation we find that, albeit investing less in R&D, also the service industries reap rewards in terms of growing value added insofar as have success in introducing product innovations. Focusing on the offshoring indicators, we do not note substantial differences between Table 7 and Table 8, the main finding being that, as expected, offshoring strategies are mostly pursued by manufacturing industries; coefficients referring to service industries turns out not significant and always show a negative sign, suggesting that they occupy an inferior positioning along transnational value chains. In the other hand, the technological dimension of offshoring strategies strikingly emerges from the coefficients related to manufacturing industries. Consistently, the high-tech offshoring indicator present in both tables positive and significant coefficients, while the low-tech ones show about the same magnitude but with a negative sign. We interpret this finding as a confirmation that knowledge spillovers implied by international trade of intermediate goods – whose technological content alloes the organizational and production techniques upgrading of firms – turns out to be crucial for the growth performance of manufacturing industries.

Table 9 reports the results of the estimations of our structural equation using input-innovation variables and the distinguishing between the growth performance of Science based and Specialized suppliers industries, which compose the high-tech cluster, and Scale and information intensive and Supplier dominated industries, which compose the low-tech cluster. As expected, we note that both R&D and new machinery expenditure per employee show a positive and significant association with the growth rate of high-tech industries. Rather surprisingly, the low-tech cluster of industries presents positive and significant coefficients related to the expenditure in R&D, while our proxy of input-innovation capturing the efforts to introduce new process turns out not significant. Conversely, whether we focus on Table 10 – reporting the results of the estimations performed with the same clustering but including output-innovation variables – we find that the relationships that emerge are exactly as expected. More precisely, Table 10 shows that the variable proxying a technology-driven competitiveness strategy, i.e. turnover due to new or improved product, always presents a strongly positive association with the growth rate of high-tech industries, while the variable proxying a cost-based competitiveness strategy, i.e. share of firms introducing process innovation, presents all the time a strongly positive relationship with performances of low-tech cluster only. We speculate that these apparently contrasting findings stemming from the innovation dynamics documented by Table 9 and 10 might be due to the fact that our input- and output-innovation variables capture heterogeneous dynamics within the clusters. In particular, whether industries belonging to the low-tech cluster generally reap rewards in terms of growing value added from the successful introduction of process innovation, low-tech industries which put major efforts in R&D expenditure are those which grow the most.

Turning our attention on demand dynamics, we find the confirmation that industries for which the exports coefficients are strong and significant are the high-tech ones. This result underlines the crucial prominence of technology in international trade and accounts for the major role that absolute advantages given by the quality of products have in driving the dynamics of global competitiveness of industries together with their growth performance (Dosi et al., 2015; Guarascio and Pianta, 2016; Guarascio et al., 2016). Finally, Table 9 and 10 report consistent results concerning the connection between offshoring and value added dynamics of industries. Both tables report that high-tech industries which pursue relatively more intensively offshoring activities experiment higher growth rates, albeit when we distinguish the such activities according to their technological content the high-tech offshoring indicator maintains a positive sign but loses significance, while the impact directly to the detriment of value added generation emerges clearly. On the other side, coefficients of offshoring indicators turn out constantly nonsignificant for the low-tech cluster of industries, suggesting that the latter are little involved in global value chains.

Table 11 and 12 address the core-periphery dimension and report empirical evidence about the way in which the structural relations under investigation are shaped by the belonging of industries to different clusters of countries. As expected, Table 11 shows a positive and significant association between the expenditure in R&D – which in our framework represents a proxy for technology-driven competitiveness strategy – and the growth patterns of core countries' industries; conversely, the opposite emerges as regards industries belonging to peripheral countries, whose poorer production matrix leads them to rely mostly on competitiveness strategies aimed at reducing costs and improving efficiency. Such finding is strongly confirmed also by Table 12 – which reports results of the estimated regressions including output-innovation variables –, the only difference being that growth patterns of core countries' industries result positively associated also with the share of firms introducing process innovation at industry level. This finding suggests that core countries get strong production efficiency together with product quality improvements, i.e. produce high-value added products with relatively low prices –, while peripheral countries pursue mainly low-road strategies of competitiveness aimed at aimed at reducing production costs through the introduction of labour-saving innovations.

Furthermore, both tables show that the dynamics of demand components play a crucial role in driving the process of structural change of countries. Notably, the coefficients of domestic final demand for peripheral countries present always higher values then those related to core countries, suggesting that the growth patterns of industries belonging to peripheral countries relies more on the dynamics of internal demand with respect to core countries, whose stronger technological capabilities allow them to better capture the flows of foreign demand.

Focusing on the offshoring dynamics, we note that the growth of value added of core countries present a positive and significant association with the narrow offshoring indicator, suggesting that the involvement in global value chains represent for them a valuable strategy to gain competitiveness. Moreover, when we split the offshoring indicator in Table 11 with the aim of capturing the technological dimension of international fragmentation of production, we note that the coefficient of high-tech offshoring turns out positive and significant for core countries only, while the low-tech offshoring indicator shows a negative and nonsignificant coefficient (results reported in Table 12 are consistent with these findings, the only difference being that the high-tech offshoring indicator loses significance while maintains a positive sign, while the low-tech offshoring indicator maintains a negative sign and turns out weakly significant). Conversely, offshoring coefficients are never significant for peripheral countries and in Table 12 also the high-tech offshoring indicator turns out to have a negative sign. These results are consistent with a reading according to which core countries occupy a dominant positioning along global value chains and the acquisition of intermediate inputs from foreign industries allow them to acquire products complementary to their productive matrix, while for peripheral countries the internationalization of production seems to be associated with a weakening of their industrial structure.

Table 13 and 14 assess the way in which the process of structural change, defined by the uneven growth patterns of industries, is shaped by the business cycle. The tables split the performance of industries to address the heterogeneity affecting the relationships between the structural factors we account for and the dynamics of industries value added during upswings – represented by the time periods 1996-2000, 2003-2008, 2012-2014 – and downswings – constitute by the periods 2000-2003 and 2008-2012. As expected, Table 13 shows that innovative efforts aimed at product quality improvements and technological upgrading are associated with the upswing phases of business cycle, when growing demand and expanding markets allow to successfully pursue technology-driven competitiveness strategies. Conversely, during recessions a lower profitability breaks down the relationship between R&D expenditure and value added growth of industries, with the latter putting greater efforts in processes of production restructuring – consistently, the coefficient related to the expenditure in new machinery and equipment turns out significant (except for the specification reported in column 3). However, result reported by Table 14 are not fully consistent with this story. First, during upswings industries performance shows a rather strong association not only with the turnover due to new products, but also with the relatively intensity with which they introduce process innovations. Second, during downswings our product innovation proxy turns out strongly significant, while our variable capturing process innovation is nonsignificant. Although these findings are quite puzzling, we speculate that the results of the tables which refer to the upward phases might be consistent, since we detect a positive association between the value added growth of industries with the R&D expenditure and the successful introduction of innovations, both product and process ones, on the one hand. On the other hand, during downswings industries with higher turnover due to product innovation experience higher growth rates, while at the same time they put efforts to reduce costs through the acquisition of new machinery and equipment.

From Table 13 and 14 major differences do not emerge as regards the changing patterns of demand components. While the coefficients of domestic final demand are constantly positive and significant, the ones related to exports – albeit positive – turns out nonsignificant during downward phases, suggesting that the collapse of international trade linked to recession phases weakens the "exports pull" effects. Finally, the offshoring strategies seems to have a role in shaping the structural economic dynamics of industries during upward phases of business cycle only, since the coefficients of all the indicators of internationalization of production turn out nonsignificant during recessions. The analysis of the technological trajectories of offshoring strategies shows clearly that the patterns of global production fragmentation which are positively associated with increases in value added are those driven by the foreign acquisition of intermediate inputs from high-tech industries, stressing that the connection between offshoring activities and economic growth is structurally mediated by technology.

Table 6. Baseline equation

	(1)	(2)	(3)		(4)	(5)	(6)
ΔVA ΔVA ΔVA	ΔVA	ΔVA	ΔVA	ΔVA ΔVA ddddΔVA	ΔVA	ΔVA	ΔVA
R&D exp. per emp.	0.163***	0.150***	0.151***	Turnover due to new or improved products	0.0570***	0.0557***	0.0557***
	(0.0456)	(0.0459)	(0.0465)		(0.0143)	(0.0142)	(0.0142)
Expenditure in new mach. and equipment per emp.	0.205*	0.207*	0.226**	Share of firms introducing process innovation	0.0385***	0.0374***	0.0398***
	(0.107)	(0.106)	(0.110)		(0.0108)	(0.0107)	(0.0111)
ΔDomestic final demand	0.165***	0.179***	0.178***	ΔDomestic final demand	0.182***	0.192***	0.188***
	(0.0274)	(0.0270)	(0.0274)		(0.0257)	(0.0257)	(0.0256)
ΔExports	0.0907***	0.0842***	0.0882***	Δexports	0.0618**	0.0611**	0.0655**
	(0.0295)	(0.0298)	(0.0314)		(0.0254)	(0.0264)	(0.0277)
ΔNarrow offshoring		0.243***		Δnarrow offshoring		0.113	
		(0.0899)				(0.0776)	
ΔOffshoring HT			0.205**	Δoffshoring HT			0.0864
			(0.103)				(0.0933)
ΔOffshoring LT			-0.0739	Δoffshoring LT			-0.115*
			(0.0655)				(0.0638)
Time, country and Pavitt dummies	Yes	Yes	Yes	Time, country and Pavitt dummies	Yes	Yes	Yes
Observations	833	824	823	Observations	786	778	776
R-squared	0.366	0.383	0.381	R-squared	0.414	0.423	0.426

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. All the innovation variables present a lag (except for the last period) according to the time structure of the panel.

Table 7. Manufacturing vs. Service industries (input-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	Manufacturing	*Services*	*Manufacturing*	*Services*	*Manufacturing*	*Services*
R&D exp. per emp.	0.237***	0.0521	0.243***	0.0338	0.226***	0.0664
	(0.0447)	(0.0831)	(0.0455)	(0.0790)	(0.0446)	(0.0818)
Expenditure in new mach. and equipment per emp.	-0.123	0.890***	-0.125	0.886***	-0.103	0.830***
	(0.122)	(0.174)	(0.121)	(0.173)	(0.124)	(0.172)
ΔDomestic final demand	0.0973***	0.260***	0.106***	0.281***	0.111***	0.269***
	(0.0225)	(0.0436)	(0.0223)	(0.0436)	(0.0217)	(0.0442)
ΔExports	0.211***	0.0594*	0.205***	0.0535	0.209***	0.0677**
	(0.0339)	(0.0308)	(0.0363)	(0.0342)	(0.0370)	(0.0336)
ΔNarrow offshoring			0.0864	0.453		
			(0.0763)	(0.291)		
ΔOffshoring HT					0.250***	-0.269
					(0.0868)	(0.230)
ΔOffshoring LT					-0.205***	-0.0322
					(0.0620)	(0.101)
Time and country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	833	833	824	824	823	823
R-squared	0.421	0.421	0.437	0.437	0.446	0.446

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the R&D expenditure per employee and expenditure in new machinery and equipment per employee present a lag (except for the last period) according to the time structure of the panel. The list of manufacturing and service sectors is reported in the final Appendix on the SID database.

Table 8. Manufacturing vs. Service industries (output-innovation variables)

	(1)		(2)		(3)	
	ΔVA		ΔVA		ΔVA	
	Manufacturing	*Services*	*Manufacturing*	*Services*	*Manufacturing*	*Services*
Turnover due to new or improved products	0.0555*** (0.0173)	0.0640*** (0.0217)	0.0548*** (0.0173)	0.0612*** (0.0213)	0.0534*** (0.0171)	0.0513** (0.0204)
Share of firms introducing process innovation	0.0175 (0.0116)	0.0488*** (0.0167)	0.0181 (0.0118)	0.0467*** (0.0168)	0.0165 (0.0116)	0.0527*** (0.0172)
ΔDomestic final demand	0.114*** (0.0222)	0.238*** (0.0434)	0.118*** (0.0222)	0.257*** (0.0454)	0.121*** (0.0217)	0.243*** (0.0451)
ΔExports	0.188*** (0.0350)	0.0283 (0.0256)	0.187*** (0.0370)	0.0295 (0.0290)	0.198*** (0.0377)	0.0414 (0.0279)
ΔNarrow offshoring			0.0390 (0.0752)	0.188 (0.240)		
ΔOffshoring HT					0.201** (0.0805)	-0.449** (0.205)
ΔOffshoring LT					-0.179*** (0.0653)	-0.0437 (0.0986)
Time, country and Pavitt dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	778	778	776	776
R-squared	0.442	0.442	0.451	0.451	0.469	0.469

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the turnover due to new or improved products and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel. The list of manufacturing and service sectors is reported in the final Appendix on the SID database.

Table 9. High-tech vs. Low-tech industries (input-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	High-tech industries	*Low-tech industries*	*High-tech industries*	*Low-tech industries*	*High-tech industries*	*Low-tech industries*
R&D exp. per emp.	0.104**	0.191**	0.0931*	0.188**	0.113**	0.178**
	(0.0501)	(0.0874)	(0.0502)	(0.0886)	(0.0498)	(0.0902)
Expenditure in new mach. and equipment per emp.	0.531**	0.0618	0.524**	0.0674	0.579**	0.0825
	(0.215)	(0.139)	(0.211)	(0.140)	(0.228)	(0.143)
ΔDomestic final demand	0.183***	0.167***	0.205***	0.173***	0.184***	0.176***
	(0.0408)	(0.0261)	(0.0421)	(0.0266)	(0.0373)	(0.0264)
ΔExports	0.193***	0.0356	0.170***	0.0385	0.210***	0.0364
	(0.0387)	(0.0270)	(0.0386)	(0.0281)	(0.0376)	(0.0281)
ΔNarrow offshoring			0.288**	0.0750		
			(0.126)	(0.0925)		
ΔOffshoring HT					0.172	0.190
					(0.127)	(0.149)
ΔOffshoring LT					-0.523***	-0.0247
					(0.184)	(0.0565)
Time, country and Pavitt dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	833	833	824	824	823	823
R-squared	0.404	0.404	0.416	0.416	0.424	0.424

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the R&D expenditure per employee and expenditure in new machinery and equipment per employee present a lag (except for the last period) according to the time structure of the panel. High-tech cluster is composed by Science based and Specialized suppliers industries; Low-tech cluster is composed by Scale and information intensive and Supplier dominated industries (Bogliacino and Pianta, 2010, 2016). See the final appendix on the SID database for further detail.

Table 10. High-tech vs. Low-tech industries (output-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	High-tech industries	*Low-tech industries*	*High-tech industries*	*Low-tech industries*	*High-tech industries*	*Low-tech industries*
Turnover due to new or improved products	0.0880***	0.0188	0.0903***	0.0184	0.0851***	0.0185
	(0.0201)	(0.0178)	(0.0202)	(0.0180)	(0.0198)	(0.0178)
Share of firms introducing process innovation	0.00933	0.0380***	0.00479	0.0373***	0.0135	0.0360***
	(0.0149)	(0.0101)	(0.0153)	(0.0102)	(0.0144)	(0.0106)
ΔDomestic final demand	0.180***	0.176***	0.198***	0.180***	0.175***	0.184***
	(0.0385)	(0.0251)	(0.0398)	(0.0255)	(0.0338)	(0.0255)
ΔExports	0.129***	0.0337	0.114***	0.0375	0.149***	0.0377
	(0.0337)	(0.0243)	(0.0340)	(0.0256)	(0.0329)	(0.0264)
ΔNarrow offshoring			0.219**	-0.0180		
			(0.104)	(0.0897)		
ΔOffshoring HT					0.0669	0.144
					(0.121)	(0.151)
ΔOffshoring LT					-0.471***	-0.0410
					(0.169)	(0.0574)
Time and country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	778	778	776	776
R-squared	0.431	0.431	0.439	0.439	0.448	0.448

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the turnover due to new or improved products and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel. High-tech cluster is composed by Science based and Specialized suppliers industries; Low-tech cluster is composed by Scale and information intensive and Supplier dominated industries (Bogliacino and Pianta, 2010, 2016). See the final appendix on the SID database for further detail.

Table 11. Core vs. Peripheral countries (input-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	Core	*Periphery*	*Core*	*Periphery*	*Core*	*Periphery*
R&D exp. per emp.	0.221***	-0.0331	0.201***	-0.0358	0.207***	-0.0407
	(0.0475)	(0.0362)	(0.0478)	(0.0363)	(0.0483)	(0.0413)
Expenditure in new mach. and equipment per emp.	0.0938	0.453*	0.0957	0.452*	0.115	0.440*
	(0.108)	(0.236)	(0.107)	(0.235)	(0.113)	(0.239)
ΔDomestic final demand	0.142***	0.217***	0.161***	0.220***	0.164***	0.215***
	(0.0317)	(0.0360)	(0.0311)	(0.0372)	(0.0316)	(0.0382)
ΔExports	0.0887***	0.0950***	0.0780**	0.0927**	0.0827**	0.0962**
	(0.0340)	(0.0355)	(0.0341)	(0.0360)	(0.0361)	(0.0391)
ΔNarrow offshoring			0.358***	0.0509		
			(0.112)	(0.105)		
ΔOffshoring HT					0.248*	0.0875
					(0.135)	(0.128)
ΔOffshoring LT					-0.0668	-0.0560
					(0.0814)	(0.0978)
Time and country dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	833	833	824	824	823	823
R-squared	0.374	0.374	0.395	0.395	0.389	0.389

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the R&D expenditure per employee and expenditure in new machinery and equipment per employee present a lag (except for the last period) according to the time structure of the panel. Core countries are France, Germany, the Netherlands and the United Kingdom; peripheral countries are Italy and Spain.

Table 12. Core vs. Peripheral countries (output-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	Core	*Periphery*	*Core*	*Periphery*	*Core*	*Periphery*
Turnover due to new or improved products	0.0790*** (0.0192)	0.0208 (0.0174)	0.0785*** (0.0192)	0.0212 (0.0176)	0.0760*** (0.0193)	0.0223 (0.0175)
Share of firms introducing process innovation	0.0261** (0.0128)	0.0726*** (0.0175)	0.0223* (0.0128)	0.0742*** (0.0178)	0.0289** (0.0134)	0.0726*** (0.0186)
ΔDomestic final demand	0.161*** (0.0295)	0.220*** (0.0335)	0.173*** (0.0297)	0.220*** (0.0346)	0.171*** (0.0297)	0.217*** (0.0346)
ΔExports	0.0512* (0.0295)	0.0952*** (0.0315)	0.0483 (0.0304)	0.0951*** (0.0323)	0.0538* (0.0322)	0.0945*** (0.0332)
ΔNarrow offshoring			0.208** (0.0968)	-0.00762 (0.0965)		
ΔOffshoring HT					0.0940 (0.117)	-0.0146 (0.121)
ΔOffshoring LT					-0.148* (0.0849)	-0.00604 (0.0855)
Time, country and Pavitt dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	778	778	776	776
R-squared	0.426	0.426	0.437	0.437	0.437	0.437

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the turnover due to new or improved products and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel. Core countries are France, Germany, the Netherlands and the United Kingdom; peripheral countries are Italy and Spain.

Table 13. Upswing vs. Downswing of business cycle (input-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	Up	*Down*	*Up*	*Down*	*Up*	*Down*
R&D exp. per emp.	0.147***	0.0718	0.133**	0.0659	0.115**	0.0944
	(0.0559)	(0.0738)	(0.0563)	(0.0742)	(0.0559)	(0.0752)
Expenditure in new mach. and equipment per emp.	0.201	0.239*	0.179	0.258*	0.207	0.229
	(0.169)	(0.142)	(0.165)	(0.142)	(0.165)	(0.142)
ΔDomestic final demand	0.195***	0.170***	0.210***	0.180***	0.227***	0.177***
	(0.0332)	(0.0317)	(0.0337)	(0.0322)	(0.0355)	(0.0321)
ΔExports	0.230***	0.0211	0.204***	0.0239	0.200***	0.0265
	(0.0365)	(0.0239)	(0.0360)	(0.0257)	(0.0380)	(0.0267)
ΔNarrow offshoring			0.338**	0.0309		
			(0.135)	(0.0987)		
ΔOffshoring HT					0.466***	-0.141
					(0.139)	(0.139)
ΔOffshoring LT					-0.115	-0.0891
					(0.0839)	(0.0794)
Time, country and Pavitt dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	833	833	824	824	823	823
R-squared	0.411	0.411	0.426	0.426	0.434	0.434

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the R&D expenditure per employee and expenditure in new machinery and equipment per employee present a lag (except for the last period) according to the time structure of the panel. Upswing phase includes the three following periods: 1996-2000, 2003-2008 and 2012-2014; downswing phase includes the two following periods: 2000-2003 and 2008-2012.

Table 14. Upswing vs. Downswing of business cycle (output-innovation variables)

	(1) ΔVA		(2) ΔVA		(3) ΔVA	
	Up	*Down*	*Up*	*Down*	*Up*	*Down*
Turnover due to new or improved products	0.0552***	0.0587**	0.0526***	0.0579**	0.0489***	0.0543**
	(0.0167)	(0.0257)	(0.0167)	(0.0260)	(0.0164)	(0.0268)
Share of firms introducing process innovation	0.0263**	0.0155	0.0245**	0.0144	0.0262**	0.0212
	(0.0112)	(0.0158)	(0.0113)	(0.0160)	(0.0113)	(0.0168)
ΔDomestic final demand	0.160***	0.154***	0.171***	0.162***	0.176***	0.153***
	(0.0253)	(0.0249)	(0.0255)	(0.0260)	(0.0256)	(0.0254)
ΔExports	0.116***	0.0238	0.105***	0.0248	0.118***	0.0262
	(0.0265)	(0.0216)	(0.0260)	(0.0224)	(0.0293)	(0.0227)
ΔNarrow offshoring			0.219*	0.0507		
			(0.122)	(0.0986)		
ΔOffshoring HT					0.269**	-0.0358
					(0.121)	(0.133)
ΔOffshoring LT					-0.179**	-0.135
					(0.0859)	(0.0823)
Country and Pavitt dummies	Yes	Yes	Yes	Yes	Yes	Yes
Observations	786	786	778	778	776	776
R-squared	0.419	0.419	0.428	0.428	0.436	0.436

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the turnover due to new or improved products and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel. Upswing phase includes the three following periods: 1996-2000, 2003-2008 and 2012-2014; downswing phase includes the two following periods: 2000-2003 and 2008-2012.

5. Conclusions

In the present chapter we built on an integrated approach which combines a Post-Keynesian view on structural economic dynamics with a Neo-Schumpeterian perspective on technological change. According to this framework, structural change is conceived as the dynamic outcome of the uneven growth patterns of industries, which result from the interaction between industries' differential technological developments, industries' differential involvement in modern process of international fragmentation of production and industries' differential growth rates of demand.

This approach allows to read the patterns of long-run transformation of the economies as shaped by structural factors operating both on the supply- and demand-side. On the one side, the "technology push" effects come from the technological opportunities opened up by different kinds of innovation as well as from the positioning of industries along global value chains. On the other side, the "demand pull" effects come from the different flows of demand captured by industries. In this context, the role of demand is crucial, as it allows to realize those opportunities offered by the industry-specific trajectories of technological change and production internationalization. Within this framework, in Section 1 we detected four key sources of industry heterogeneity with the aim of addressing different structural dimensions of the process of structural change. The four identified dimensions are the following: manufacturing vs. service industries; high-tech vs. low-tech industries; core vs. peripheral countries; upswing vs. downswing of business cycle.

In Section 2 we took advantage of the SID database to provide large descriptive evidence on the relationships between the technological performance of industries, the offshoring strategies which shape their competitiveness, the industry-specific dynamics of different demand flows and the growth patterns of industries. In Section 3 we proposed a simple empirical model to assess the relationships between the structural factors considered and the growth rate of value added of industries. Nonetheless, we estimated our model explicitly accounting for the four sources of variety previously detected – checking how they affect the strength and direction of structural relationships under investigation – and for both input- and output-innovation variables (the former capturing the innovative efforts pursued by industries, the latter the successful in introducing innovation).

We briefly summarize our main results. We found that the growth rate of value added of manufacturing industries is strongly associated with technology-driven competitiveness strategies, proxied by the expenditure in R&D, the search for product quality improvements and the introduction of new products; the tradability of manufacturing products lead exports to emerge as a pivotal source of demand; finally, the foreign acquisition of high-tech intermediate inputs shows a positively significant relationship with manufacturing growth performance, suggesting that the production internationalization provides competitiveness gains. Conversely, while a relationship between the output-innovation variable and the economic performance of service industries holds, the growth rate of the latter seems more connected to the expenditure in new machinery and equipment, confirming the role of service industries as "product users" of manufacturing industries; moreover, offshoring indicators shows a weakly negative link with service industries performance.

As regards the high- and low-tech industry clusters, we found contrasting evidence when we control for both input- and output-innovation variables. High-tech industries show an association with process and mainly product innovation, a strong relationship with exports dynamics and a significantly positive one with narrow and high-tech offshoring activities. Low-tech industries present a strong association with process innovation strategies, although their growth rates turn out linked also to the expenditure in R&D; they mainly rely on domestic demand and are little involved in global value chains.

With respect to the core-periphery dimension we noted that industries belonging to core countries report a strong relationship with both our input- and output-innovation variables proxying the search for technological upgrading and quality product improvements; a significantly positive association with both domestic and foreign demand and a strongly positive relationship with the intensity of offshoring activities (mainly aimed at acquiring foreign high-tech inputs complementary to their technological capabilities). Conversely, industries of peripheral countries seems to pursue mainly cost-based strategies of competitiveness, since they show a strong association with both our input- and output-innovation proxies of process innovation (namely expenditure in new machinery and share of firms introducing new process) only; notably, these industries rely on domestic final demand much more than core's industries, while offshoring indicators seems to have not linkages with the value added dynamics of low-tech industries.

Finally, we investigated whether structural relationships among technology, demand, offshoring and industries' value added dynamics are affected by the business cycle. We found that during upswings industries present a positive association with both R&D expenditure, turnover due to new products and process innovation and, as expected, the relationship with demand component are stronger during upward phases of the cycle; finally, the heterogeneity concerning the offshoring strategies persist, with the narrow and the high-tech indicators which show a positive link with growth of value added of industries, low-tech offshoring has a negative and weakly negative coefficient. During recessions we found a rather surprising positive and significant association with the output-innovation variable related to product innovation, although it seems that at the same time increases in expenditure in new machinery and equipment are (weakly and) positively linked to the growth performance of industries. Moreover, the collapse of international trade during recessions turns out exports coefficients nonsignificant, while the domestic final demand coefficient loses magnitude; finally, offshoring strategies do not show connection with the change of value added of industries during recessions.

The analysis provided in the present chapter allowed to assess the complex picture which emerges when searching for the factors related to the uneven growth rates of industries. The variety stemming from the empirical investigation permitted to highlight the unequal technological opportunities of industries, the differentiated relevance of demand conditions and the structural role played by offshoring activities, linking these factors to the process of structural change conceived as unbalanced changing composition of the economies as captured by the different growth rates of industries.

Pasinetti's analysis on structural economic dynamics highlights that the fundamental dynamic instability of the economic system requires appropriate structural economic policies whether a coordination between the supply- and demand-side has to be achieved (Pasinetti, 1981, 1993). As stressed by Andreoni and Scazzieri (2014), such coordination calls for proper institutional conditions and targeted and selective measures able to capture structural opportunities and overcome constraints that arise from the unfolding of production process over time. Accordingly, economic policy should play an essential role in "managing" the instability generated endogenously by the structural evolution of the economic system. In other words, the necessity to shape the process of structural change asks for a revitalization of industrial policy, understood as «selective government intervention or policy that attempts to alter the structure of production in favor of sectors that are expected to offer better prospects for economic growth in a way that would not occur in the absence of such intervention in the market equilibrium» (Pack and Saggi, 2006, pp. 267-268). An industrial policy for Europe should therefore be recognized as the proper tool to govern the process of structural change, in order to shape the technological trajectories of industrial development, financing innovations, supporting public productions that meet new needs and fostering a path of structural convergence among the European countries to drastically reduce the ongoing pattern of social and economic polarization (Celi et al., 2018; Landesmann et al., 2013; Landesmann, 2015; Mazzucato, 2013; Pianta, 2014; Pianta and Lucchese, 2012).

Appendix of Chapter 2

Table A.1 provides robustness checks related to the estimation of the baseline equation performed using input-innovation variables, reported in Table 6, column 3 of the main text.

We start testing the heteroskedasticity of the residuals. First, we perform the Breusch-Pagan test performing a Weighted Least Squares estimation. Moreover, we also perform the White test, although it only applies to estimations performed with standard OLS method. As expected, both tests strongly reject the null hypothesis of homoskedasticity, confirming that the variance of the error term differs across observations; these results support our choice to perform estimations with heteroskedasticity- and autocorrelation-robust standard errors.

Moreover, we test the serial correlation of residuals applying the test proposed by Cumby and Huizinga (1990, 1992) and developed for STATA by Baum and Schaffer (2013), which can be used in several circumstances in which other tests like the Box-Pierce/Ljung-Box test, the Durbin's h-test or the Breusch-Godfrey test are not applicable. The null hypothesis of the test is that residuals are serially uncorrelated. Since we use a first-difference estimator with dummy variables, we are not really concerned about autocorrelation problems. Indeed, the Cumby and Huizinga test does not reject the null hypothesis of serially uncorrelated residuals of the estimated equation.

We use the Variance Inflation Factor (VIF) to test for multicollinearity problems. Notwithstanding the inclusion of time, Pavitt and country dummies, the VIF value is equal to 2.28, below 4 and much below 10 (the thresholds usually taken as reference in the literature).

Table A.2 provides robustness checks related to the estimation of the baseline equation performed using output-innovation variables, reported in Table 6, column 6 of the main text.

We start testing the heteroskedasticity of the residuals. First, we perform the Breusch-Pagan test performing a Weighted Least Squares estimation. Moreover, we also perform the White test, although it only applies to estimations performed with standard OLS method. As expected, both tests strongly reject the null hypothesis of homoskedasticity, confirming that the variance of the error term differs across observations; these results support our choice to perform estimations with heteroskedasticity- and autocorrelation-robust standard errors.

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We use the Variance Inflation Factor (VIF) to test for multicollinearity problems. Notwithstanding the inclusion of time, Pavitt and country dummies, the VIF value is equal to 2.51, below 4 and much below 10 (the thresholds usually taken as reference in the literature). Therefore, we conclude that multicollinearity is not a cause for concern.

Table A.1 Robustness checks for the baseline equation (w/input-innovation variables)

Heteroskedasticity (Breusch-Pagan test)
WLS regression (time, country and Pavitt dummies included) Ho: constant variance (homoskedasticity) F(18, 805) = 11.15 Prob > F = 0,0000
Heteroskedasticity (White test)
OLS regression (time, country and Pavitt dummies included) Ho: homoskedasticity Ha: unrestricted heteroskedasticity chi2(121) = 259.69 Prob > chi2 = 0,0000
Autocorrelation of residuals (Cumby-Huizinga test)
WLS regression (country and Pavitt dummies included) H0: variable is MA process up to order q (with q = 0: serially uncorrelated) HA: serial correlation present at specified lags >q chi2 = 2.171 p-value = 0,1407
Multicollinearity (Variance Inflation Factor)
WLS regression (time, country and Pavitt dummies included) Mean VIF = 2,28

Table A.2 Robustness checks for the baseline equation (w/output-innovation variables)

Heteroskedasticity (Breusch-Pagan test)
WLS regression (time, country and Pavitt dummies included) Ho: constant variance (homoskedasticity) F(16, 828) = 11.77 Prob > F = 0,0000
Heteroskedasticity (White test)
OLS regression (time, country and Pavitt dummies included) Ho: homoskedasticity Ha: unrestricted heteroskedasticity chi2(121) = 274.43 Prob > chi2 = 0,0000
Autocorrelation of residuals (Cumby-Huizinga test)
WLS regression (time, country and Pavitt dummies included) H0: variable is MA process up to order q (with q = 0: serially uncorrelated) HA: serial correlation present at specified lags >q chi2 = 2.072 p-value = 0,1500
Multicollinearity (Variance Inflation Factor)
WLS regression (time, country and Pavitt dummies included) Mean VIF = 2,51

Chapter 3

Structural Dynamics of Income Distribution: Technology, Wages and Profits

1. Introduction

The aim of this chapter is to develop a theoretical investigation and an empirical analysis of technological, organizational and institutional factors which shape the capital-labour conflict as reflected in the functional income distribution. For this purpose, we take simultaneously into account the diversified impact that different kinds of innovation and offshoring processes, together with changing labour market institutions, exert on wage and profit growth.

Our analysis combines a Neo-Schumpeterian approach to the dynamics of technological change and a Post-Keynesian view regarding the conflictual nature of income distribution. We try to build bridges between these two theoretical paradigms analyzing the drivers of distributive outcomes. In particular, we consider the introduction of new production technologies – distinguishing between product and process innovation –, global restructuring through offshoring of production and the decreasing bargaining power of trade unions.

First, we conceive technological change according to an evolutionary perspective, considering the technological trajectories of industries and their path-dependent nature; the latter is given by the cumulative and irreversible character of innovation, as well as its intrinsically dynamic and out-of-equilibrium occurrence. Notably, we emphasize the distributive consequences of different competitiveness strategies – i.e. a technology-driven versus a cost-based one – identifying the various channels affecting the dynamics of wages and profits.

Second, globalization – fostered by international liberalization of capital flows and commodity trade – has reshaped the world's industrial landscape. Firms and industries are increasingly integrated in a global network of production built up along transnational value chains. This process is driven by two factors: on the one side, corporations' need to exploit technological opportunities associated to economies of scale, foreign knowledge and new sources of not-domestically produced intermediate inputs; on the other side, the increase in the power of capital over labour with the "threat effect" that delocalization strategies (and the resulting fragmentation of labour) exert on workers' organizational capacity.

Third, we argue that the balance of power between capitalists and workers is fundamentally shaped by social norms, employment protection legislation, patterns of collective bargaining and the rise of precarious employment. The long run decline of unionization in most OECD countries is representative of the institutional changes that have weakened workers' bargaining power in the last three decades; we therefore consider union membership rate as a factor in labour compensation.

With the aim of providing an assessment of the relationships investigated, we propose an empirical model starting from the one developed by Pianta and Tancioni (2008). In the original model, the conflictual dynamics of wages and profits and the relationships between innovation, productivity and the distributive components are identified through panel data estimations. They find that productivity exerts a positive effect on both wages and profits, while only profits seem to gain from the introduction of product and process innovations; conversely, higher wages tend to be associated with higher innovation expenditure. Finally, insightful heterogeneity especially related to wages emerges when the authors distinguish between high- and low-tech industries.

We build on this model to improve it considerably. On the conceptual ground, we develop a structural two-equation model to investigate the simultaneous impact of labour productivity growth and the introduction of product and process innovations on the rate of growth of profits and wages. Furthermore, the distributive impact of different offshoring strategies – distinguished according to their technological specificity – and the (decreasing) strength of trade unions are included as additional key variables, providing a more comprehensive assessment of factors which shape income distribution in the era of globalization.

On the empirical ground, we perform an industry-level analysis exploiting the Sectoral Innovation Database (SID), which enables to investigate further the technological trajectories of sectors, their patterns of structural evolution as well as their economic performance. The SID includes data on 21 manufacturing and 17 service sectors for six major European countries (France, Germany, Italy, the Netherlands, Spain and the United Kindgom) from 1994 to 2014, allowing us to extend the empirical analysis provided by Pianta and Tancioni (2008). On the one hand, because of the much longer time dimension, our analysis provides a proper dynamic analysis of the medium-term relationships under investigation; on the other hand, our two-digit industry-level disaggregation accounts for 38 manufacturing and service sectors, against the 11 sectors analyzed by Pianta and Tancioni; as a result, our research enables to draw more general conclusions about income distribution dynamics. Another improvement concerns the consideration we deserve to the national and sectoral systems of innovation literature; country specificities are accounted for and the technological trajectories of industries are considered through the use of the Pavitt's taxonomy as revised by Bogliacino and Pianta (2010, 2016).

We briefly summarize our main empirical results as follows. Despite the structural asymmetries between industries' patterns, we always find a remarkable and significant negative relation between the rate of change of wages and profits, while labour productivity growth appears to support both distributive components. As regards technological change, we find that product innovation is positively associated with increasing profits as well as rising wages; conversely, the introduction of new production processes seems to have no impact on profits except through a reduction of wages. Furthermore, our analysis confirms offshoring processes as a modern driver of profits while represent a reliable firms' weapon to reduce labour costs. When we distinguish between high- and low-tech offshoring strategies we generally find that the former is positively associated with capital compensation and has a negative but not significant effect on labour compensation; on the contrary, low-tech offshoring is mainly found to be detrimental for wages, without being beneficial for profits if not through the labour-cost channel. Finally, union density tends to be positively associated with the wage dynamics.

The structure of the chapter is the following. Section 2 summarizes the state of the art on the determinants of functional income distribution and presents the approach developed here. We break down this section in four subsections to discuss the impact that labour productivity performance, innovation dyanmics, offshoring strategies and union density may have on the distributive patterns of industries. Section 3 provides a brief description of the SID database, i.e. the industry-level database on which our empirical analysis is based on. In Section 4 an amount of descriptive evidence is presented to assess the large relationships between our technological, structural and institutional variables and income distribution dynamics. In particular, the role of technology on the evolution of profits and wages is addressed in Section 4.1, while Section 4.2 provides evidence on the role of offshoring on income distribution. Section 4.3 addresses the role of trade unions and explores the distributive impact of union density. A simultaneous model on income distribution dynamics is presented in Section 5 and estimation results are discussed. Section 6 provides an interpretation of the main findings and draws some conclusions.

2. State of the art and proposed approach

In this section we provide a review of the theoretical and empirical literature which addresses the determinants of functional income distribution dynamics, focusing on those analyses which emphasize the impact of structural, technological and institutional factors. We will then propose an approach according to which the distributive patterns are fundamentally shaped by the balance of power between capital and labour and where innovation and offshoring strategies play a crucial role. Our focus will be on the impact that innovation, offshoring processes and union membership have on the rate of change of wages and profits.

The functional distribution of income and the social, political and economic forces governing its historical dynamics is a central topic of Political Economy. Technology, trade and power relations have traditionally been detected as key factors underpinning the evolution of wages and profits. While the conflict between capital and labour was fully acknowledge by Adam Smith (1776), David Ricardo

(1951 [1821]) is recognized as the Classical economist who put most attention on this subject. Karl Marx (1976 [1867]) investigated the social relations of production on which capital accumulation relies and stressed the role of technology-based dynamic competition as a driver of the cyclical evolution of capitalism; this concept has then been taken up and considerably developed by Schumpeter (1934, 1939), who proposed a technology-driven business cycle theory according to which the economic equilibrium is constantly broken by disruptive innovations.[42] The Neoclassical approach initiated in the late XIX century mainly by Jevons, Menger and Walras switched the focus of economic research from the development of capitalist system to the optimal allocation of scarce resources. Most important, marginalist theoretical framework is grounded on a static competition mechanism (operating through firms' cost-minimization strategies and market price adjustments) within an equilibrium analysis able to provide a harmonious conception of income distribution, i.e. an analytical view such that there is no conflict between capitalists and workers given that – market "imperfections" and "failures" aside – each "factor of production" is remunerated according to its marginal productivity. Growing economic disparities, straddling the end of XIX and the beginning of XX century, and the Great Depression which followed the "Great Crash" of 1929 (Galbraith, 1955) have, however, challenged the neoclassical approach and its faith on alleged self-regulating markets. Nonetheless, in those years Michal Kalecki (1935 [1933]) anticipated the theoretical insights of Keynes (1936) developing a Marxian-flavor theory of growth and distribution, which assigned major relevance to the conflictual nature of wage and profit setting and to the role that distributional outcomes play on the dynamics of effective demand. This theoretical framework, based on a demand-led growth theory, has laid the foundations for the birth of Post-Keynesian economics (Harcourt, 2006; Kurz and Salvadori, 2010; Lavoie, 2014).[43]

We build on conflictual theories of distribution – as the Classical, Marxian, Post-Keynesian/Kaleckian ones – to contribute to the economic literature which has tried to explain the structural determinants of income distribution dynamics over the last four decades. As is widely recognized, since the end of the Seventies a series of interrelated technological and structural factors – together with a major turning point in economic policy – have occurred by favoring capital over labour income and exacerbating disparities (Franzini and Pianta, 2016; Glyn, 2006; Onaran and Guschanski, 2017; Piketty, 2014).

Previous research has concentrated on the long-term decline of labour share of income, providing different explanations according to the theoretical approach (Dunhaupt, 2013). Several studies belonging to the neoclassical tradition have identified technological progress and globalization as the most relevant factors affecting income distribution (Abdih and Danninger, 2017; Bentolila & Saint-Paul, 2003; Bassanini and Manfredi, 2014; European Commission, 2007; IMF, 2017a; Karabarbounis and Neiman, 2014; OECD, 2012, 2018a). According to these studies, Information and Communication Technology (ICT) combined with modern developments in robotic and automation fostered a capital-biased technological change, promoting both a decline in the price of capital relative to labour and a process of replacing workers (in particular those who perform routine jobs as they are more easily automatized) with machines (Acemoglu, 2002, 2003; Acemoglu and Restrepo 2017, 2018; Goos et al., 2014). The consequence is an increase in the capital-output ratio, which in turn

[42] On the similarities between Marx's and Schumpeter's conception about the inherently dynamic and out-of-equilibrium nature of capitalist development see, among the others, Fagerberg (2003, 2005).

[43] According to a number of scholars who agree with this theoretical view – in particular, for those who share a neo-Kaleckian perspective – income distribution dynamics and demand growth regimes of countries essentially determine the patterns of economic growth of the latter. Bhaduri and Marglin (1990) represents the cornerstone of this stream of literature. Lavoie and Stockhammer (2013) provide an introduction to the wage-led/profit-led theoretical debate and a summary of the main empirical works concerning the topic. Onaran and Obst (2016) estimate a multi-country demand-led growth model for the European Union and find that the EU15 as a whole is a wage-led economy; they hence suggest the implementation of a wage coordination in Europe to reverse the fall in the wage share and the rising inequality as well as to pursue a sustainable growth path after the Great Recession. For an application of a similar empirical model to major developed and developing countries see Onaran and Galanis (2013). On the policy prescriptions for a wage-led-oriented recovery for Europe see also Onaran and Stockhammer (2016).

reduces the labour share to the extent that the elasticity of substitution between capital and labour is found to be larger than one (e.g. Bassanini & Manfredi, 2014; Karabarbounis and Neiman, 2014). Moreover, the impact of internationalization of production on the wage share emerges as crucial; indeed, according to the neoclassical framework, capital-abundant countries offshore labour-intensive tasks in labour-abundant countries. This results in a growing capital-output ratio in the former countries and – whether capital acts as a gross substitute for labour – in a declining labour share (Bassanini and Manfredi, 2014; European Commission, 2007; IMF, 2017a). Nonetheless, technology and trade may be interrelated, since the former may be induced by the latter; for example, Bloom et al. (2013) developed a theoretical model according to which the opportunity cost of introducing innovation falls as a consequence of trade liberalization with a low-wage country (namely China) and their empirical results suggest that sectors more exposed to the Chinese import competition increased technical change (see Bloom et al., 2016).[44]

Post-Keynesian literature detected the shift in the balance of power between capital and labour as the primary factor explaining the decline of the wage share in national income. Although the role of technological change is accounted for in the most recent empirical studies (Guschanski 2016, 2017, 2018; Stockhammer, 2017), major prominence is given to the role of labour market institutions, globalization, financialization and welfare state retrenchment (Dunhaupt, 2013; Stockhammer, 2009, 2013). According to this stream of research, the change of paradigm in economic policy occurred in the Eighties led to new institutional arrangements harmful to workers; in particular, they resulted in a downsizing of the welfare state and a sharp reduction of union density and collective bargaining coverage, while labour market reforms reduced employment protection legislation and spread precarious work (Bengtsson, 2014a; Charpe, 2011; Stockhammer, 2013). Globalization favored the most mobile (rather than the most abundant) production factor, i.e. capital, and supported offshoring practices aimed at reducing labor costs (Jayadev, 2007; Rodrik, 1997; Stockhammer, 2017). Moreover, financialization enhanced the fall-back options of capital and increased the shareholder value orientation of firms, with major consequences in terms of corporate governance and workers' bargaining capacity (Dunhaupt, 2012, 2016; Guschanski and Onaran, 2018; Kohler et al., 2018; Lin and Tomaskovic-Devey, 2013).

One of the most complete studies in this field is provided by Guschanski and Onaran (2017), who exploited industry-level data to investigate the determinants of the wage share for 14 countries from 1970 to 2014. They show that "74 percent of all sectors experienced a decline in the wage share between 1980 and 2007" and that "most of these sectors (…) are classified as high-skilled, the opposite from what we would expect according to the hypothesis of skill-biased technological change" (p. 15). According to their estimation results, offshoring (mainly to emerging countries and Eastern Europe) has a strong negative impact on the wage share within sectors, together with institutional and social factors such as the welfare state retrenchment, the decrease of union density and the overall rise in inequality. As far as technological change is concerned, they find that Total Factor Productivity and capital intensity have a significant and negative impact on the labour share until the mid-Nineties, although the theoretical and empirical soundness of the former variables remains very questionable (Felipe and McCombie, 2013).

Nonetheless, many recent studies addressed the personal dimension of income distribution emphasizing the growing inequalities occurred in the last decades (e.g. Alvaredo et al., 2013, 2018; Atkinson et al., 2011; Bogliacino and Maestri, 2014; Piketty and Saez, 2003; Tridico, 2018).[45] In this

[44] Van Reenen (2011) provides a comprehensive review of the neoclassical literature which addressed the role of technology and trade on wage inequality and job polarization, encompassing the skill-biased, the task-biased and the trade-induced technological change theory.

[45] Palley (2016) clarifies the theoretical conflict among neoclassical and Post-Keynesian economists concerning the identification of the fundamental mechanisms which triggered the crisis of 2007/8 and the subsequent stagnation, stressing the role that these different schools of thought attribute to income inequality. Sturn and van Treeck (2013) provide a survey of the literature regarding the role of income inequality in causing the Great Recession; they concentrate the analysis on the U.S., Germany and China and emphasize how the private consumption patterns crucially depend not only

regard it is worth nothing that, as demonstrated by Daudey and Garcia-Penalosa (2007), functional income distribution represents a key explanatory determinant of personal distribution of income and, as Atkinson (2009) has confirmed, it is thus an element of major relevance to understand current income inequality. These findings are broadly supported by Wolff and Zacharias (2013), who empirically show the crucial role of inter-class inequality in explaining the increase of personal income inequality.[46]

In the rest of this section we propose an overview about the role of some key factors detected by recent studies as remarkably relevant in shaping the wage and profit dynamics (Abdih and Danninger, 2018; Bogliacino, Guarascio and Cirillo, 2018; IMF, 2017b) and the related theoretical and empirical literature which focused on them.

2.1 Labour productivity

In line with Pianta and Tancioni (2008), the first factor we focus on is labour productivity. We recognize the dynamics of labour productivity as a major driver of industries' growth and decline (Pasinetti, 1981) and hence a determinant of different potential income distribution patterns. A robust labour productivity growth provides room to boost both profits and wages, softening some extent the distributive conflict. On the other side, looking at wage as a cost, a large literature along Marxian and Kaldorian lines (Foley and Michl, 1999; Kaldor and Mirrlees, 1962) argues that high wages could spur labour productivity encouraging firms to shift to high value-added productions and fostering a Marxian labour-saving technological change (Basu, 2010; Campbell and Tavani, 2018; Fejio and Lamonica, 2013; Hein and Tarassow, 2010; Marquetti, 2004; Naastepad, 2006; Storm and Naastepad, 2012, 2017).[47] Furthermore, as stressed by Post-Keynesian tradition (Lavoie, 2006), wages are the main source of income for final consumption, which is in turn a major component of effective demand whose growth stimulates capital formation, learning-by-doing processes and markets' expansion (Arrow, 1962; Kaldor, 1966; Verdoorn, 1949). The latter promotes a deeper division of labour, triggering static and dynamic increasing returns to scale (Sylos Labini, 1984a; Young, 1928).[48] It

on changes in the personal and functional distribution of income but also on a series of institutional country-specific factors (see also van Treeck (2014) for a focus on the U.S.). Behringer and van Treeck (2017) merge the 'Varieties of Capitalism' perspective with Post-Keynesian growth regimes approach to highlight the role of income disparities in fueling global current account imbalances while Belabed et al. (2018) reach similar conclusions developing a stock-flow consistent macroeconomic model calibrated for the USA, Germany and China. Stockhammer (2011) provides an interpretation of the European crisis detecting the current account imbalances between Germany and peripheral Europe as the outcome of different finance-dominated accumulation regimes; notably, he argues for a change in the role of wage policy to reduce the German trade surplus. For a reading at least partially different that downsizes the relevance of German wage policy as the root of European current account imbalances see Horn et al. (2017).

[46] In addition, growing personal income and wealth inequality may result in strong imbalances in the command over resources and hence in unbalanced power relations among different social groups with contrasting interests. Cole (2018) has recently investigated the link between material inequality and power asymmetries performing an empirical analysis on a sample of more than one hundred countries from 1981 to 2011. He estimates the causal effect of income inequalities on the distribution of political power and the enjoyment of civil liberties according to the socio-economic position and finds that inequality in the distribution of income is harmful to political equality and the enjoyment of civil rights; it follows that, in the face of growing inequalities, the political power of the wealthiest sections of the population grows. As Stiglitz argued (2012), this implies that powerful elites gain a huge political power which allows them to influence deeply the political debate in their favor (a phenomenon known as "regulatory capture"), hampering pro-labour redistribution policies and worsening further the workers' bargaining position.

[47] According to neoclassical economic theory a positive relationship between real wage and labour productivity finds its theoretical reason in the well-known theory of efficiency wages proposed by Shapiro and Stiglitz (1984). Nevertheless, Lavoie (2014, pp. 303-309) consistently calls it "Webb effect", referring to the work by Sydney Webb (1912).

[48] Sylos Labini (1979, 1984a, 1984b) summarizes the mechanisms which lie behind labour productivity growth as a "Smith effect" – given by the expansion of the market which fosters labour division and learning-by-doing – and a "Ricardo effect" – triggered by new capital-intensive investments spur by the growth rate of (relative) labour cost, i.e. the difference between wages and price of machines. For a recent application of Sylos Labini's framework to the analysis of the determinants of labour productivity in some member states of the Euro Area see Carnevali et al. (2016). Crespi and Pianta (2008a, 2008b) perform an empirical industry-level investigation which covers six major European countries,

follows that considering simultaneously the "supply-side" and "demand-side" of the story might lead to detect what Myrdal (1957) would call a circular and cumulative causation mechanism between wage and productivity dynamics (O'Hara, 2008).

Furthermore, profits are generally recognized as an important source of self-financing, notably for small and medium size firms with limited access to financial markets (Bogliacino and Gomez, 2014; Cantwell, 2002; Forges Davanzati and Pacella, 2014; Hall, 2002; O'Sullivan, 2005). It follows that high profits could spur labour productivity as long as reinvested in R&D, new machinery and equipment and organizational improvements, giving rise to 'virtuous circle' phenomena (Bogliacino and Pianta, 2011, 2013a, 2013b; Bogliacino et al., 2017).[49] The dynamics of labour productivity of industries assumes thus a crucial relevance in our investigation as it embodies other drivers of growth such as capital investment and organizational improvements, allowing to carry out our analysis on income distribution according to a structural change perspective.

2.2 Innovation

Following a Neo-Schumpeterian evolutionary perspective, the role of sectoral systems of innovation (Malerba, 2002, 2004a, 2004b) and technological change are put at the core of our investigation of the distributional patterns of industries. We conceive innovative patterns of sectors according to their technological regimes, essentially defined by the knowledge base on which they rely, the degree of appropriability of innovations, the technological opportunities they can exploit and the incremental character of their technological advances, i.e. the degree of cumulativeness of their technological capabilities (Breschi et al., 2000; Malerba, 2006; Malerba and Orsenigo, 1997). In order to account for the technological trajectories of sectors while reducing the heterogeneity which stems from an industry-level analysis, we use the Pavitt's taxonomy as revisited by Bogliacino and Pianta (2010, 2016).[50] First, we provide descriptive evidence on the technological and economic dynamics of industries grouping them on the basis of the Revised Pavitt categories, showing the divergences and commonalities in their performance. Second, we build a set of Pavitt dummies which captures the Pavitt category to which each industry belongs to and we exploit this set of dummy variables in our empirical investigation; in such a way, we explicitly control for the structural and technological patterns of industries (Dosi, 1982, 1988).

It is worth noting that income distribution dynamics represents at once a major determinant and a consequence of innovative efforts. As a determinant, the process of monopoly profit-seeking and the strategic reaction to wage pressure push firms to introduce product as well as process and organizational innovations. Therefore, the patterns of income distribution have a role in inducing firms to introduce different kinds of innovation in order to gain a leading position on the market (and the associated new flows of profit) and/or to pursue restructuring processes aimed at reducing labour costs. On the other hand, technological change is a driver of productivity growth and, whether combined with a strong demand growth, it may result in higher profits and wages. In turn, the latter is likely to fuel economic growth spurring further technological change and structural evolution of the economies (Crespi and Pianta, 2007; Guarascio et al., 2016; Guarascio and Pianta, 2016; Saviotti and Pyka, 2017).

Most important, we introduce a fundamental Schumpeterian distinction between product and process innovation, that are meant as the outcomes of different innovative strategies, i.e. a

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providing evidence about the role of demand growth and innovation dynamics on labour productivity performance of sectors.

[49] From a theoretical point of view, interesting insights come from Lima (2000, 2004), who explicitly combines a Neo-Schumpeterian approach to technical change with a Post-Keynesian perspective on growth and distribution to develop theoretical models which endogenize technological innovation. In this kind of models, labour-saving technological change is modeled in order to result a non-linear function of, respectively, market concentration and functional income distribution.

[50] A detailed description of the Revised Pavitt classes according to which we classify sectors is provided in the final Appendix on the SID database.

technology-driven and a cost-based competitiveness strategy, respectively (Pianta, 2001). In particular, product (or service) innovation is conceived as the "high road" to competitiveness, aimed at improving the quality of goods to open up new markets, consistently with the evolution of demand; in other words, it allows to "intercept" the changing composition of effective demand along the development path of the economies (Leon, 1967; Pasinetti, 1981).[51] Given this, we hold that such a strategy is likely to spur both profits and wages, inasmuch as industries populated mostly by firms introducing product innovations are those expected to get the greatest growth potential, providing room for rising both the distributive components. Furthermore, a technological competitiveness strategy aimed to develop new products relies more on an environment which favors cooperation among workers within firms (facilitating search procedures, taking advantage of employees' cumulative knowledge and favoring their skill upgrading); thanks to the latter, a sharing mechanism of the rents stemming from virtuous innovation processes is more likely to occur, benefiting also workers (Buchele and Christiansen, 1999; Cantwell, 2005; Kleinknecht et al., 2016).

On the other side, a cost competitiveness strategy is likely to have a positive effect on profits, insofar as it enables price reductions of firm's goods and hence an expansion of market shares (this dynamics may develop along industrial restructuring processes aimed at increasing productive efficiency); this innovation strategy is likely to be detrimental for wages, insofar as it may imply the expulsion of workers from the production process (or accredit the firing threat) narrowing thus their bargaining power (Bogliacino, 2009; Cirillo, 2017; Vivarelli, 2014).

2.3 Offshoring

Another key aspect that affect the balance of power between capital and labour is globalization (Rodrik, 1997). Globalization process and the changing composition of international trade flows represent crucial aspects of modern capitalist economy at global level. Since the Eighties, worldwide liberalization of trade and capital markets occurred; at the same time, technological advances allowed a strong reduction of communication and transport costs, stimulating greater integration of production systems and boosting trade flows of intermediate inputs. The introduction of new organizational strategies related to the localization of production and the choices with respect to the sources of supply for intermediate goods (namely offshoring practices) spurred the emergence of hierarchical global values chains, along which different economic actors (namely country, regions and firms) are located according to their economic and technological power (Milberg and Winkler, 2013).

Stockhammer (2017) provides an empirical analysis for both advanced and developing countries for the period 1970-2007 and detects globalization – together with technological change, welfare state retrenchment and financialization – as a prominent determinant of wage share. From a theoretical viewpoint he stresses how international trade affects income distribution through changing the bargaining position between capital and labour and criticizes both theoretically and empirically the trade-distribution nexus as explained by Classical trade theory stemming from the Stolper and Samuelson (1941) theorem.[52] Nonetheless, performing a country-level investigation, he is led to use trade openness as a standard proxy for globalization – as is usual in the literature (Harrison, 2005; Jayadev, 2007) –, a reliable but unsatisfying measure of modern internationalization production processes. In fact, what needs to be accounted for is that the ongoing liberalization of cross-border mobility of commodities witnessed not just a growing worldwide trade of final goods, but mainly a marked increase of intermediate inputs which has reshaped further the organizational strategies of firms and industries (Feenstra and Hanson, 1996; Hummels et al., 2001). This process led to the so-called international fragmentation of production and the emerging of global values chains. In other

[51] See Saviotti and Pyka (2017) for a recent contribution which draws from Pasinetti's structural change theory to investigate the interactions between income distribution dynamics, the evolution of demand patterns and the process of differentiation of economic system.

[52] Contrary to the distributive effects of trade Stolper-Samuelson theorem predicts, Stockhammer (2017) finds a significant negative effect of globalization on wage share in both advanced and developing economies; it follows that globalization does not seem to have provided benefit to labour-abundant emerging economies' workers.

words, the process of disintegration of production at global level implied the development of new industrial links along transnational supply chains, the latter characterized by structural asymmetries at industry and country level.[53]

From an analytical point of view, the industry-level analysis that we carry out is particularly suitable for investigating the global flows of intermediate inputs and their aftermaths in terms of income distribution.[54] We capture the impact of international fragmentation of production making use of different offshoring proxies developed by Feenstra and Hanson (1996, 1999), distinguishing between domestically produced and foreign imported intermediate inputs. Nonetheless, we argue that technological capabilities of industries represent a crucial component defining their positioning in modern global value chains. Hence, we also distinguish between high- and low-tech flows of imported intermediate inputs according to the knowledge base of foreign industries which source the intermediate inputs (Guarascio et al., 2015).

Offshoring processes might exert a positive impact on industries' profits for two main reasons. First, the engagement in global supply chains arguably provides firms with cheaper intermediate inputs for production (this should be true especially for low-tech offshoring processes) and gives access to new supply sources of commodities and non-domestically produced varieties of goods. Second, the internationalization of business strategies may entail major organizational improvements, the availability of advanced technologies, the indirect access to foreign final markets and the possibility of taking advantage of international technological spillovers (primarily for high-tech offshoring-intensive industries) (Campa and Goldberg, 1997; Colantone and Crinò, 2014; Hummels et al., 2018; Pöschl et al., 2016; Tajoli and Felice, 2018).

On the other hand, the effect of offshoring on wages is likely to be negative. The growing international fragmentation of production has changed the industrial landscape and the firms' competitive strategies in developing and advanced countries, resulting in what has been called a "new international division of labour" (Brewer, 2011; Frobel et al., 1978). Under this scenario, industries with higher organizational capabilities could join global networks of production to offshore the medium and low-value added stages of production with the aim of reducing labour cost. Firms in capital-abundant countries may localize strategically labour-intensive tasks in developing and newly industrialized countries (e.g. BRICS as well as Eastern Europe countries), where wages are lower and employment protection, fiscal and environmental regulations are far less stringent (Rodrik, 1997; Feenstra, 1998). For the very same reasons, they can likewise import low price intermediate inputs from abroad, dismissing domestic productions and laying off workers. Offshoring is thus likely to represent a credible threat against workers' rights and claims for better working conditions and higher wages (Burke and Epstein, 2001; Choi, 2001; Kramarz, 2017).

Nevertheless, all the effects potentially exerted by offshoring activities on income distribution are conditioned by technological and institutional characteristics of firms and industries (Freeman and Louca, 2001). In other words, if there is a good chance that low-tech offshoring processes act as a weapon in the hands of capitalists to reduce workers' bargaining power and hence their wages, high-tech offshoring might instead be a symptom of a more technology-oriented competitive strategy (Guarascio et al., 2015). As far as it triggers technological complementarities between domestic and foreign industries, both static (i.e. as input-output links) and dynamic (i.e. as interdependencies and feedbacks), high-tech offshoring process may affect the technological change of sectors in different directions (Malerba, 2002). The inflow of intermediate inputs from high-tech foreign sectors could entail a general knowledge-based upgrading of firms' productive system, enhancing domestic

[53] Simonazzi et al. (2013) provide a remarkable investigation which tackles the roots of the persistent current account surplus of Germany focusing on the structural reorganization of its economic system, the integration of Eastern European economies in its global network of production and the concurrent pauperization of the productive matrix of Southern European countries. For a comprehensive overview of these dynamics in the wake of the European crisis see Celi et al. (2018).

[54] For a comprehensive survey of the mainstream literature on the impact of offshoring on employment and wages see Hummels et al. (2018).

workers' complementary skills with a positive impact on their remuneration. On the other hand, an increasing acquisition of high technology and external knowledge from abroad may be the hint of a technological dependence linked to the subordinated position occupied along the global value chain by a certain industry, thus restricting room for wage increases.[55] Therefore, we regard the impact of high-tech offshoring on growth rate of labour compensation as theoretically ambiguous.

2.4 Union density

Finally, labour market institutions shall be taken into account as further element able to impact on capital-labour relationship and thus on income distribution. According to a Post-Keynesian perspective of labour market functioning, a strong employment protection legislation and thus the degree of flexibility of labour markets are not primarily responsible for the level of employment, but they are key factors which shape fundamentally the workers' bargaining power and thus the share of national income the workers earn (Stockhammer et al. 2014; Brancaccio et al., 2018). Among the elements of this kind for which one may choose to control for, the constraint due to the limited availability of industry-level data leads us to consider the industries' union density as a good proxy of the bargaining position of workers, able to affect their compensation alongside their working conditions. The rationale is that more unionized industries are expected to be the ones in which coordinated collective bargaining is wider and pro-labour employment and social standards are more binding.[56]

Bengtsson (2014b) estimates a panel Error Correction Model (ECM) model from 1960 to 2007 for 16 advanced economies and finds an overall positive association between union density and wage share. Tridico (2018) makes use of panel estimation techniques to assess the role of financialization, labour flexibility, trade union density and public social spending as determinants of personal income inequality for 25 OECD countries from 1990 to 2013; despite several robustness checks, he always finds a significant negative relationship between unionization and the Gini index. Most notably, researchers belonging to the IMF Staff as Florence Jaumotte and Carolina O. Buitron (2015) perform an empirical analysis for 20 developed countries during 1980-2010 and demonstrate that decreasing union density has to be recognized as a remarkable explanation of growing income inequalities since the Eighties. In particular, they provide evidence that the fairly general long-run decline of unionization inside and outside Europe and thus the remarkable reduction of trade unions' power (see Table 2 at the beginning of this section) might have harmed considerably the ability of workers' organizations to increase wages;[57] according to them, this would be especially true for low- and middle-income workers, justifying the rise of top income shares of managers and shareholders. OECD (2018b) has recently confirmed these findings, highlighting that coordinated collective bargaining systems are linked with better employment outcomes and lower wage inequality.

Given that the time period covered by our database starts in the mid-Nineties, i.e. after a couple of decades during which industrial relations have been reshaped and union density has experienced a major decline (OECD, 2017), the expected positive impact of sectoral union membership rate on labour compensation might be mitigated. A similar result would be consistent with the analysis carried out by Pontusson (2013), who finds that – since the Seventies – OECD countries in which union density is declined strongly have experienced relatively higher increases in income inequality, but this relationship seems to be weaker since the early Nineties; the author conjectures that the reason

[55] Lucarelli and Romano (2016) proposed the notion of "technological foreign constraint" as a remarkable factor explaining the long-term Italian crisis within the broader European recession started in 2010.

[56] Koeniger et al. (2007) show that labour market institutions critically affected the evolution of wage inequality in eleven OECD countries between 1973 and 1998; notably, they find that union density – as well as the strictness of employment protection law, unemployment benefit duration, unemployment benefit generosity and the size of the minimum wage – is negatively associated with wage inequality.

[57] For a deeper discussion on the benefits coming from unions' collective power for employees see Furåker and Bengtsson (2013).

may lie in the changing member composition of the trade unions and the following softening of the solidarity character of unions' wage claims.

In addition, we argue that the existence of powerful trade unions and centralized collective bargaining systems may also have an independent negative effect on profits. Insofar as unions are able to monitor the unfolding of the working process – e.g. ensuring respect for the safety conditions of workers in the workplace with the aim of protecting their welfare and minimizing occupational accidents –, the "rigidities" within the production process become more binding and the monitoring and organizational costs for firms are likely to rise.

3. The database

The database that we use in our analysis is the Sectoral Innovation Database (SID). This dataset includes industry-level data in two-digit NACE Rev. 1 classification for 21 manufacturing and 17 service sectors for six major European countries – France (FR), Germany (DE), Italy (IT), the Netherlands (NL), Spain (ES) and the United Kingdom (UK). The time span covered by the dataset is 1994-2014.

In this section we briefly present the main variables employed in the empirical analysis, while we refer to the final Appendix on the SID database for further detail.

Innovation variables

As regards the technological efforts of industries, we identify the following key innovation variables among those included in the SID: share of firms introducing product innovations, share of firms introducing process innovations, share of firms introducing innovations to open up new markets or increase market share and the expenditure in the acquisition of new machinery and equipment per employee. Data are drawn from the following five European Community Innovation Surveys (CIS) collected by Eurostat: CIS 2 (1994-1996), CIS 3 (1998-2000), CIS 4 (2002-2004), CIS 7 (2008-2010) and CIS 9 (2012-2014). The latter five survey waves are therefore matched with economic, productive structure and labour market data at industrial level.

Economic and distributive variables

Concerning the economic and distributive dynamics of sectors, we focus on the growth pattern of wages, profits, employment and productivity at industrial level. Wage and productivity variables are expressed in worked hours, whereas profits are gross operating surplus and employment is measured as the number of employees (in thousands) at industrial level. Data are drawn from the Structural Analysis Database (STAN) provided by the OECD and from the Socio Economic Accounts (SEA) released by the World Input-Output Database (WIOD).

Offshoring variables

We use four different offshoring indicators built exploiting the World Input-Output Tables (WIOT) provided by the World Input-Output Database (Timmer et al., 2015, 2016). The first one is the broad offshoring indicator, which consists in the ratio between the expenditure for the intermediate inputs imported by a given industry from whatever foreign industries and the expenditure for the total intermediate inputs used by that industry. The narrow offshoring indicator consists instead in the ratio between the expenditure of a given industry for the intermediate inputs imported from foreign industries of the same type (corresponding to the diagonal terms of the import-use matrix) and the expenditure for the total intermediate inputs used by that industry (Feenstra and Hanson, 1996, 1999).[58]

Furthermore, we relate the international fragmentation of production with its technological dimension discriminating intermediate inputs according to their origin (domestic or imported) and their technological content. With regard to this second aspect, we build on the Revised Pavitt

[58] Further detail regarding the offshoring variables included in the SID database and the procedure we followed for their construction are reported in Section 4 of Chapter 1 of the present work.

Taxonomy provided by Bogliacino and Pianta (2010, 2016) and adopt the following criterion: Science based or Specialized suppliers industries are classified as high-tech industries (HT) and the imported intermediate inputs coming from these industries represent the numerator of the high-tech offshoring indicator; Scale and information intensive industries are classified as low-tech industries (LT) and the imported intermediate inputs coming from these industries represent the numerator of the low-tech offshoring indicator.[59]

Union density

The role of labour market institutions is capture by union density – computed as the share of union membership at industry level – drawn from the ICTWSS database (Visser, 2016).

The time structure of the SID database

The dataset is a panel over five periods covering a time span from 1994 to 2014. Economic, distributive and offshoring variables are computed for the periods 1996-2000, 2000-2003, 2003-2008, 2008-2012 and 2012-2014; for the economic and distributive variables we compute the compound annual growth rate that approximates the difference in logarithmic terms, while for the offshoring indicators we take the simple difference. Innovation variables are taken from five waves of innovation survey and each survey is matched with the economic variables of the corresponding period. Finally, union density refers to the first year of each of the five economic period, i.e. 1996, 2000, 2003, 2008, 2012, and are computed as the union membership rate at industry level. Further detail on the temporal structure of the dataset are reported in the final Appendix on the SID database.

The list of variables and the unit of measure

Table 1 summarizes all the variables employed in this chapter, their measurement unit (as computed for our empirical analysis) and the main sources from which they are drawn. All the monetary variables are in euros and constant terms.

Table 1. List of variables

Variable	Unit	Source
Rate of growth of wages	Annual rate of growth	SID – (OECD-STAN)
Rate of growth of profits	Annual rate of growth	SID – (OECD-STAN)
Rate of growth of productivity	Annual rate of growth	SID – (OECD-STAN/WIOD-SEA)
Rate of growth of employment	Annual rate of growth	SID – (OECD-STAN/WIOD-SEA)
New machinery exp. per employee	Thousands euros/employee	SID – (EUROSTAT-CIS)
Share of firms introducing new products	Share	SID – (EUROSTAT-CIS)
Share of firms introducing new processes	Share	SID – (EUROSTAT-CIS)
Share of firms innovating to open new markets	Share	SID – (EUROSTAT-CIS)
Union density	Share	SID – (ICTWSS)
Rate of growth of broad offshoring	Simple difference	SID – (WIOT)
Rate of growth of narrow offshoring	Simple difference	SID – (WIOT)
Rate of growth of high-tech offshoring	Simple difference	SID – (WIOT)
Rate of growth of low-tech offshoring	Simple difference	SID – (WIOT)

Source: Sectoral Innovation Database.

Note: Rate of growth are compound average annual rate of growth computed over two to five years periods (1996-2000; 2000-2003; 2003-2008; 2008-2012; 2012-2014).

The next section provides large descriptive evidence on the relationships between technology, offshoring, union density and wage and profit dynamics for the whole sample covered by the SID.

[59] A detailed description of the Revised Pavitt classes according to which we classify sectors is provided in the final Appendix on the SID database.

4. Descriptive evidence on income distribution dynamics

This section provides descriptive evidence regarding the key relationships among the main variables that we are investigating. Since income distribution dynamics is shaped by a wide range of economic, political and technological forces, we try to disentangle this complexity identifying critical relations at industry and country level. For this purpose, in what follows we focus on the dynamics of profits and wages in relationship with three crucial factors: technological change, globalization of production and unionization.

It must be noted that, unless otherwise stated, in the tables and figures that follow values for profits, wages, labour productivity and employment refer to the compound average annual rate of change over the specified period; all the monetary variables are in euros at constant prices.

Standard descriptive statistics of our main variables are summarized in Table 2, that reports the average unweighted values for the whole sample of industries over the period 1994-2014.[60]

Table 2. Descriptive statistics of main variables

Variable		
Profits (% change)	Mean	2,13
	Std. dev.	3,90
Wages (% change)	Mean	2,08
	Std. dev.	1,46
New products (%)	Mean	31,98
	Std. dev.	16,12
New markets innov. (%)	Mean	28,84
	Std. dev.	14,62
New processes (%)	Mean	27,95
	Std. dev.	11,18
New machinery exp. per emp.	Mean	1,26
	Std. dev.	1,08
Employment (% change)	Mean	-0,70
	Std. dev.	3,41
Labour productivity (% change)	Mean	4,58
	Std. dev.	2,55
Broad Offshoring (% change)	Mean	5,59
	Std. dev.	7,46
Narrow Offshoring (% change)	Mean	0,58
	Std. dev.	5,93
Union density (% change)	Mean	-6,01
	Std. dev.	5,14

Source: Our elaboration on Sectoral Innovation Database.

Note: Profits are sectoral gross operating surplus and wages are sectoral wages per worked hour. Expenditure for new machinery and equipment is expressed in thousands of euros for employee and reflects the average value over the period. New products, innovations to open new markets ("new markets innov.") and new processes reflect the average share of innovators at sectoral level for each variable over the period. Offshoring variables and union density are computed as the average simple difference over the period.

[60] More precisely, given the time structure of our database and the availability of data coming from different sources, Table 2 provides descriptive statistics for the main innovation variables for the period 1994-2014, while the values of all the other variables reported in the table refer to the period 1995-2014.

4.1 The role of technology

Technology plays a key role in determining the industries' innovation effort and their subsequent economic performance. Table 3 reports descriptive statistics of the main indicators under investigation, emphasizing the distinction between high- and low-tech industries clustered according to the previously introduced Revised Pavitt Taxonomy-based criterion. It provides a detailed picture of the structural relationship between the technological trajectories of industries and their economic, distributive and innovation performance.

As expected, all indicators are higher in high-tech industries, confirming the technological dimension as a key aspect of modern economies. Unsurprisingly, the gap between high- and low-tech industries is larger for the variable which captures the share of firms introducing product innovations at sectoral level, while it is smaller if we look at the main source of embodied technical change for low-tech industries, i.e. the expenditure in new machinery and equipment. It is worth noting that, although the labour productivity growth is slightly higher in high-tech industries, the low-tech industries experience an even stronger employment reduction that we could interpret as a symptom of the structural change process of economies towards knowledge intensive sectors.

Table 3. Descriptive statistics by technological intensity of industries

Variable		High-tech industries	Low-tech industries
Profits (% change)	Mean	2,74	1,80
	St. dev.	3,89	3,88
Wages (% change)	Mean	2,29	1,97
	St. dev.	1,37	1,49
New products (%)	Mean	41,68	26,93
	St. dev.	16,97	13,12
New markets innov. (%)	Mean	35,20	25,54
	St. dev.	16,03	12,67
New processes (%)	Mean	30,70	26,51
	St. dev.	10,34	11,37
New machinery exp. per emp.	Mean	1,35	1,21
	St. dev.	0,99	1,12
Labour productivity (% change)	Mean	4,86	4,44
	St. dev.	2,45	2,60
Employment (% change)	Mean	-0,07	-1,02
	St. dev.	3,93	3,08
Broad Offshoring (% change)	Mean	7,05	4,81
	St. dev.	7,40	7,40
Narrow Offshoring (% change)	Mean	-0,12	0,93
	St. dev.	5,58	6,09
Union density (% change)	Mean	-5,45	-6,30
	St. dev.	4,58	5,40

Source: Our elaboration on Sectoral Innovation Database.

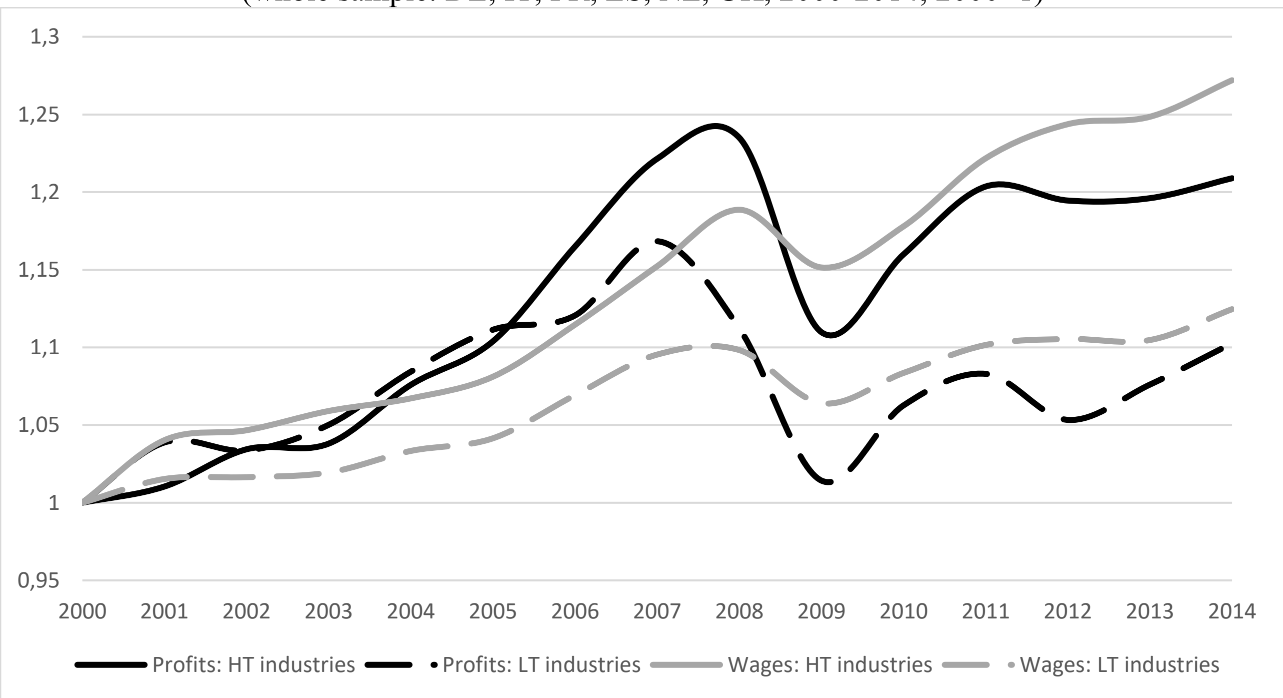
Note: Profits are sectoral gross operating surplus and wages are sectoral wages per worked hour. Expenditure for new machinery and equipment is expressed in thousands of euros for employee and reflects the average value over the period. New products, innovations to open new markets ("new markets innov.") and new processes reflect the average share of innovators at sectoral level for each variable over the period. Offshoring variable is computed as the average simple difference over the period.

4.1.1 Technology and income distribution patterns

In this section we provide a set of figures which enable us to summarize the heterogenous role which technology plays in the structural evolution of the economies and on wage and profit dynamics. For this purpose, in Figure 1 profits and wages for individual industries are aggregated on the basis of the technological intensity of the sectors; the aggregation in high-tech and low-tech groups has been carried out according to the Revised Pavitt Taxonomy proposed by Bogliacino and Pianta (2010, 2016) with the aim of capturing major structural differences in the relationship between technological change and the economic performance of industries. The high-tech group includes Science based and Specialized suppliers sectors, while the low-tech group includes Scale and information intensive and Supplier dominated sectors.[61]

Up to the crisis the dynamics of profits in high-tech and low-tech industries has been roughly the same, but the disruptive impact of the crisis of 2007/2008 hit firstly and strongly the low-tech industries, widening the gap between the two. That gap became even larger after the second European slump occurred in 2011 and is the outcome of the higher growth rate high-tech industries' profits compared to the low-tech ones. A similar dynamics holds for wages, where the divergence between labour compensation widens during the crisis due to the faster recovery in high-tech industries. Since we are examining profits and wages respectively as the total capital compensation and the wage bill of industries, Figure 1 accounts also for the process of structural change of the economies and the way in which it is interwined with the crisis of accumulation process in Europe. The crisis has hit the industries that rely on "low value-added" productions more strongly, inducing a shift in the composition of production towards technology-intensive industries.

Figure 1. Dynamics of profits and wages in high-tech and low-tech industries
(whole sample: DE, IT, FR, ES, NL, UK, 2000-2014; 2000=1)



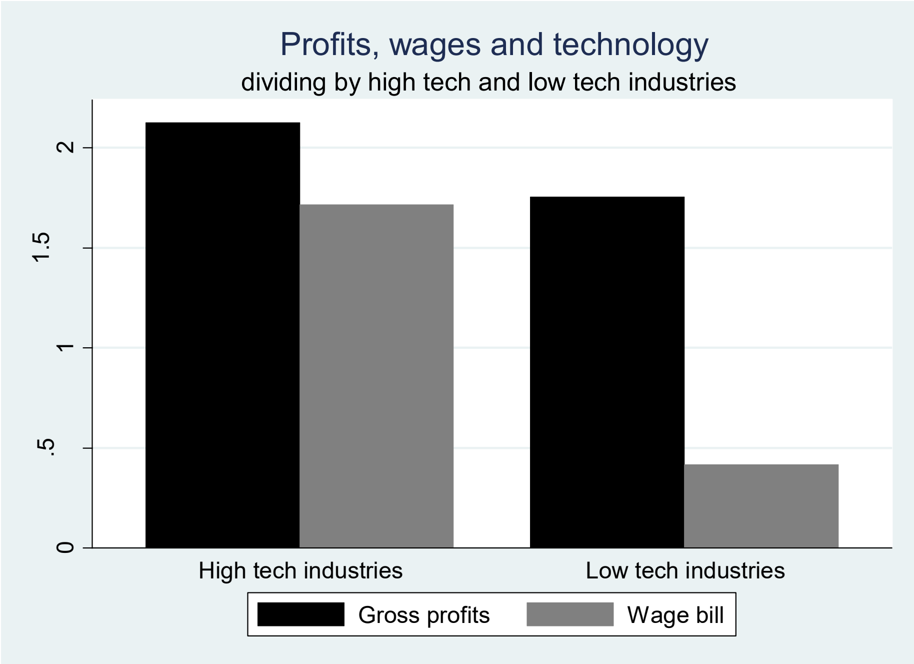
Source: Our elaboration on WIOD-SEA database.

Note: Profits are total capital compensation and wages are the overall labour compensation (gross of social security contributions). We exclude the following thirteen sectors over the fifty-six ones reported by WIOD: crop and animal production and hunting; forestry and logging; fishing and aquaculture; mining and quarrying; electricity and gas; water collection; sewerage and other waste management services; construction; public administration, defence and compulsory social security; education; human health and social work activities; activities of households as employers; activities of extraterritorial organizations.

[61] See the final Appendix on the SID database for further details on the Revised Pavitt Taxonomy and the list of sectors classified accordingly.

Figure 2 provides further evidence on the role played by technology on process of structural change of the economies and on distributional dynamics. Both gross profits and wage bill are grown faster in industries with stronger technological capabilities compared to those less engaged in technological efforts. The wide gap between the growth rate of wage of the two groups of industries seems confirming a prevailing strategy aimed to reduce labour costs in low-tech ones.

Figure 2.



Source: Our elaboration on Sectoral Innovation Database.
Note: Gross profits are sectoral gross operating surplus and wage bill is sectoral labour compensation of employees. Industries are grouped in high-tech (Science based and Specialized suppliers sectors) and low-tech (Scale and information intensive and Supplier dominated sectors) clusters according to the Revised Pavitt Taxonomy proposed by Bogliacino and Pianta (2010, 2016).

We focus now on the role that different kinds of innovative efforts have on the evolution of profits and wages. In doing so, we classify industries according to both their technological patterns – using the Revised Pavitt Taxonomy (Bogliacino and Pianta, 2010, 2016) – and the country they belong. Therefore, in the following figures the first two characters of each observation stand for the country (FR stands for France, DE for Germany, IT for Italy, NL for the Netherlands, ES for Spain and UK for the United Kingdom), while the last two ones identify the technological classification of sectors: Science based industries (SB), Specialized suppliers industries (SS), Scale and information intensive industries (SI) and Supplier dominated industries (SD).

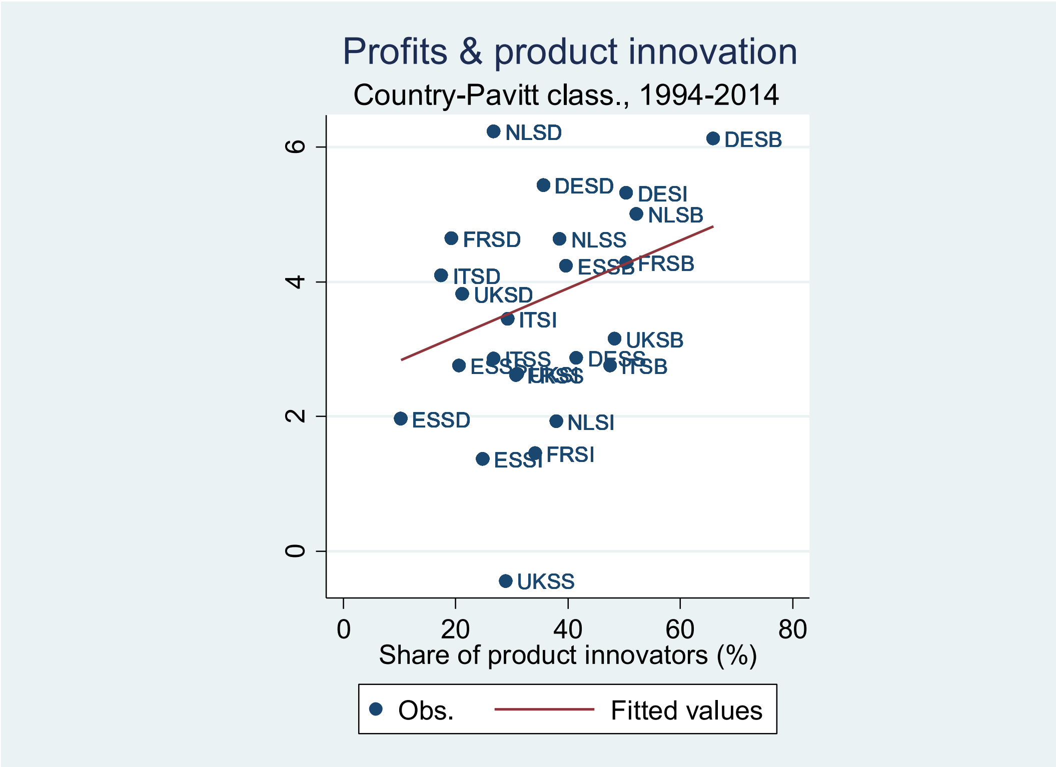
This type of sorting enables to capture both the industry and country dimension regarding the innovation–income distribution nexus. Mostly, we deal with the huge heterogeneity characterizing the innovative behavior of industries with the aim of underlining the contrasting impact that different kinds of innovation have on capital and labour compensation.

4.1.2 Technology and profits

Figure 3 and Figure 4 provide empirical evidence about the effects that product and process innovations have on the growth rate of profits per hour worked for the whole sample of industries. In both graphs a positive relationship arises, showing that profits growth is supported by the introduction of both new products and processes. Moreover, Figure 5 provides evidence on expenditure for new machinery and equipment per employee (an indicator of process innovation) and its relationship with profit growth, showing that the same pattern is broadly confirmed.

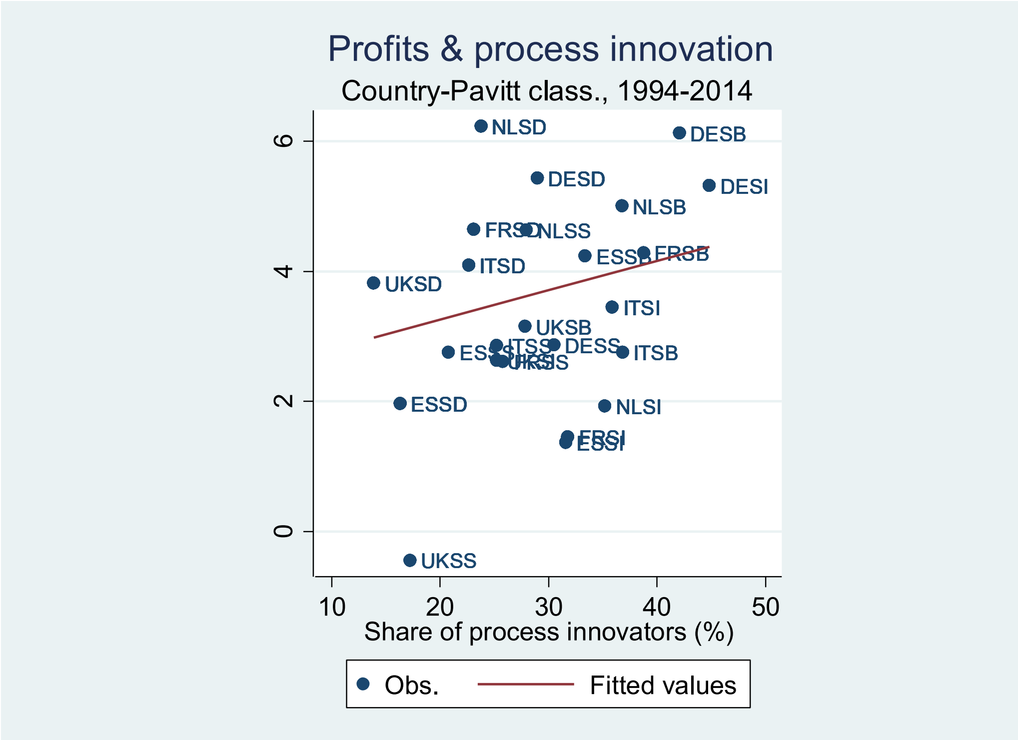
In particular, countries with stronger technological efforts (e.g. Germany) tend to obtain higher profits than less innovative economies (e.g. Spain); nonetheless, the evidence shows that, within each country, industry groups with higher innovation (e.g. Science based) tend to have a higher profit growth than low technology ones (e.g. Supplier dominated). As it will emerge also in the figures that follow, this last element suggests, first, the key relevance of the technological trajectories of industries (more than the country to which they belong); second, it supports our structural change perspective with regard to the overall performance of countries, whose economic performance ends up to depend crucially from the industrial specialization and the related dominant competitiveness strategy pursued.

Figure 3.



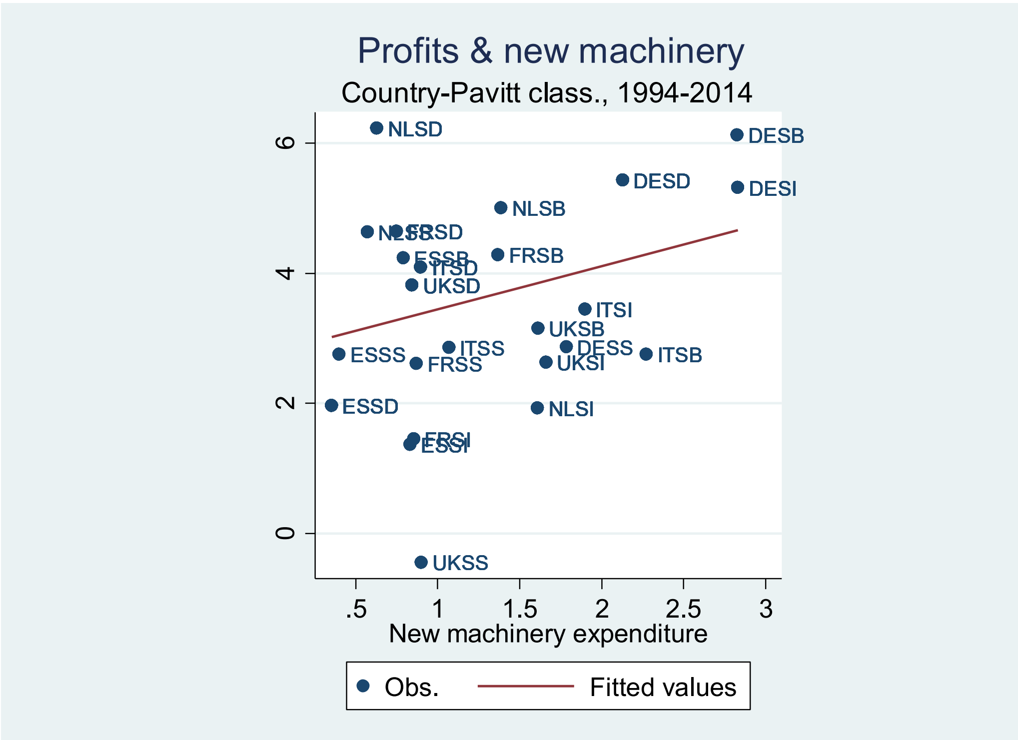
Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the unweighted average values of industries grouped according to the country-Pavitt classification. Profits are sectoral gross operating surplus; the share of product innovators reflects the average share of firms introducing product innovations at sectoral level over the period.

Figure 4.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Profits are sectoral gross operating surplus; the share of process innovators reflects the average share of firms introducing process innovations at sectoral level over the period.

Figure 5.



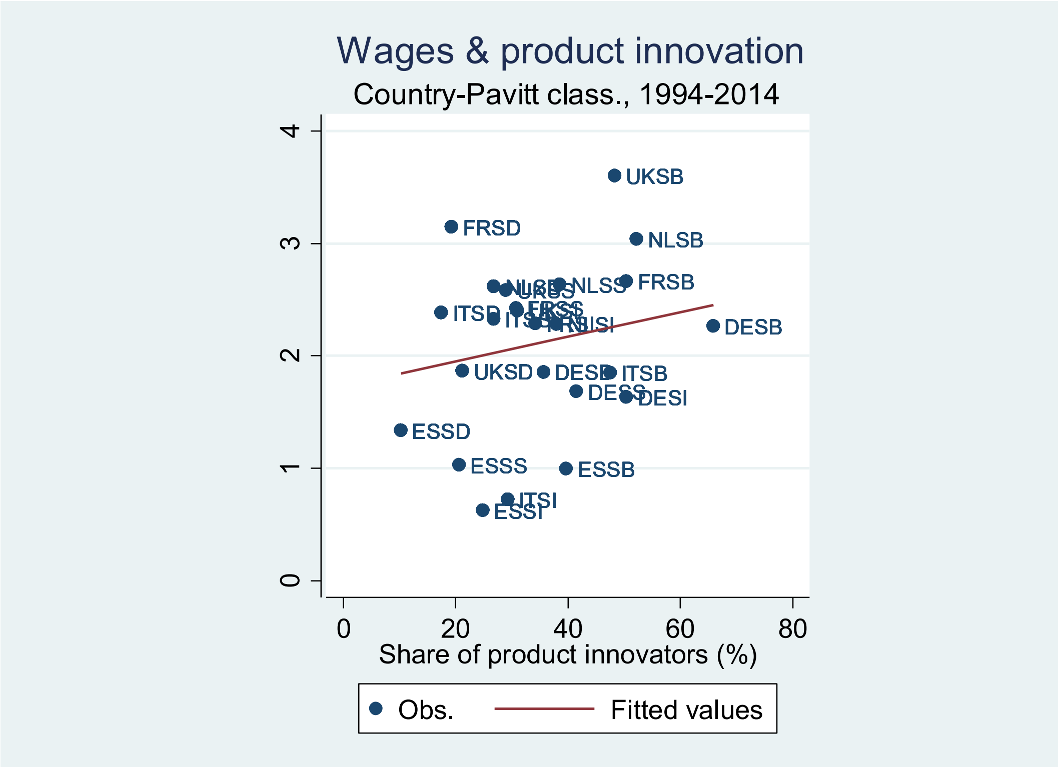
Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Profits are sectoral gross operating surplus; expenditure for new machinery and equipment is expressed in thousands of euros for employee at constant prices and reflects the average value over the period.

4.1.3 Technology and wages

We move now to the descriptive analysis of the relationship between technological change and the dynamics of wages. Figure 6 and 7 plot respectively the impact that the introduction of product innovation and innovation introduced with the aim of opening up new markets have on the rate of growth of wage per worked hour. Both figures show a positive relationship, suggesting that the introduction of new products and the innovative effort pursued to increase market shares have a positive effect on wages.[62]

The opposite relationship is found when we look to Figure 8, which shows that those sectors and countries which pursue strongly a strategy aimed to introduce process innovations experimented a lower wage growth. The same dynamics, though less markedly, emerges from the relationship between the investment in new machinery and equipment and the growth rate of wages reported in Figure 9, supporting our hypothesis on the expenditure in new machinery as a proxy of process innovation.[63]

Figure 6.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Wages are sectoral wages per worked hour; the share of product innovators reflects the average share of firms introducing product innovations at sectoral level over the period.

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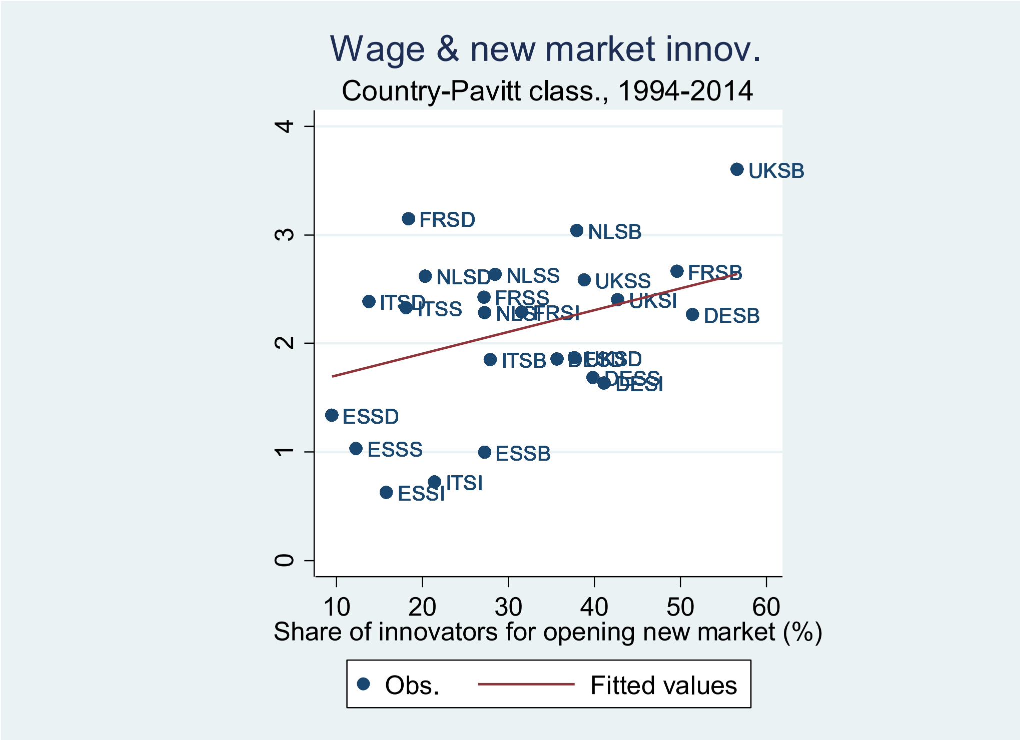
[62] A fairly clear distinction also emerges between the countries belonging to the "core" of European Union, namely Germany, the Netherland, France and the United Kingdom (mainly given by the technological performance of their high-tech industries), and the "peripheral" European countries (as Italy and Spain); nonetheless, it is worth noting that Germany observations are usually below the fitted values line, providing evidence about the slow German wage growth and pointing out a limited sharing of the rents generated by innovation.

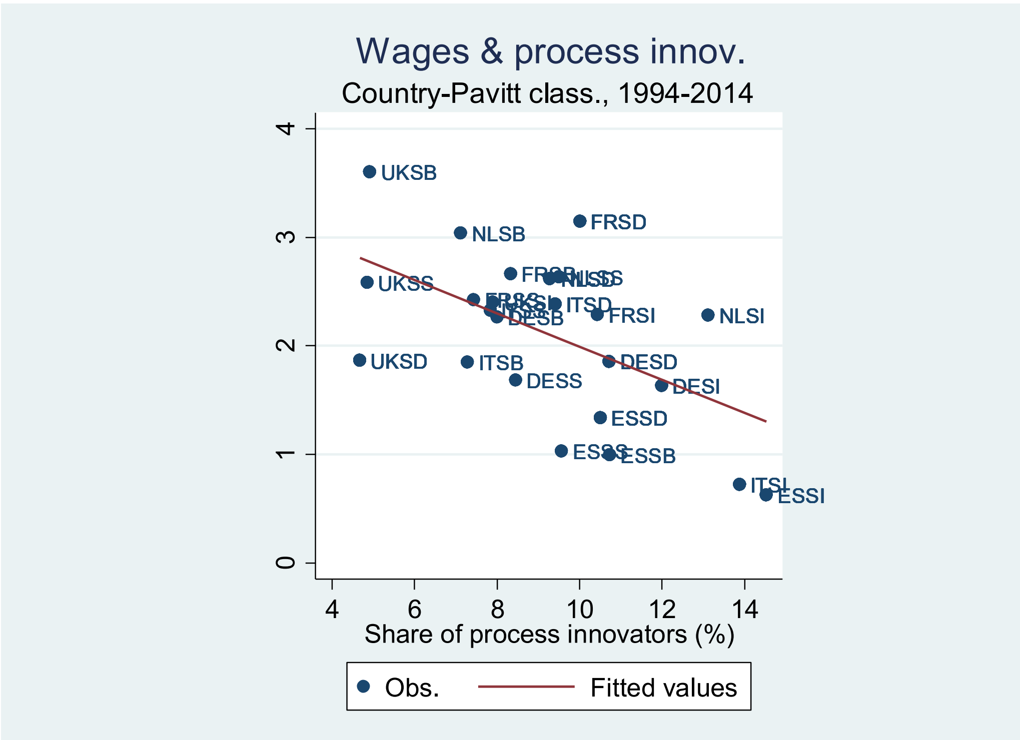
[63] Although confirming the general relationship between wages and different kinds of innovation, it is worth noting the poor performance of Spain in terms of technological capabilities and, subsequently, growth of labour and capital compensation compared to the other European countries.

Figure 7.



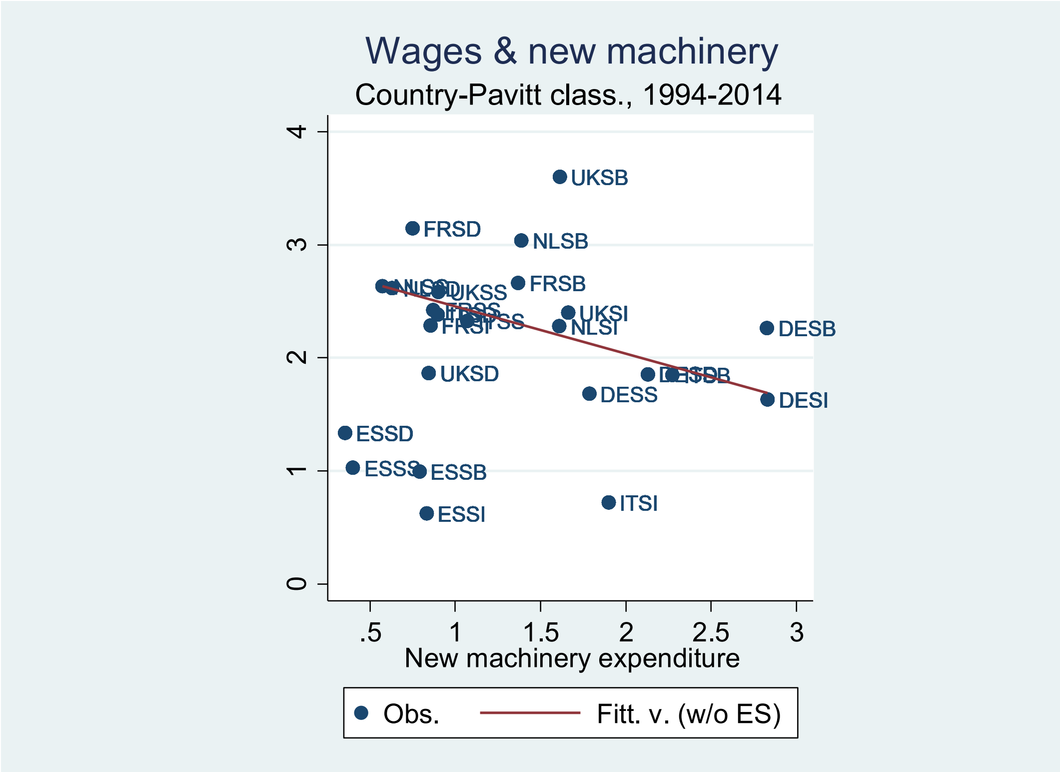
Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Wages are sectoral wages per worked hour; the share of innovators for opening new markets reflects the average share of firms introducing innovations with the aim of open up new markets at sectoral level over the period.

Figure 8.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Wages are sectoral wages per worked hour; the share of process innovators reflects the average share of firms introducing process innovations at sectoral level over the period.

Figure 9.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Wages are sectoral wages per worked hour; expenditure for new machinery and equipment is expressed in thousands of euros for employee at constant prices and reflects the average value over the period.

4.2 The role of offshoring

Globalization has led to an increasing international fragmentation of production. Table 4 provides empirical evidence on the impact of offshoring activities on main distributional, technological and economic variables and the interaction between the globalization of production and the technological trajectories of industries. For this purpose, we group high- and low-tech offshoring intensive sectors according to the intensity of broad offshoring processes experienced by industries during the period, using the annual median value of the indicator as a threshold. The "high offshoring intensive" group thus includes all sectors registering a value of the broad offshoring indicator that is above the median one; conversely, "low offshoring intensive" industries are those which register a value of the aforementioned variable that is below the median one. Then, within the two offshoring categories we distinguish between high- and low-tech industries and we find that, as expected, wages grow considerably more in those industries in which production relies less on offshoring processes and more on high technology.

Profits are higher in the most internationalized high-tech sectors, suggesting that technology advances industries involved in global value chains take advantage of both a reduction of labour costs and foreign technological spillovers; conversely, the lowest profit increase is found in low-tech industries more prone to suffer from import penetration, implying a subordinate position of those industries with respect to their international production network.

The crucial relevance of being embedded in global supply chains for the technological development of industries is revealed by the results shown for the innovation variables, whose values are systematically higher in the most offshoring-intensive industries. Accordingly, labour productivity shows a similar pattern. This finding suggests the importance of foreign acquisition of knowledge in pursuing technological upgrading and the prominence of offshoring strategies designed to reach this goal.

As expected, the employment dynamics is broadly negative, especially in those industries not located on the technological frontier and whose competitiveness strategy relies more on offshoring processes. Consistently, the only sectors experienced a positive occupational pattern are those which combine a relatively sustained technological progress with a relatively little use of delocalization strategies.

Finally, the overall reduction of union density among European industries emerges and the low-tech sectors less involved in offshoring processes turn out to be the ones which experienced mostly the unionization rate decline.

Table 4. Descriptive statistics by offshoring and technological intensity of industries

	High offsh. intensive		**Low offsh. intensive**	
Variable	***High-tech***	***Low-tech***	***High-tech***	***Low-tech***
Profits (% change)	3,41	0,89	1,79	2,59
Wages (% change)	2,04	2,01	2,64	1,94
New products (%)	48,65	29,32	31,68	24,84
New markets innov. (%)	39,71	27,08	28,70	24,19
New processes (%)	35,96	28,48	23,15	24,79
New machinery exp. per emp.	1,69	1,49	0,86	0,95
Labour productivity (% change)	5,37	4,74	4,12	4,17
Employment (% change)	-0,24	-1,75	0,18	-0,38
Union density (% change)	-5,43	-5,56	-5,48	-6,96

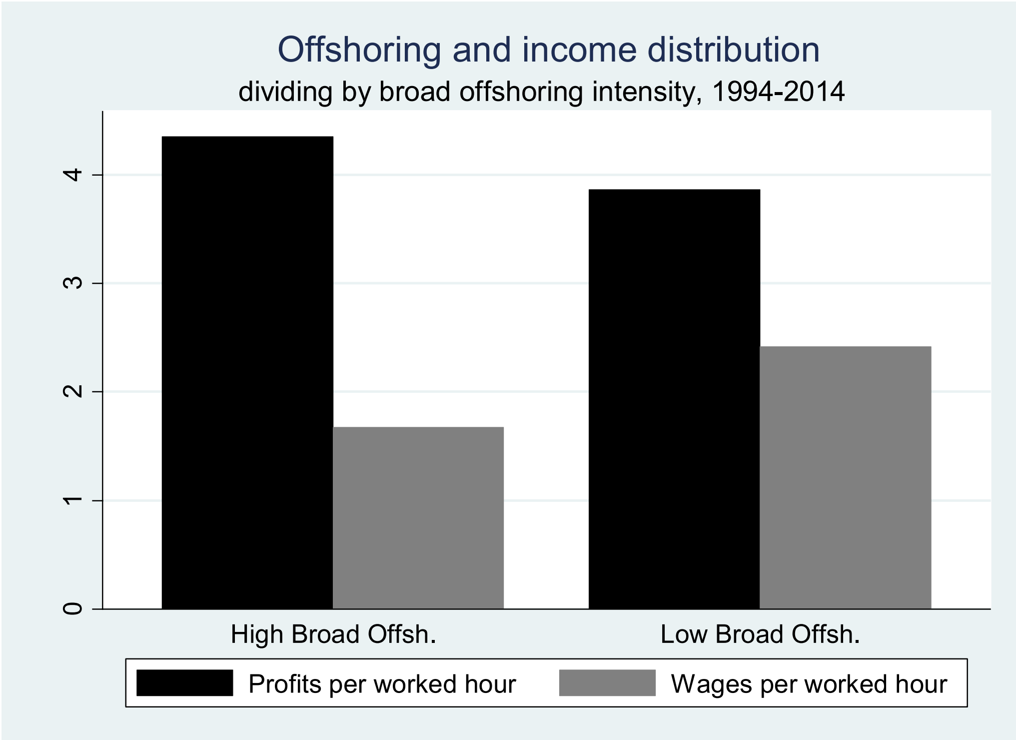
Source: Our elaboration on Sectoral Innovation Database.

Note: Profits are sectoral gross operating surplus and wages are sectoral wages per worked hour. Expenditure for new machinery and equipment is expressed in thousands of euros for employee and reflects the average value over the period. New products, innovations to open new markets and new processes reflect the average share of innovators at sectoral level for each variable over the period. The values for individual industries are aggregated in high and low offshoring intensive industries according to the median criterion previously introduced; the high-tech (SB and SS sectors) and low-tech (SI and SD) industries are clustered according to the Revised Pavitt Taxonomy proposed by Bogliacino and Pianta (2010, 2016).

Figure 10 and 11 report the average rate of growth of profits per worked hour and of wages per worked hour distinguishing industries according to their broad and narrow offshoring intensity. As previously, we applied the median criterion to discriminate industries according to their offshoring intensity. Both graphs confirm that sectors relatively more involved in global value chains show the higher rate of growth of profits and the lower rate of growth of wages.

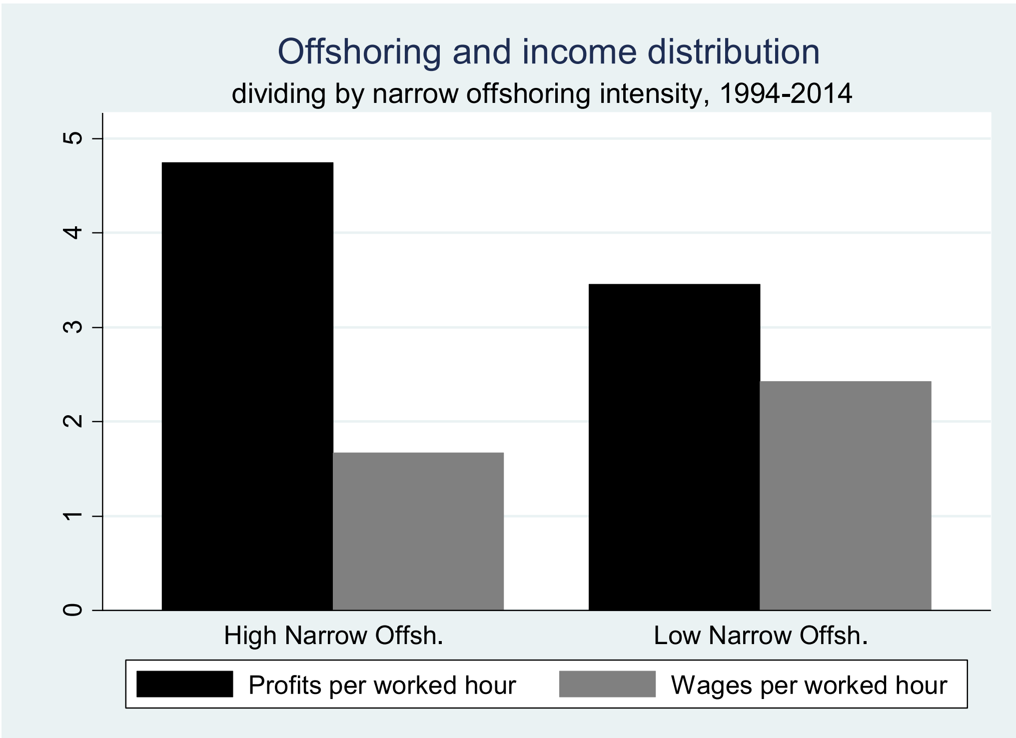
These empirical findings support our hypothesis according to which globalization of production has a positive effect on capital compensation, providing industries with valuable intermediate inputs not available domestically and pushing downward wages through the harmful effect that delocalization strategies have on workers' bargaining power.

Figure 10.



Source: Our elaboration on Sectoral Innovation Database.
Note: Profits are sectoral gross operating surplus per worked hour and wages are sectoral wages per worked hour. The values for individual industries are aggregated in high and low broad offshoring intensive industries according to the median criterion previously introduced.

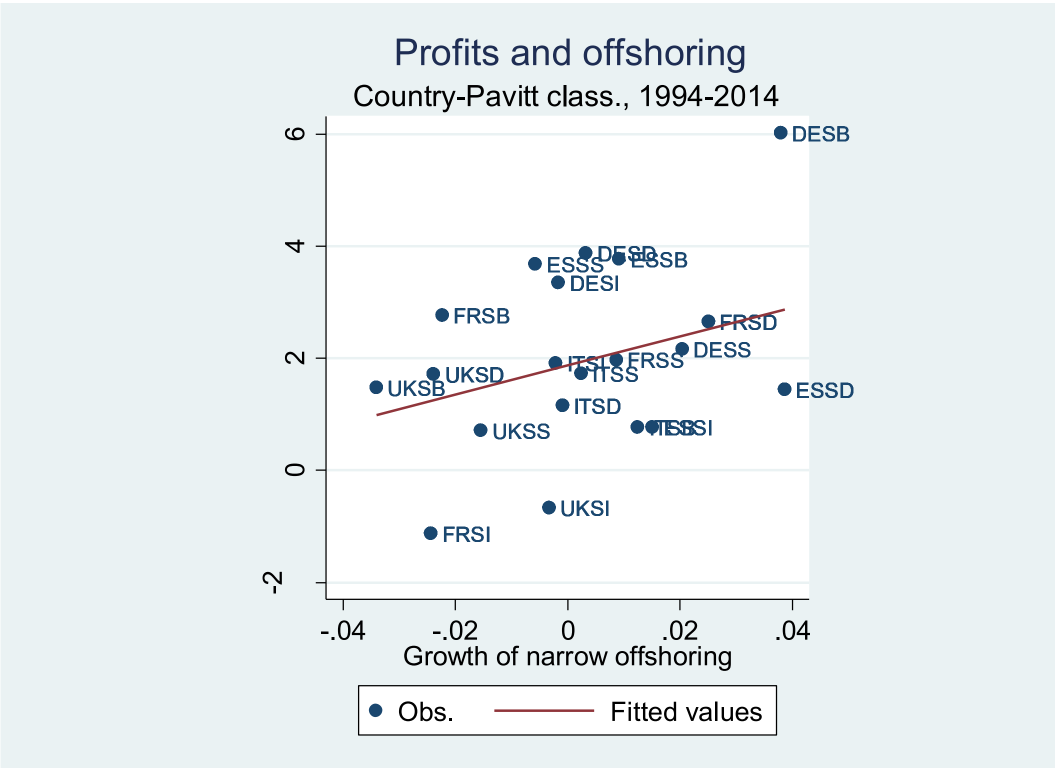
Figure 11.



Source: Our elaboration on Sectoral Innovation Database.
Note: Profits are sectoral gross operating surplus per worked hour and wages are sectoral wages per worked hour. The values for individual industries are aggregated in high and low narrow offshoring intensive industries according to the median criterion previously introduced.

Figure 12 shows the empirical relationship between the rate of growth of gross profits and the (narrow) offshoring efforts pursued by industries over the period. The observations are grouped according to a country-Pavitt classification displaying considerable heterogeneity along these two dimensions.[64] As expected, the graph suggests a positive relationship between the internalization of production and profits. Nonetheless, it is worth noting that United Kingdom appears to be the only country which experienced an overall decreasing internationalization of its production structure, while Germany (and to a less extent Spain) seems to be the country which has gained more from the global fragmentation of its production processes. Consistently with our framework, the opposite relationship is found when we relate the growth rate of wages per worked hour with the growth of narrow offshoring (Figure 13). Indeed, despite a remarkable country-Pavitt heterogeneity, a negative relation between wages and offshoring is detected.

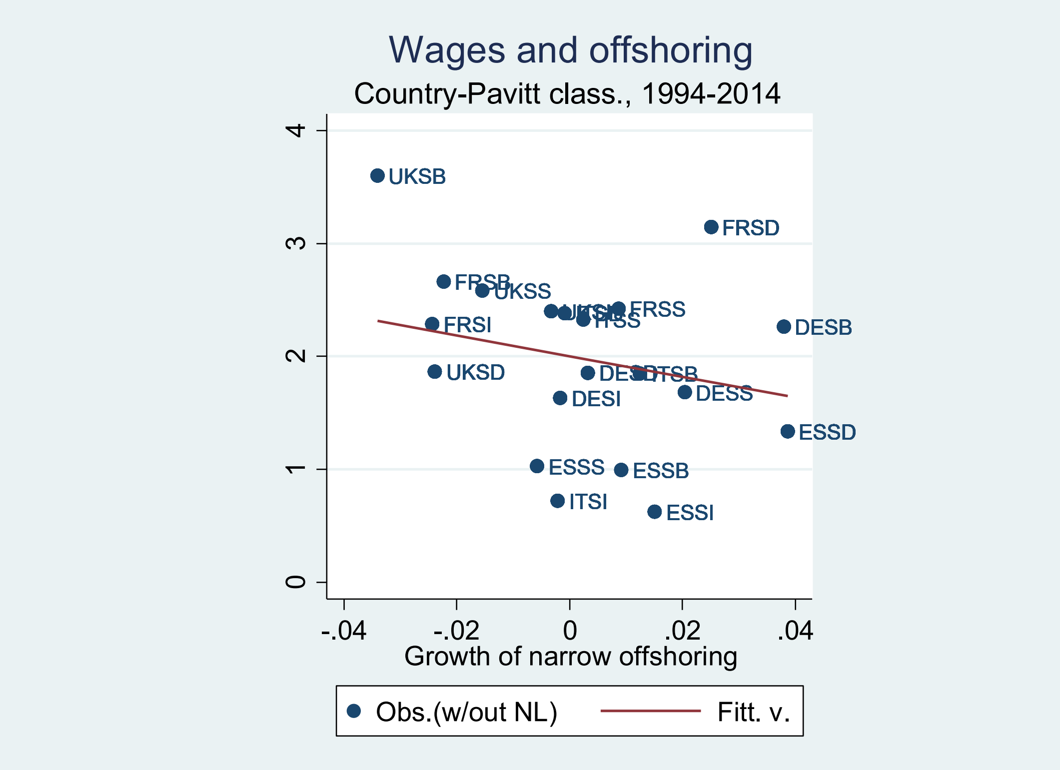
Figure 12.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Profits are sectoral gross operating surplus; the growth of narrow offshoring is computed as the average simple difference over the period.

[64] Figure 10 and 11 exclude the Netherlands from the sample. From a descriptive point of view, the Netherlands' offshoring observations are misleading because of the small dimension of this country (compared to the others) and for the "seaport effect" which stems from being a trade hub.

Figure 13.



Source: Our elaboration on Sectoral Innovation Database.
Note: Observations refer to the average values of industries grouped according to the country-Pavitt classification. Wages are sectoral wages per worked hour; the growth of narrow offshoring is computed as the average simple difference over the period.

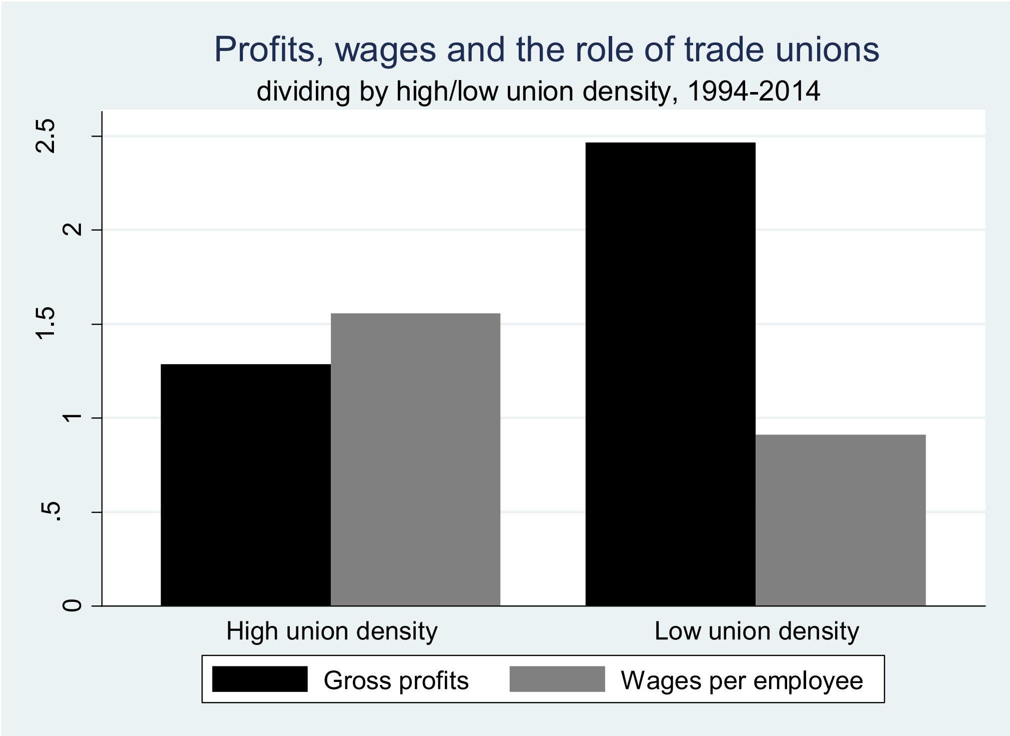
4.3 The role of trade unions

Institutional differences in industrial relations represent a key element which shape power relations between capital and labour. Notably, labour market institutions, their heterogenous effectiveness and the different actors which contribute to design their social and economic role, have major impact on the distributional dynamics in the various sectors.

Figure 14 provides stylized evidence on the effect of union density on profit and wage dynamics. For this purpose, we grouped high- and low-union density industries according to the level of the union membership rate of the sectors during the period, using the annual median value of the indicator as a threshold. The "high union density" group thus includes all sectors registering a value of the union membership rate that is above the median one; conversely, "low union density" industries are those which register a value of the aforementioned variable that is below the median one.

The distinction between highly and not highly unionized industries emerges clearly from the figure, suggesting trade unions as relevant actors in shaping the dynamics of income distribution and restating indirectly the role of collective wage bargaining. Consistently, the growth of profits is twice in industries in which the union density is below the median with respect to the ones in which the union density is above it. The opposite is true for wages, which experienced a stronger increase in those industries characterized by a higher union membership rate.

Figure 14.



Note: Profits are sectoral gross operating surplus and wages are sectoral wages per employee. The values for individual industries are aggregated in high- and low-union density clusters according to the median criterion explained in the main text.

5. A simultaneous model for the dynamics of profits and wages

We follow the approach proposed by Pianta and Tancioni (2008) to develop a simultaneous model to investigate the dynamics of profits and wages focusing for the role of labour productivity growth, heterogenous innovation strategies, international fragmentation of production and labour market institutions.

As already discussed (see Section 2), labour productivity is regarded as a pivotal component in the structural change process of the economies; since it represents a factor which captures both the growth of capital investment and value added, as well as the organizational improvements carried out by industries, it is a key element to account for in our analysis about the determinants of distributional patterns. Moreover, the complex outcomes of innovation are fully addressed as far as we distinguish between product and process innovation and assess their different impact on income distribution. We take also into account the growing importance of transnational value chains, whose distributive impact we capture thanks to different offshoring proxies. Finally, we built an industry-level variable, namely union density, to account for the role played by labour market institutions in affecting the bargaining power of workers and thus the dynamics of capital and labour compensation.

In the next section our two-equation model for the analysis of the determinants of gross profits and wage per worked hour dynamics is presented.

5.1 The wage equation

On the basis of the theoretical considerations provided in the previous sections, we set up a log-linear equation for the determination of wage dynamics as the following:

$$log(W_{ijt}) = \alpha_1 log(PROF_{ijt}) + \alpha_2 log(PROD_{ijt}) + \alpha_3\, log(NP_{ijt}) + \alpha_4 log(MACH_{ijt}) + \alpha_5 log(OFFSH_{ijt}) + \alpha_6 log(UD_{ijt}) + u_{ij} + \varepsilon_{ijt}$$

where i, j and t identify, respectively, industry at two-digit level according to NACE (Rev. 1) classification, country and time.

First, wages are affected by the dynamics of profits in order to capture the conflictual relation between capital and labour. Wage per worked hour is indicated by W, while $PROF$ stands for gross profits at sectoral level[65]. The sectoral labour productivity, as a driver of industries' evolution and thus of their distributive patterns is indicated by $PROD$.

With regard to innovation, we move beyond the notion of an undifferentiated technological change stressing the heterogenous distributive impact of technological and cost competitiveness strategies. For this purpose, our wage equation includes a variable mainly associated with a trajectory of technological competitiveness (NP) and another one mostly related to a cost-based competitive strategy ($MACH$). Following Pianta (2001), the former is proxied by the introduction of new products in the market, while the latter by the adoption of new processes (e.g. those which promote mechanization of production).

$OFFSH$ stands for the offshoring indicator, capturing the role of international fragmentation of production.[66] The measures of offshoring process that we implement in our model include both a

[65] Following Pianta and Tancioni (2008), we use total sectoral profit as a proxy of capital compensation, although the investigation of rate of return on capital would be the most proper variable for our analysis. Unfortunately, missing data on industries' capital fixed assets makes such analysis unfeasible. However, considering that capital stock does not change rapidly at industry level, assuming total profit as a good return of capital proxy appears to be reasonable. Conversely, sectoral wage bill depends directly on the number of workers or, more accurately, on the working time performed by employees (given the widespread use of precarious and part time jobs nowadays). Hence, wage per worker hour is considered a more appropriate measure to capture the distributional impact of our covariates and the relationship between labour and capital remuneration.

[66] Values of all the offshoring variables have been multiplied by 100.

narrow offshoring indicator (Feenstra and Hanson, 1999) and a technology-based offshoring proxy developed by Guarascio et al. (2015). The latter enables to distinguish between high-tech and low-tech offshoring strategies according to the nature of knowledge, patterns of innovation and market structure of foreign industries from which the inflow of imported intermediate inputs origins – as described above, this distinction relies on the Revised Pavitt taxonomy developed by Bogliacino and Pianta (2010, 2016).

The essential role played by institutions of labour market in shaping the workers' bargaining power is captured by UD, which stands for union density, i.e. the union membership rate at industrial level. Finally, u controls for time-invariant fixed effects and ε represents the standard idiosyncratic error term.

By taking the first difference of the equation we get rid of the time-invariant components, reducing potential endogeneity bias. Hence the final formulation of the wage equation is the following:

$$\Delta log(W_{ijt}) = \alpha_1 \Delta log(PROF_{ijt}) + \alpha_2 \Delta \log(PROD_{ijt}) + \alpha_3 \Delta\, log(NP_{ijt}) + \alpha_4 \Delta log(MACH_{ijt}) + \alpha_5 \Delta log(OFFSH_{ijt}) + \alpha_6 \Delta log(UD_{ijt}) + \Delta\varepsilon_{ijt}$$

As it has already been stated, the variables regarding wages, profits and productivity at sectoral level are computed as compound annual average rate of change which proxies the difference in logarithmic terms. Our expectation is to find a negative relationship between profit growth and wage growth because of the distributive conflict between capital and labour, while we expect a positive impact of labour productivity growth on the dynamics of labour compensation.

The innovation variables proxying technological and cost competitiveness strategy are measured, respectively, by share of firms introducing new products (NP) and by expenditure for new machinery per employee ($MACH$) – an indicator of embodied technical change representing our process innovation proxy. We already stressed how these latter indicators can be conceived as intrinsically dynamic as far as grasp the changing innovative efforts of firms along the technological trajectories of industries. Consistently with the theoretical considerations provided in Section 2.2, we expect a positive impact of product innovation on wage growth, while the job destruction threat stemming from the introduction of process innovation is expected to exert a negative effect on labour compensation growth.

Likewise, union density is computed as share of union membership at industrial level at the beginning (i.e. in the first year) of every time windows. As our proxy of workers' bargaining power, we expect it has a positive impact on wage growth.

Finally, the variation of offshoring intensity of sectors is computed as the simple difference between the last and the first year of each time period under observation. As previously discussed in Section 2.4, we expect to find a broadly negative impact of narrow offshoring on wage growth and mainly of low-tech offshoring, while contrasting theoretical insights make the impact of high-tech offshoring on wages harder to predict.

5.2 The profit equation

The second equation of our simultaneous model concerns the determinants of industrial gross profits and stems from the theoretical analysis provided above. As well as for wage equation, Pianta and Tancioni (2008)'s specification of profit equation is extended to assess the soundness of their empirical findings when both manufacturing and service sectors are accounted for and a much longer time span is considered. Nonetheless, our theoretical considerations lead us to control also for the impact of globalization (conceived as the rising integration of industries in hierarchical global networks of production) and of trade unions' activity on income distribution. From a formal point of view, we introduce the following log-linear equation of profit dynamics:

$$log(PROF_{ijt}) = \alpha_1 log(W_{ijt}) + \alpha_2 log(PROD_{ijt}) + \alpha_3\, log(NP_{ijt}) + \alpha_4 log(MACH_{ijt}) + \alpha_5 log(OFFSH_{ijt}) + \alpha_6 log(UD_{ijt}) + u_{ij} + \varepsilon_{ijt}$$

where i stands for industry at two-digit level, j for country and t for time.

Social conflict is accounted for by the presence of wages at the right-hand side of the equation. As for previous equation, $PROF$ indicates gross profits, W stands for wage per worked hour and $PROD$ for labour productivity at industrial level. Whether the distributive conflict would be capture by the coefficient related to the wage growth, that we expect to be negative, labour productivity growth should represent a driver of industries' competitiveness and thus of profit growth; it follows that, according to our expectation, labour productivity will show a positive and significant sign.

Furthermore, we take into account the channels through which different kinds of innovation affect profits (irrespective of their impact on wages) by including NP and $MACH$ among regressors. The former still accounts for the introduction of new products and, reflecting a technology-based competitiveness strategy, we expect it exerts a robust positive impact on profit growth. The latter stands for the expenditure in machinery and equipment and represents a proxy of process innoavation; it captures the impact of cost-based competitiveness strategy pursued by industries and is expected to have a positive coefficient.

As illustrated above, $OFFSH$ and UD stand for the offshoring indicator and the union membership rate at industrial level, respectively. According to the theoretical framework provided in Section 2.3 and 2.4, we expect a positive impact of offshoring indicators on profit growth and a negative coefficient of union density. Lastly, time-invariant fixed effects and the error term are captured by u and ε, respectively.

Differentiating the equation to get rid of time-invariant unobservable effects we obtain the following final specification for profits:

$$\Delta log(PROF_{ijt}) = \alpha_1 \Delta log(W_{ijt}) + \alpha_2 \Delta \log(PROD_{ijt}) + \alpha_3 \Delta\, log(NP_{ijt}) + \alpha_4 \Delta log(MACH_{ijt}) + \alpha_5 \Delta log(OFFSH_{ijt}) + \alpha_6 \Delta log(UD_{ijt}) + \Delta\varepsilon_{ijt}$$

where the way in which the variables are computed is the same explained above.

5.3 Econometric strategy

The econometric strategy adopted to estimate empirically the wage and profit equation relies on panel data techniques suitable for dealing with datasets marked by a large cross sectional and relatively reduced temporal dimension.

First, the estimation procedure is performed after having differentiated the equations to get rid of any time-invariant individual effects. Considering that the latter may have a simultaneous impact on both the dependent variable and the regressors – leading to biased estimates –, first-differencing removes this source of endogeneity. Furthermore, we calculate long differences with two- to five-years lags, softening considerably the autoregressive character of variables. As already mentioned, offshoring indicators are computed as simple difference while profit, wage, and productivity variables are compound average annual rate of variation both over the following periods: 1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014.

Second, the temporal structure of the panel is designed to harmonize the different sources of data we exploit and, remarkably, to account for the time needed by innovation to unfold its economic effects. Except for the last period (for which the CIS data do not allow us to account for a time lag), innovation variables – i.e. NP and $MACH$ – refer to a lagged period as compared to dependent economic variables (i.e. wages and profits). Indeed, the former refer to the following periods: 1994-1996, 1998-2000, 2002-2004, 2008-2010, 2012-2014. Similarly, union density refers to the first year of each period the dependent variables are computed on. This allows us to reduce the presence of simultaneity-related endogeneity and to account, at once, for the time required by technological advances to impact on distributional outcomes.

Third, we include a set of time, country and sectoral (i.e. Pavitt classes and manufacturing) dummies as additional control, with the aim of reducing the potential endogeneity bias which may stem from other sources of observable heterogeneity. Primarily, time dummies are conceived as essential to control for the business cycle; otherwise, time-specific effects – that likely impact on all variables under observations – would be captured by the error term raising endogeneity problems. Nevertheless, from a theoretical point of view, country and sectoral dummies are fundamental tools to control for, respectively, national and sectoral systems of innovation (Freeman, 1995; Lundvall, 1992; Malerba, 2002, 2004a). Regarding the former, the complex institutional features of countries represent a source of heterogeneity which is likely to shape deeply the distributive patterns between capital and labour as well as the public and private agents' incentive structures and degree of uncertainty regarding technological progress. On the other hand, Pavitt dummies account explicitly for the technological and structural patterns of industries avoiding the risk of multicollinearity that would be induced by the inclusion of a great number of sector-specific dummies; moreover, too many dummy variables may prevent the model to get a sufficient number of degrees of freedom for adequately powerful statistical tests. Finally, since manufacturing industries experience relatively greater involvement in global value chains than service ones (Agnese and Ricart, 2009), manufacturing dummy is introduced when offshoring variables are accounted for, removing in this way another potential source of endogeneity.

Fourth, estimations are performed using the weighted least squares (WLS) estimator. The reason lies in the fact that industry data are grouped data of unequal size, thus their contribution in terms of information is asymmetric, affecting the consistency of the estimator (Wooldridge, 2002). Following Guarascio and Pianta (2016), we achieve consistency using the number of employees in the sectors (as observed in the first year of each economic period) as weights, rather than industries' value added; indeed, the latter depends on price variations and results in a more unstable measure of sectors' size.

Fifth, it is well known that industry-level data are usually affected by heteroskedasticity and, not unexpectedly, the results of the Breusch-Pagan test performed on baseline WLS regressions confirms that the variance of the error term differ across observations. Therefore, we carry out all the estimations applying heteroskedasticity- and autocorrelation-robust standard errors.[67]

Sixth, since industries' evolution is shaped fundamentally by their technological regimes and institutional setting, common factors impacting simultaneously on both dependent variables (i.e. rate of growth of profits and wages) may occur, affecting in this way regressions' stochastic disturbances. In other terms, the error terms of the two estimated equations might be correlated insofar as the equations have unobservable omitted variables in common. Hence, in the next section we also report estimations using the Seemingly unrelated regression estimator (SURE), which exploits correlation among regression equations' residuals to gain efficiency (Zellner, 1962).

Seventh, we assess the resilience of our findings reporting in the last part of the next section the results of the estimated equations performed with a different product innovation proxy, namely the share of firms innovating with the aim of opening up new markets, associated with a technology-driven strategy of competitiveness.

Finally, we get rid of a potential omitted variable bias in the wage equation controlling for the employment structure of industries as a factor which might reasonably impact on the level of wage

[67] An extensive diagnostic concerning variables endogeneity and specification's robustness is provided in Appendix A, Table A.1 and A.3; moreover, Table A.4 reports several endogeneity tests on labour productivity growth in the profit equation. As will be noted, the only reason to be concerned with in Table A.1 regards the endogeneity test on labour productivity growth in the wage equation. Applying a control function approach (Wooldridge, 2015), under the null hypothesis of labour productivity exogeneity, the test returns a p-value = 0,082. This result may cast doubts on the exogeneity of labour productivity growth in the wage equation; the extension of the model we propose below allows to get rid of this potential source of concern. All the other robustness checks broadly confirm the appropriateness of our estimation strategy and the reliability of the main empirical results reported in the next section.

in the sector. For this purpose, in Appendix A.1, Table A.2, we also include the share of managers and the share of manual workers – classified according to the ISCO professional groups – as covariates in the wage equation.[68]

6. Results

Estimation results of the simultaneous model are reported in Table 5 and 6, which show – respectively – the empirically estimated specification of the wage and profit equations. Furthermore, Table 7 provides the outcome of the simultaneous system estimated using the SURE model.

6.1 The estimated wage equation

Starting from Table 5, the first finding is the always negative and significant coefficient of profit variation; this result is confirmed in column 1 and 2 – which report our baseline models on wage growth determinants – as well as looking at the next columns (that is, even controlling for offshoring and union density), supporting the earlier evidence provided by Pianta and Tancioni (2008) and hence the relevance of the distributive conflict between capital and labour.[69]

In accordance with our theoretical framework, the introduction of new products is positively correlated with a relatively higher wage growth, while a fairly clear negative impact on labour compensation stems from mechanization-oriented innovative efforts. Indeed, an important positive effect of product innovation on wages emerges constantly – except for baseline specifications – whilst, by contrast, the expenditure in new machinery and equipment presents an always negative and almost always significant coefficient. The heterogenous impact of product and process innovation are therefore broadly confirmed; this finding emphasizes the crucial relevance of distinguishing between technological and cost competitiveness strategies when the distributive impact of technological change is at stake.

Moreover, labour productivity growth is found to be positively correlated with wage growth, signaling the former as a key factor able to open up room for wage increases.[70]

Column 3 and 4 of Table 5 account for the role of international fragmentation of production and union density, the latter proxied by the sectoral union membership rate. Sectors relatively more committed in pursuing offshoring processes witness lower rate of growth of wages, confirming the "delocalization strategy" wielded by firms as a valuable weapon to bend workers' claims. With regard to union density, the results show that it has a significantly positive impact on wage dynamics (column 3), although controlling for the full set of dummies turns out the coefficient to be still positive but not significant (column 4). Similarly, the constantly negative coefficient of our process innovation proxy – i.e. expenditure in new machinery – loses significance in column 4 only because of the inclusion of Pavitt and country dummies. Nonetheless, the F-test controlling for the joint significance of Pavitt and country dummies does not reject the null hypothesis that their coefficients are not statistically different from zero. Therefore, we argue that results shown in column 3 are not fundamentally challenged.

Estimation results distinguishing offshoring index according to the technological pattern of foreign source industries are reported in column 5 and 6. Whether the previous findings are broadly

[68] The introduction of the share of managers and of manual workers in the wage equation does not change considerably our estimation results insofar as their effects do not turn out to be significant in explaining the wage dynamics. Further details on the ISCO professional categories are reported in the final Appendix on the SID database.

[69] It is important to stress that we are performing an industry-level analysis, reason why this result is not so trivial as it may appear. Indeed, along the structural change process of the economies, we observe sectors that experience high growth rate alongside others which decline. We might thus witness a contemporary growth of both profits and wages in the former and the opposite dynamics in the latter.

[70] Nonetheless, the theoretical discussion provided above regarding potential circular mechanism of causation between wage and productivity dynamics – i.e. the likely two-way relationship between these variables – and the endogeneity test performed in Appendix A, Table A.1, raises doubts on the exogeneity of labour productivity growth. However, when we change the specification of the wage equation removing this cause of concern (see Chapter 4), the impact of our key wage determinants is empirically confirmed.

unchanged, a source of heterogeneity concerning offshoring emerges. Both in terms of magnitude and statistical significance, the negative impact of low-tech offshoring on wages is stronger than the high-tech offshoring one, where the latter shows a significant and negative sign, though. These findings suggest that, on the one hand, low-tech offshoring processes represent a reliable strategy pursued by capitalists to push downward wages arguably intensifying worldwide competition among workers and fostering various forms of social dumping. On the other hand, also high-tech offshoring processes appears to be detrimental for wages, although the technological upgrading that they might encourage seems to soften their impact.

Finally, we note that in the last column of Table 5 (column 6) union density and new machinery and equipment expenditure (which also proxies embodied technical change) lose significance, although maintaining a negative sign. Nonetheless, this outcome is due to the inclusion of Pavitt and country dummies, whose coefficients are not jointly different from zero according to the reported F-test. It follows that the results (namely the relevance of our process innovation proxy and union density) stemming from the specification estimated in column 5 are not substantially questioned.

6.2 The estimated profit equation

We focus now on Table 6, which shows the results stemming from the empirical estimation of profit equation. As expected, a significant and negative coefficient is always associated to the dynamics of the other distributive component, i.e. wage growth. This result is found in column 1 and 2 – which report our baseline models on profit growth determinants – as well as in the next ones.

Industries which intensely pursue knowledge-based technological trajectories underpinned by product innovation tend to gain higher profit, while the sign of our process innovation proxy – i.e. the expenditure in new machinery – turns out to be curiously never significant, although always positive.[71] Since we also include wage dynamics as regressor in the profit equation – bearing in mind the significant negative impact of the expenditure in new machinery on the former (see Table 5) –, an explanation might be the absence of a (labour cost-) independent impact of our process innovation proxy on profit growth. This meant that process innovation has labour cost reduction as main effect while does not foster profits except by this channel.

Moreover, as found by Pianta and Tancioni (2008), the strongly significant and positive coefficient of industries' labour productivity growth confirms it as a driver of industrial development and a key element on which profit growth relies.[72]

As column 3 and 4 of Table 6 show, controlling also for offshoring dynamics and union density tightened up our previous findings and provide a richer overview of profit growth determinants. On the one hand, industry-level membership rate does not seem to play any role; it is likely that, since we control also for wage growth as determinant of profit dynamics, union density has not any effect on the latter but through wages (which tend to increase more in sectors with higher union density, as shown by Table 5). On the other hand, narrow offshoring indicator consistently appears positively and significantly correlated with profit variation, showing that industries relatively more involved in global value chains experience a higher growth rate of capital compensation.

Column 5 and 6 investigate further the role of offshoring and shed light on the underlying reasons which justify its prominence. In fact, distinguishing offshoring processes according to the technological nature of foreign source industries, low-tech offshoring index turns out not significant,

[71] In column 6 our product innovation proxy turns out with a positive but not significant coefficient, while all the other coefficients do not change considerable their sign, significance and magnitude. This outcome stems from the inclusion of country dummies in column 6, as far as the inclusion of Pavitt dummies does not turn out insignificant the coefficient related to product innovation (see Appendix A, Table A.5). Whether the joint significance of Pavitt and country dummies is confirmed by the reported p-value of the F-test in column 6, it is worth noting that country dummies are very slightly significant; using Germany as reference (i.e. excluding the dummy for Germany to avoid multicollinearity), only the dummy for Italy results significant at 10%. Hence, we hold that the statistical relevance of the variable proxying product innovation in the profit equation is not fundamentally questioned.

[72] See Appendix A.1, Table A.4, for a number of robustness checks concerning the exogeneity of labour productivity growth in the profit equation. Three out of four tests do not reject the hypothesis of exogeneity of the regressor.

while high-tech offshoring indicator has a positive and significant impact on profit dynamics. An explanation might be the following: cost-based offshoring strategies do not have any role but reducing wages (an effect already accounted for by wage variation as included regressor), while technology-driven delocalizations spur profits supplying industries with not-domestically produced flows of goods and giving them access to new sources of knowledge. As already noted previously, the same arguably holds for union density – whose coefficient turns out not significant in column 6 – since its impact is captured by wage growth regressor, while it does not seem to have any autonomous (i.e. labour cost-indipendent) influence on profits.

6.3 The wage-profit SURE model

Table 7 reports the empirical results coming from the estimation of the simultaneous system on wage and profit dynamics using the Seemingly Unrelated Regression Estimation (SURE) model. As previously mentioned, this estimation technique accounts for the common factors which might impact simultaneously on both dependent variables, namely the wage and profit growth rate, and exploits correlation among them to gain efficiency (Zellner, 1962).

The estimation results of the baseline wage-profit SURE model are reported in the first pair of columns and largely confirm the results found in Table 5 and 6. In particular, the negative relationship between profit growth and wage growth is reaffirmed, while the coefficient related to the introduction of new products is positive and strongly significant with respect to the dynamics of both wages and profits. On the other hand, our proxy of process innovation, namely the expenditure in new machinery and equipment, loses significance compared to the previously found results and seems having no role in shaping distributional dynamics.

Whether labour productivity growth is confirmed as a driver of both profits and wages – able to capture the evolution of key factors which spur capital and labour compensation as capital investment growth and organizational improvements –, the coefficient related to union density turns out to be significant for the wage equation only. This result is consistent with previous findings and suggests that industries with higher union density experiment a stronger growth of wages.

The impact of international fragmentation of production, as captured by our narrow offshoring indicator, is significant and positive with respect to profit growth, while it presents a significant negative effect on wage growth. Notably, this result represents a strong confirmation of our previous findings, shedding light on the asymmetric impact that offshoring strategies have on distribution of income.

However, when we move to the second pair of columns reported in Table 7, distinguishing offshoring processes according to the technological dimension of the internationalization of production, some at least partially unexpected results emerge. On the one hand, the effects of high-tech and low-tech offshoring strategies on profit growth lose significance, reporting positive coefficients, though. On the other hand, just the high-tech offshoring turns out to have a negative and significant impact on wage growth, although both high- and low-tech offshoring indicators show a negative coefficient.

The third and last pair of columns reported in Table 7, which control for the full set of dummy variables, largely reaffirms previous findings. On one hand, it confirms the conflictual relationship between profits and wages and, on the other, the room provided by labour productivity increases to rise both capital and labour compensation. Furthermore, the capability of pursuing a technology-based competitiveness strategy (resulting in the introduction of new products) results a driving factor of development whose benefits tend to be shared between capital and labour. Nonetheless, whether the signs of the union density coefficients are those expected (i.e. a negative one with respect to profits and a positive one with respect to wages), they are no longer significant. Finally, with regard to offshoring strategies, both high- and low-tech offshoring coefficients are associated with higher profits on one hand and with lower wages on the other hand; nonetheless, as in the second pair of columns, just the high-tech offshoring coefficient in the wage equation turns out to be significant.

Table 5. The wage equation

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔWages	(5) ΔWages	(6) ΔWages
ΔProfits	-0.0410***	-0.0421***	-0.0373**	-0.0420***	-0.0400***	-0.0437***
	(0.0142)	(0.0143)	(0.0146)	(0.0151)	(0.0146)	(0.0152)
Share of firms introducing product innovation	0.00901	0.00957	0.0199**	0.0247***	0.0226***	0.0258***
	(0.00655)	(0.00722)	(0.00780)	(0.00896)	(0.00793)	(0.00913)
Expenditure in new mach. and equipment per emp.	-0.321**	-0.278**	-0.279**	-0.197	-0.278**	-0.217
	(0.127)	(0.137)	(0.133)	(0.148)	(0.132)	(0.146)
ΔProductivity	0.524***	0.521***	0.514***	0.514***	0.508***	0.508***
	(0.0492)	(0.0514)	(0.0499)	(0.0520)	(0.0500)	(0.0524)
Union density			0.0288**	0.00907	0.0277**	0.0108
			(0.0114)	(0.0198)	(0.0113)	(0.0199)
ΔNarrow offshoring			-0.250***	-0.238***		
			(0.0872)	(0.0845)		
ΔOffshoring HT					-0.184*	-0.186*
					(0.103)	(0.105)
ΔOffshoring LT					-0.196**	-0.200**
					(0.0886)	(0.0871)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	No	No	Yes**	Yes**	Yes**	Yes**
Pavitt dummies	No	Yes	No	Yes**	No	Yes**
Country dummies	No	Yes	No	Yes	No	Yes
F-test Pavitt & country dummies	-	0.1694	-	0.4102	-	0.3653
Observations	845	845	833	833	831	831
R-squared	0.505	0.516	0.519	0.528	0.522	0.532

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

Table 6. The profit equation

	(1) ΔProfits	(2) ΔProfits	(3) ΔProfits	(4) ΔProfits	(5) ΔProfits	(6) ΔProfits
ΔWages	-0.270***	-0.272***	-0.244***	-0.269***	-0.267***	-0.284***
	(0.0890)	(0.0875)	(0.0938)	(0.0930)	(0.0941)	(0.0938)
Share of firms introducing	0.0562**	0.0403	0.0626**	0.0541*	0.0628**	0.0536
product innovation	(0.0272)	(0.0293)	(0.0266)	(0.0313)	(0.0284)	(0.0332)
Expenditure in new mach.	0.277	0.390	0.494	0.628	0.507	0.667
and equipment per emp.	(0.735)	(0.755)	(0.752)	(0.773)	(0.763)	(0.783)
ΔProductivity	0.404***	0.433***	0.402***	0.427***	0.414***	0.433***
	(0.103)	(0.103)	(0.105)	(0.102)	(0.108)	(0.106)
Union density			-0.0227	0.00166	-0.0199	0.00621
			(0.0334)	(0.0541)	(0.0334)	(0.0547)
ΔNarrow offshoring			0.821***	0.787***		
			(0.253)	(0.254)		
ΔOffshoring HT					0.547*	0.549*
					(0.282)	(0.283)
ΔOffshoring LT					-0.0714	0.0172
					(0.187)	(0.189)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	No	No	Yes*	Yes**	Yes	Yes**
Pavitt dummies	No	Yes***	No	Yes***	No	Yes***
Country dummies	No	Yes***	No	Yes*	No	Yes*
F-test Pavitt & country dummies	-	0.0002	-	0.0003	-	0.0004
Observations	845	845	833	833	831	831
R-squared	0.109	0.146	0.132	0.170	0.123	0.163

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

Table 7. The simultaneous wage-profit model (SURE model)

	(1)		(2)		(3)	
	SURE		SURE		SURE	
	ΔProfits	ΔWages	ΔProfits	ΔWages	ΔProfits	ΔWages
ΔWages	-0.516***		-0.555***		-0.637***	
	(0.0829)		(0.0833)		(0.0829)	
ΔProfits		-0.0876***		-0.0935***		-0.107***
		(0.0141)		(0.0140)		(0.0140)
Share of firms introducing product innovation	0.0998***	0.0353***	0.101***	0.0373***	0.119***	0.0430***
	(0.0187)	(0.00774)	(0.0191)	(0.00788)	(0.0205)	(0.00846)
Expenditure in new mach. and equipment per emp.	-0.0842	-0.132	-0.0553	-0.101	0.168	0.0216
	(0.248)	(0.102)	(0.252)	(0.103)	(0.263)	(0.108)
ΔProductivity	0.506***	0.321***	0.524***	0.322***	0.509***	0.311***
	(0.0581)	(0.0224)	(0.0586)	(0.0225)	(0.0587)	(0.0227)
Union density	0.0122	0.0345***	0.0154	0.0325***	-0.0108	0.00202
	(0.0279)	(0.0114)	(0.0279)	(0.0114)	(0.0450)	(0.0185)
ΔNarrow offshoring	0.398***	-0.115*				
	(0.147)	(0.0607)				
ΔOffshoring HT			0.130	-0.127*	0.0919	-0.133*
			(0.175)	(0.0716)	(0.175)	(0.0715)
ΔOffshoring LT			0.135	-0.0570	0.121	-0.0661
			(0.138)	(0.0568)	(0.139)	(0.0570)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes***	Yes***	Yes**	Yes***	Yes***	Yes***
Country dummies	No	No	No	No	Yes	Yes***
Pavitt dummies	No	No	No	No	Yes***	Yes***
Observations	836	836	834	834	834	834
R-squared	0.141	0.327	0.135	0.329	0.162	0.350

Note: Seemingly Unrelated Regression Equations (SURE) model; * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

6.4 Further evidence using a different product innovation proxy

In this section we test the robustness of our previous findings using a different product innovation variable, namely the share of firms which innovate with the aim of opening new markets in the sector, whose design and time structure is the same of previously employed innovation proxies insofar as it is likewise drawn from the CIS provided by Eurostat (Pianta et al., 2018).[73]

Following the econometric strategy described in Section 5.3, Table 8 reports the results of the Weighted Least Squares estimation of the wage and profit equation performed with robust standard errors. The first three columns provide estimation results about the determinants of wage growth, controlling for different sets of dummy variables gradually inserted in the specifications. Using the same scheme, the last three columns – which mirror the first three – report the outcomes of the estimated profit equation.

Moreover, the empirical results of the wage-profit simultaneous model estimated using the SURE model, which includes our new proxy for product innovation, are reported in Table 9.

6.4.1 Results of the equation-by-equation estimation strategy

The results reported by the first three columns of Table 8 confirm our previous findings about the impact of profit growth, technological change, union density and offshoring on wage dynamics. While the distributive conflict between wage and profit growth is reaffirmed by the negative and significant coefficient of profits regressor, the impact of our new product innovation variable is consistently positive and significant, meaning that industries populated predominantly by firms which pursue strongly a technological competitiveness strategy tend to experiment a higher growth rate of wages. On the other hand, our proxy of process innovation, namely the expenditure in new machinery and equipment, has a negative and significant coefficient in two out of three of our wage specifications, supporting our theoretical assumption about the basically harmful effect that cost-based competitiveness strategies have on labour compensation.

The impact of union density on wage growth is less clear. While the specification reported in the first column shows that industries with higher union membership rate have higher wage growth, in the second and third column the union density coefficient turns out not significant.

Finally, the negative effect of international fragmentation of production on workers' bargaining power is largely confirmed. First, our narrow offshoring indicator presents a negative and strongly significant coefficient; second, when we distinguish offshoring processes according to their technological content, the negative impact of offshoring on wages holds, confirming low-tech offshoring as the most detrimental strategy for wage growth.

Moving to the last three columns offers the possibility to test our previous findings about the determinants of profit growth. The negative impact of wage growth on profit dynamics is reaffirmed, while the positive effect of our new product innovation proxy – as compared to the not significant impact of industry spending on new machinery and equipment – supports our theoretical hypothesis about the major role played by technology-oriented strategy of competitiveness to increase market share and achieve higher profits.

The driving role of labour productivity – which shows a positive and significant impact on profit growth – is unchanged, while union density seems to have no effect on capital compensation; as union density tends to have a positive impact on wages, this means that our data are not able to detect any impact of union density on profits independently from wages.

With regard to offshoring, all the indicators employed in our empirical analysis show that industries more involved in global value chains achieve higher profits. Furthermore, the distinction between high- and low-tech offshoring suggests that the industries' propensity to internationalize production to attain technological advances matters; as the last two columns show, industries which more intensely pursue high-tech offshoring strategies gain higher profits, while the coefficients related to low-tech offshoring indicators are positive but not significant.

[73] See also Section 3 of the present chapter for a description of the database used in our empirical analysis.

6.4.2 Results of the wage-profit SURE model

Table 9 shows the results of the estimation of the wage-profit simultaneous system using the Seemingly Unrelated Regression Estimation (SURE) model. In particular we perform three SURE models which take into account both our narrow offshoring indicator and then for the heterogeneity which stems from the distinction between high- and low-tech offshoring strategies; moreover, we follow our econometric strategy gradually inserting different sets of dummy variables; in this way, we check the robustness of our findings to the inclusion of factor variables which accounts for the time structure of our data, the potentially different dynamics of manufacturing and service industries, the institutional specificities of countries and the technological trajectories of sectors (the latter are accounted for through the use of Pavitt dummies).

The main results of previously estimated models are broadly confirmed. The expected negative relationship between wage and profit growth is found and the positive and significant impact of our new product innovation proxy, i.e. the share of firms which innovate with the aim of opening new markets in the sector, is consistent with our theoretical framework. Moreover, in the first two SURE models the coefficients related to the expenditure in new machinery and equipment present the expected positive sign in profit equations and the negative one in the wage equations, although not significant; in the third specification of the model – which includes the full set of dummy variables – the positive impact of new machinery expenditure has a positive and significant effect on profit growth.

Labour productivity growth has a positive and significant impact on both wage and profit growth rate, with the positive impact constantly stronger on profits. In the first two estimated models union density shows a positive and significant effect on wage growth, confirming that in industries with a higher union membership rate wages tend to be higher. Curiously, when we include the full of set of dummies the signs of union density coefficients are reversed and the coefficients of union density turn out not significant; this outcome might be due to the inclusion of country dummies and the relatively limited variability of union density proxy at industry level.

Previous results on the role played by the international fragmentation of production on wage and profit dynamics are strongly confirmed. Our narrow offshoring indicator, namely the variable which accounts for the fragmentation of production within industries, shows a clearly asymmetric effect, having a significantly positive impact on profit growth and a significant and negative effect on wage growth. This means that, on the one hand, the industries most involved in global value chains tend to achieve greater profits, while this phenomenon represents a credible threat of productive delocalization that limits workers' demands and translates into relatively lower wages.

Finally, a remarkable heterogeneity stems from the distinction between high- and low-tech offshoring strategies; while both our high- and low-tech offshoring indicators present a positive coefficient in the profit equation, only the former has a significant impact on capital compensation. This means that the imports of intermediate inputs from technologically advanced industries represent an important source of knowledge which improves the competitiveness of industries and their ability to increase profits. As it is clear from the findings reported in the last column, a specular result applies to wages. Although both the high- and low-tech offshoring variables present negative coefficients in the wage equations, the specification of the wage equation which controls for the full set of dummies shows low-tech offshoring strategies are the most detrimental for wages. This result is consistent with our theoretical framework, according to which the acquisition of intermediate inputs from foreign industries characterized by labour-intensive productions represents a way to augment the worldwide competition among workers and reduce wage pressure.

Section 5 has modelled the conflictual relationship between labour and capital compensation proposing a simultaneous two-equation system to highlight the impact that technological change, labour market institutions and internationalization of production exert on the rate of growth of wages and profits at industry level. Both the equation-by-equation estimation strategy and the SURE model have been exploited and several robustness checks have been provided, including the estimation of the growth rate of wages and profits performed using a different proxy for product innovation.

In the next section an extension of the present model is proposed. Our aim is assessing the reliability of our findings within a slightly different theoretical framework which accounts explicitly for the employment dynamics of industries.

Table 8. The wage and profit equations using a different product innovation proxy

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔProfits	(5) ΔProfits	(6) ΔProfits
ΔProfits	-0.0289** (0.0147)	-0.0308** (0.0146)	-0.0244* (0.0144)			
ΔWages				-0.202* (0.104)	-0.221** (0.104)	-0.178* (0.105)
Share of firms aiming to open up new markets	0.0361*** (0.00740)	0.0400*** (0.00735)	0.0356*** (0.00939)	0.0605** (0.0252)	0.0585** (0.0266)	0.0221 (0.0365)
Expenditure in new mach. and equipment per emp.	-0.271* (0.143)	-0.273* (0.140)	-0.165 (0.163)	0.716 (0.759)	0.731 (0.771)	0.926 (0.808)
ΔProductivity	0.474*** (0.0511)	0.466*** (0.0509)	0.466*** (0.0471)	0.484*** (0.117)	0.493*** (0.121)	0.484*** (0.120)
Union density	0.0219* (0.0120)	0.0194 (0.0118)	-0.0224 (0.0193)	-0.0309 (0.0347)	-0.0260 (0.0351)	0.0475 (0.0580)
ΔNarrow offshoring	-0.320*** (0.0963)			0.998*** (0.285)		
ΔOffshoring HT		-0.247** (0.112)	-0.239* (0.123)		0.709** (0.314)	0.891*** (0.323)
ΔOffshoring LT		-0.263*** (0.0938)	-0.304*** (0.0910)		0.0895 (0.200)	0.288 (0.214)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes***	Yes***	Yes**	Yes**	Yes**	Yes***
Pavitt dummies	No	No	Yes**	No	No	Yes***
Country dummies	No	No	Yes***	No	No	Yes**
F-test Pavitt and country dummies	-	-	0.0004	-	-	0.0009
Observations	705	704	704	705	704	704
R-squared	0.551	0.557	0.581	0.148	0.138	0.173

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees).
[*] significant at 10%, [**] significant at 5%, [***] significant at 1%. Variables referring to the share of firms aiming to open up new markets and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

Table 9. The simultaneous wage-profit model using a different product innovation proxy (SURE model)

	SURE (1)		SURE (2)		SURE (3)	
	ΔProfits	ΔWages	ΔProfits	ΔWages	ΔProfits	ΔWages
ΔWages	-0.489***		-0.512***		-0.482***	
	(0.0898)		(0.0903)		(0.0898)	
ΔProfits		-0.0843***		-0.0873***		-0.0832***
		(0.0155)		(0.0154)		(0.0155)
Share of firms aiming to	0.101***	0.0465***	0.0992***	0.0485***	0.107***	0.0492***
open up new markets	(0.0211)	(0.00872)	(0.0215)	(0.00883)	(0.0242)	(0.0100)
Expenditure in new mach.	0.348	-0.0626	0.311	-0.0600	0.585**	0.0878
and equipment per emp.	(0.262)	(0.109)	(0.264)	(0.109)	(0.281)	(0.117)
ΔProductivity	0.553***	0.334***	0.563***	0.332***	0.500***	0.324***
	(0.0636)	(0.0247)	(0.0642)	(0.0249)	(0.0645)	(0.0251)
Union density	0.00472	0.0293**	0.0111	0.0279**	0.0267	-0.0221
	(0.0305)	(0.0126)	(0.0307)	(0.0126)	(0.0491)	(0.0204)
ΔNarrow offshoring	0.544***	-0.118*				
	(0.162)	(0.0678)				
ΔOffshoring HT			0.348*	-0.125	0.461**	-0.129
			(0.198)	(0.0817)	(0.201)	(0.0835)
ΔOffshoring LT			0.143	-0.0773	0.227	-0.102*
			(0.145)	(0.0599)	(0.147)	(0.0612)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Pavitt dummies	No	No	No	No	Yes***	Yes***
Country dummies	No	No	No	No	Yes***	Yes**
Observations	705	705	704	704	704	704
R-squared	0.154	0.358	0.144	0.358	0.187	0.382

Note: Seemingly Unrelated Regression Equations (SURE) model; * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the share of firms aiming to open up new markets and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

7. Conclusions

The present chapter provided a theoretical and empirical analysis about the role played by technological change, internationalization of production and labour market institutions in shaping the distributive patterns of industries. From a theoretical point of view, we combined a Neo-Schumpeterian perspective on the dynamics of technological change and a Post-Keynesian approach on the conflictual relationship between capital and labour income. According to this framework, we focused on the impact that different kinds of innovation, heterogeneous offshoring strategies and labour market institutions have on wage and profit dynamics.

In particular we reviewed the theoretical and empirical literature which deals with this topic, we presented the industry-level database our empirical analysis is based on (namely the SID database) and we provided large descriptive evidence on the relationships between the distributive dynamics of industries and the role played by technological change, offshoring intensity and trade unions.

In this context, we started discussing labour productivity growth as a determinant of distributive pattern of industries and as a factor able to provide room for increasing both wages and profits. Moreover, we built on evolutionary theory to emphasize the technological trajectories of industries and the way they shape their different innovation strategies. For this purpose, we followed Pianta (2001) distinguishing between a technology-driven competitiveness strategy – which mainly relies on technological upgrading, knowledge-intensive production and introduction of new products in the market – and a cost-based competitiveness strategy – aimed at reducing labour costs and gaining production efficiency through the introduction of new processes –, assessing the channels through which they may impact on wages and profits. With regard to globalization, we have given special attention to the offshoring strategies pursued by firms and on the distributive impact they entail, stressing the technological content of the intermediate inputs offshored and the relationship between the latter and the competitiveness strategy of the industry. Finally, we took into account the role of labour market institutions in shaping the power balance between capital and labour. We discussed the long-term decreasing bargaining power of trade unions and its consequences in term of wage and profit dynamics.

On the empirical ground, we extended the model proposed by Pianta and Tancioni (2008) and performed an econometric analysis to investigate the impact of innovation, offshoring and union density on the distributive patterns of industries. Our main empirical results stemming from the estimated model are the following.

First, the profit growth rate of industries emerges as always negative correlated with the rate of growth of wages (and viceversa), highlighting the relevance of the distributive conflict between capital and labour, while labour productivity growth is found to have a positive impact on both wage and profit growth – signaling the former as a driver of industrial development and a key factor able to soften the distributive conflict.

Second, the introduction of new products is generally associated to relatively higher wages and profits, while the introduction of new processes, proxied by the expenditure in new machinery and equipment, tends to show a negative impact on labour compensation. The heterogenous impact of product and process innovation seems thus confirmed, underlining the important distinction between technological and cost competitiveness strategies when the distributive impact of technological change is at stake.

Third, sectors relatively more committed in the internationalization of production witness lower rate of growth of wages, confirming the “delocalization strategy” pursued by firms as a factor weakening workers’ wage claims; furthermore, narrow offshoring indicator – capturing the fragmentation of production within industries – consistently appears positively and significantly associated to profit growth, showing that industries relatively more involved in global value chains get higher profits. Furthermore, whether we distinguish offshoring trajectories of industries according to the technological patterns of foreign source industries, the negative impact of low-tech offshoring on wages is stronger than the high-tech offshoring one, suggesting that low-tech offshoring processes provide capitalists with the opportunity to push downward wages arguably intensifying worldwide competition among workers and fostering various forms of social dumping. On the other hand, high-tech offshoring indicator has a positive and significant impact on profit dynamics, likely because technology-driven delocalizations supply industries with not-domestically produced flows of goods, giving them access to new sources of knowledge.

Finally, union density tends to have a positive impact on wage dynamics, although it loses significance when country-specific institutional characters of labour market are accounted for.

Appendix of Chapter 3

This Appendix reports several robustness checks related to the simultaneous wage-profit model estimated in Section 6 of the present chapter.

A.1 The wage equation: robustness checks

The tables reported in this part of the Appendix provide robustness checks related to the estimations results shown in Table 5 of the main text, i.e. regarding the WLS estimation of the wage equation.

In Table A.1 we focus on the baseline wage equation providing a series of diagnostic tests to check the reliability of the estimated regression.[74] We start testing the heteroskedasticity of the residuals of the wage equation. First, we perform the Breusch-Pagan test performing a Weighted Least Squares estimation, i.e. the approach we use in the present work for the equation by equation estimations since we deal with industry-level data. Moreover, we also perform the White test, although it only applies to estimations performed with standard OLS method. As expected, both tests strongly reject the null hypothesis of homoskedasticity, confirming that the variance of the error term differs across observations and thus supporting our choice to estimate the wage equation with heteroskedasticity- and autocorrelation-robust standard errors.

Moreover, we test the serial correlation of residuals applying the test proposed by Cumby and Huizinga (1990, 1992) and developed for STATA by Baum and Schaffer (2013), which can be used in several circumstances in which other tests like the Box-Pierce/Ljung-Box test, the Durbin's h-test or the Breusch-Godfrey test are not applicable. The null hypothesis of the test is that residuals are serially uncorrelated. Since we use a first-difference estimator with dummy variables, we are not really concerned about autocorrelation problems. Indeed, the Cumby and Huizinga test does not reject the null hypothesis of serially uncorrelated residuals of the estimated wage equation. Nonetheless, the p-value of the test is quite low (it is equal to 0.1146) thus we argue that using Huber-White standard errors robust to heteroskedasticity and autocorrelation of residuals is the best choice.

We use the Variance Inflation Factor (VIF) to test for multicollinearity problems. Notwithstanding the inclusion of time, Pavitt and country dummies, the VIF value is equal to 2.31, below 4 and much below 10 (the thresholds usually taken as reference in the literature). When we apply the VIF test to the specification reported in column 6 of Table 5, that is the one including all the right-hand-side regressors we account for in the analysis and the full set of dummy variables, the VIF value rises to 2.77. Therefore, we conclude that multicollinearity is not a cause for concern in the wage regression.

Finally, consistently with the theoretical discussion provided in the main text (see Section 5.1), we test the endogeneity of labour productivity growth in the wage equation. For this purpose, we apply a control function approach (Wooldridge, 2015), according to which under the null hypothesis labour productivity growth is exogenous. In the first step we use the first lag of productivity growth, the share of managers and the share of manual workers in the sector as instruments.[75] The F-test of the first step is equal to 60.81 – well above the "rule of thumb" of 10 as the lower threshold referred to in the literature (see Bound et al., 1995; Staiger and Stock, 1997) – and the p-value rejects the null hypothesis of weak instruments. In the second step we regress our wage equation including the residuals predicted in the first stage as additional covariate. A test on the latter becomes an endogeneity test under the null hypothesis of labour productivity exogeneity.

The test returns a "borderline" result, as the p-value is equal to 0.082, casting doubts on the exogeneity of labour productivity growth in the wage equation of Section 5's model. Nonetheless, the extension of the model proposed in Section 6 allows to get rid of this potential source of concern,

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[74] As explained in the main text, the baseline wage equation we are referring to is the specification reported in the first and second column of Table 5 in Section 5 (depend variable: growth rate of wages; regressors: growth rate of profits, share of firms introducing product innovation in the sector, expenditure in new machinery and equipment, labour productivity growth, time, Pavitt and country dummies).

[75] See the final Appendix on the SID database for further details on variables related to the ISCO professional categories included in the SID database.

estimating a recursive wage-profit model in which labour productivity growth does not appear on the right-hand-side of the wage equation (see Section 6.2). Most important, results concerning the estimated wage equation in Section 6 are consistent with the findings stemming from the baseline wage equation estimated in Section 5, supporting the reliability of the model and our econometric strategy to deal with endogeneity (see Section 5.3).

Table A.1 Robustness checks for the baseline wage equation

Heteroskedasticity (Breusch-Pagan test)
WLS regression (time, Pavitt and country dummies included)
Ho: constant variance (homoskedasticity)
F(16, 828) = 11.93
Prob > F = 0.0000
Heteroskedasticity (White test)
OLS regression (time, Pavitt and country dummies included)
Ho: homoskedasticity
Ha: unrestricted heteroskedasticity
chi2(121) = 335.34
Prob > chi2 = 0.0000
Autocorrelation of residuals (Cumby-Huizinga test)
WLS regression (time dummies included)
H0: variable is MA process up to order q (with q = 0: serially uncorrelated)
HA: serial correlation present at specified lags >q
chi2 = 2,490
p-value = 0,1146
Multicollinearity (Variance Inflation Factor)
WLS regression (time, Pavitt and country dummies included)
Mean VIF = 2,31
Endogeneity of labour productivity growth (Control function approach)
WLS with robust standard errors (time, Pavitt and country dummies included)
Endogenous: labour productivity growth
Instruments: first lag of labour productivity growth, share of managers, share of manual workers
First stage: test F(3, 726) = 60.81
Prob > F = 0.0000
Second stage: significance of residuals predicted in the first stage
p-value = 0.082
Multicollinearity for specification of Table 5, column 6 (Variance Inflation Factor)
WLS regression (time, manufacturing, Pavitt and country dummies included)
Mean VIF = 2,77

Table A.2 reports the results of the wage regression estimated with the share of managers and of manual workers in the sector as additional regressors; unfortunately, these data are not available for the Netherlands, thus the following results refer only to five countries (France, Germany, Italy, Spain, the United Kingdom).[76] Our aim is to control for the professional composition of industries to avoid spurious regressions which may arise from endogeneity problems due to omitted variables bias. Furthermore, we check whether sectors more exposed to task-biased technological change (Goos et al., 2014; Van Reenen, 2011) have driven some extent our estimation results.[77]

Our findings largely confirm the specification of the wage equation proposed in the main text. First, the inclusion of the share of managers and of manual workers in the sector as additional regressors do not produce appreciable differences in the estimation results; second, the signs of the coefficients related to the ISCO variables turn out as expected in column 3 and 4, although it is worth noting that the F-tests on the joint significance of such regressors never reject the null hypothesis of statistical irrelevance of those variables; third, according to the F-tests regarding the inclusion of country and Pavitt dummies, it turns out that the most reliable specification is the one reported in column 3, which in turn is the one that most strongly confirms the main findings of our analysis.

[76] These two categories of workers are the result of an aggregation of the ISCO professional classification. See the final Appendix on the SID database for further details.

[77] According to this theory on job polarization, tasks more exposed to routinization should be gradually replaced by machines because of technological change and – in particular – as a consequence of computerization and robotization processes. Therefore, workers performing highly-routinized jobs would be more at risk of unemployment and experiment the lowest wage growth. Since managers and manual workers categories should respectively encompass mainly high-skill and non-routine manual job positions, according to the task-biased technological change theory we would expect positive signs for both the ISCO variables included in Table A.2 (see, among the others, Van Reenen, 2011).

Table A.2 The wage equation augmented by controlling for manager and manual worker shares

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔWages
ΔProfits	-0.0363**	-0.0385**	-0.0435***	-0.0421***
	(0.0155)	(0.0156)	(0.0164)	(0.0160)
Share of firms introducing product innovation	0.0240**	0.0287**	0.0244*	0.0285**
	(0.0122)	(0.0125)	(0.0127)	(0.0145)
Expenditure in new mach. and equipment per emp.	-0.311**	-0.323**	-0.257*	-0.260*
	(0.140)	(0.138)	(0.146)	(0.152)
ΔProductivity	0.533***	0.527***	0.521***	0.528***
	(0.0514)	(0.0516)	(0.0523)	(0.0540)
Union density	0.0260**	0.0250*	0.0234*	0.0107
	(0.0127)	(0.0127)	(0.0130)	(0.0227)
ΔNarrow offshoring	-0.287***			
	(0.105)			
ΔOffshoring HT		-0.264**	-0.271**	-0.279**
		(0.129)	(0.128)	(0.134)
ΔOffshoring LT		-0.200*	-0.194*	-0.205**
		(0.103)	(0.102)	(0.100)
Share of Managers	-0.00202	-0.00239	0.00877	0.00181
	(0.0131)	(0.0133)	(0.0133)	(0.0176)
Share of Manual workers	0.00310	0.00288	-0.00397	-0.00162
	(0.0101)	(0.0100)	(0.0105)	(0.0113)
Time dummies	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes**	Yes**	Yes*	Yes*
Pavitt dummies	No	No	Yes**	Yes**
Country dummies	No	No	No	Yes
F-test ISCO categories	0.9260	0.9266	0.6971	0.9758
F-test Pavitt dummies	-	-	0.0807	0.2007
F-test country dummies	-	-	-	0.5185
Observations	707	706	706	706
R-squared	0.526	0.530	0.536	0.540

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density, share of managers and share of manual workers are lagged as they refer to the first year of each time period.

A.2 The profit equation: robustness checks

The tables reported in this part of the Appendix provide diagnostic robustness checks related to the estimations results shown in Table 6 of the main text, i.e. regarding the WLS estimation of the profit equation.

In Table A.3 we focus on the baseline profit equation providing a series of diagnostic tests to check the reliability of the estimated regression.[78] Following the procedure pursued to test the robustness of wage equation in the previous section, we start testing the heteroskedasticity of the residuals of the profit equation. First, we perform the Breusch-Pagan test performing a Weighted Least Squares estimation, i.e. the approach we use in the present work for the equation by equation estimations since we deal with industry-level data. Moreover, we also perform the White test, although it only applies to estimations performed with standard OLS method. As expected, both tests strongly reject the null hypothesis of homoskedasticity, confirming that the variance of the error term differs across observations and thus supporting our choice to estimate also the profit equation with heteroskedasticity- and autocorrelation-robust standard errors.

In addition, we test the serial correlation of residuals applying the test proposed by Cumby and Huizinga (1990, 1992) and developed for STATA by Baum and Schaffer (2013). As already discussed, this test can we exploited in several circumstances in which other tests like the Box-Pierce/Ljung-Box test, the Durbin's h-test or the Breusch-Godfrey test are not suitable. The null hypothesis of the test is that residuals are serially uncorrelated. Although we use a first-difference estimator with time dummy variables, the Cumby and Huizinga test does reject the null hypothesis of serially uncorrelated residuals of the estimated profit equation; hence, the test supports our choice of performing the regression analysis using Huber-White standard errors robust to heteroskedasticity and autocorrelation of residuals.

We use the Variance Inflation Factor (VIF) to test for multicollinearity problems. Notwithstanding the inclusion of time, Pavitt and country dummies, the VIF value is equal to 2.43, below 4 and much below 10 (the thresholds usually taken as reference in the literature). When we apply the VIF test to the specification reported in column 6 of Table 6, that is the one including all the right-hand-side regressors we account for in our analysis and the full set of dummy variables, the VIF value rises to 2.86. Therefore, we conclude that multicollinearity is not a cause for concern in the profit regression.

[78] The baseline profit equation we are referring to is the specification reported in the first and second column of Table 6 in Section 5 (depend variable: growth rate of profits; regressors: growth rate of wages, share of firms introducing product innovation in the sector, expenditure in new machinery and equipment, labour productivity growth and time dummies).

Table A.3 Robustness checks for the baseline profit equation

Heteroskedasticity (Breusch-Pagan test)

WLS regression (time, Pavitt and country dummies included)
Ho: constant variance (homoskedasticity)
F(16, 828) = 6,52
Prob > F = 0.0000

Heteroskedasticity (White test)

OLS regression (time, Pavitt and country dummies included)
Ho: homoskedasticity
Ha: unrestricted heteroskedasticity
chi2(121) = 202,79
Prob > chi2 = 0.0000

Autocorrelation of residuals (Cumby-Huizinga test)

WLS regression (time dummies included)
H0: variable is MA process up to order q (with q = 0: serially uncorrelated)
HA: serial correlation present at specified lags >q
chi2 = 6,248
p-value = 0,0124

Multicollinearity (Variance Inflation Factor)

WLS regression (time, Pavitt and country dummies included)
Mean VIF = 2,43

Multicollinearity – specification of Table 6, column 6 (Variance Inflation Factor)

WLS regression (time, manufacturing, Pavitt and country dummies included)
Mean VIF = 2,86

Table A.4 reports a series of endogeneity tests concerning the baseline specification of the profit equation. The first column shows the test performed, the second column the variable whose exogeneity is to be checked, the third column the variables used as instruments, the fourth column the estimator employed for the diagnostic test, the fifth column the results concerning the relevance and validity of the instruments, the sixth column the results of the endogeneity tests performed and the last column summarizes the final outcome.

As theoretically discussed in the main text (see Section 2.1), a cause of concern regarding the profit equation is related to the potential two-way link between labour productivity growth and profit growth, which may arise reverse causality problems and affect the consistency of the estimation results. Hence, four post-estimation tests are reported in Table A.4, exploiting different techniques and using different combinations of instruments to check the exogeneity of labour productivity growth.

Notably, we report those tests which do not present any problems in terms of relevance and validity of the instruments; in other words, we present the results of the most meaningful tests according to the F-test and overidentification test reported in the fifth column. In this regard, note that the F-statistic related to the first stage of the Hausman test and of the test performed following a control function approach procedure – which consistently provides the same result – is equal to 66.38, i.e. well above the "rule of thumb" of 10, which would be the lower threshold to consider the weakness of instruments not an issue (Staiger and Stock, 1997). Regarding the last two endogeneity tests, note that the F-statistic performed in the first stage rejects the null hypothesis of weak instruments, while the Hansen (1982) test – which applies to estimation with robust standard error – does not reject the null hypothesis of valid instruments (i.e. uncorrelated with the error term).

The Wooldridge's (1995) robust score test is the only one over four tests that rejects (at a significance level of 5%) the null hypothesis of exogeneity of labour productivity growth. Therefore, the overall outcome of Table A.4 provides fairly support to our econometric strategy aimed at identifying the determinants of profit growth without incurring in spurious regressions. Nonetheless, further evidence about the reliability of our profit equation will be also provided by the additional endogeneity tests reported in Appendix of Chapter 4, Table A.3.

Finally, Table A.5 refers to the specification of the profit equation reported in column 6 of Table 6 (see Section 6.2). It shows that dropping the very slightly significant country dummies – using Germany as reference (i.e. excluding the dummy for Germany to avoid multicollinearity), only the dummy for Italy reports as expected a negative coefficient which is significant at 10% – turns out our product innovation proxy strongly significant. In other terms, Table A.5 provides evidence that the statistical relevance of the latter is not questioned by the inclusion of Pavitt dummies, while the sign and significance of the other regressors' coefficients are fundamentally unchanged.

Table A.4 Baseline profit equation: endogeneity tests

Test	Endogenous variable(s)	Instruments	Estimator	Test F (first stage) and overidentification tests	Final test (second stage) and endogeneity tests	Result
Hausman test	**Productivity**	QCLE, QCWO, QMWO, lagged RVA (same results with lagged RVEXP and lagged RVA as instruments)	WLS, robust s.e.	F(4, 713) = 66.38 Prob > F = 0.0000	Ho: variables are exogenous P-val > |t| = 0.474 (test on the endogenous variable's values predicted in the first stage)	***exogenous***
Control function approach	**Productivity**	QCLE, QCWO, QMWO, L.RVA (same results with lagged RVEXP and lagged RVA as instruments)	WLS, robust s.e.	F(4, 713) = 66.38 Prob > F = 0.0000	Ho: variables are exogenous P-val > |t| = 0.233 (test on the residuals predicted in the first stage)	***exogenous***
Wooldridge's (1995) robust score test and robust regression-based test after 2sls	**Productivity**	Lagged RVEXP, lagged RVA	2SLS weighted, with robust s.e. (*ivregress 2sls* Stata's command)	F(9, 698) = 138.28 Prob > F = 0.0000 Test of overidentifying restrictions: Hansen's (1982) J statistic: Score chi2(1) = 2.09946 P-val = 0.1474	Tests of endogeneity Ho: variables are exogenous Wooldridge's (1995) robust score test = 4.77382 P-val = 0.0289	**endogenous**
					Robust regression-based test F(1,698) = 2.43629 P-val = 0.1190	***exogenous***

Note: RVA=growth rate of value added; RVEXP=growth rate of exports; QCLE=share of clerks; QCWO=share of craft workers; QMWO=share of manual workers. Variables referring to the share of managers, clerks, craft and manual workers over the total number of employees in the sector present a lag (except for the last period) according to the time structure of the panel. Variables referring to the economic performance of sectors (growth rates of value added and exports) are computed as the average annual rate of change over five periods (1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014) according to the time structure of the panel. See the final Appendix on the SID database.

Table A.5 The baseline profit equation augmented with union density and offshoring, without country dummies

	ΔProfits
ΔWages	-0.290***
	(0.0961)
Share of firms introducing product innovation	0.0652**
	(0.0311)
Expenditure in new mach. and equipment per emp.	0.598
	(0.761)
ΔProductivity	0.411***
	(0.103)
Union density	-0.0364
	(0.0337)
ΔOffshoring HT	0.484*
	(0.275)
ΔOffshoring LT	-0.0694
	(0.184)
Time dummies	Yes***
Manufacturing dummy	Yes**
Pavitt dummies	Yes***
Observations	831
R-squared	0.139

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

Chapter 4

A Sequential Model of Income Distribution

1. Introduction

In this chapter we provide an extension of the model on income distribution dynamics presented in Chapter 3. As in the previous chapter, we detect labour productivity growth, technological change, offshoring strategies and labour market institutions as key determinants of income distribution patterns of industries. Nonetheless, the theoretical framework that we propose in this chapter presents some new features. Taking inspiration from the model proposed by Bogliacino, Guarascio and Cirillo (2018), we conceive the wage and profit setting as the result of a two-step bargaining process, accounting for the role of employment dynamics of sectors. According to this scheme, wages are set out in the labour market as a result of workers' bargaining power, which is shaped by employment dynamics (capturing both a "Goodwin effect" and the structural evolution of economies) and by technological, organizational and institutional factors. Profits are then realized as a residual and their dynamics depends on the level of previously determined wages, productivity patterns and on the underlying competitive strategy adopted – where the latter is fundamentally defined by the technological trajectories of industries as well as by their ability to gain from the integration in global value chains, namely from offshoring strategies. It follows that, from an empirical point of view, the model proposed is not a simultaneous but a recursive one. In this chapter we thus provide an empirical analysis – performed using the Sectoral Innovation Database (SID) – which consistently accounts for the sequential determination of labour and capital income. In this way, we also offer a more robust assessment of the results found in the previous chapter.

The structure of the chapter is the following. Section 2 summarizes the theoretical framework according to which the empirical analysis if carried out. Section 3 presents a sequential model of wage and profit setting and the econometric strategy adopted. Section 4 provides the estimation results. Section 5 proposes an interpretation of the main findings and draws some general conclusions.

2. Theoretical framework

We take inspiration from the approach proposed by Bogliacino, Guarascio and Cirillo (2018) conceiving the wage and profit setting as the result of a conflictual relationship developed according to a sequential bargaining mechanism.

Wages are determined in the first step on the basis of the bargaining power of workers in the labour market. According to our framework, the negotiating position of workers and their ability to capture a share of the innovation rent[79] – as conceived by Schumpeter (1942), i.e. monopoly profit whose seeking represents the driver of capitalism accumulation – is fundamentally settled by total employment dynamics, the different kinds of innovation introduced by firms (i.e. product and process innovation as proxy of technology-driven and cost-based competitiveness strategy, respectively), globalization process and the technological nature of the offshoring strategies pursued by firms, and trade unions' strength (proxied by union density). Subsequently, in the second step profits are realized as residual, i.e. net of the previously determined rate of wage variation, on the basis of labour productivity growth and the level of rents stemming from different technological and offshoring strategies. Notably, Bogliacino, Guarascio and Cirillo (2018) describe this framework referring to the "rent sharing" model proposed by Van Reenen (1996) and argue that technological and organizational innovation (the latter linked to the internationalization of production) creates Schumpeterian rents whose distributive mechanism rests ultimately on the balance of power relations between capital and labour.

[79] The two-step bargaining process which rules the distribution of the innovation rent is drawn by Bogliacino, Guarascio and Cirillo (2018) from the "rent sharing" model proposed by Van Reenen (1996). According to this scheme, different kinds of innovation and offshoring strategies give rise to Schumpeterian rents whose distributive mechanism rests ultimately on the balance of power relations between capital and labour.

Following this approach, three major changes are introduced with respect to the model developed in the previous chapter. First, we substitute labour productivity growth with the (lagged) employment dynamics of industries in the wage equation. In this way, the unfolding of the process of structural change of the economies and its impact on income distribution dynamics – previously proxied by industries' labour productivity performance – is now replaced by sectoral evolution of labour demand.[80] In particular, employment growth is regarded as a factor which directly contributes to shape the bargaining position of workers and thus the level of their compensation. Such a mechanism consists actually in an "industrial reserve army distribution function" as the one the Goodwin (1967) model fundamentally relies on (Stockhammer and Michell, 2016). According to the latter, distributional conflict produces endogenous growth cycles in accumulation, employment and labour share. In this perspective the key element of our concern, which drives the upward phase of the cycle, is represented by the sequence which goes from higher employment rate to higher level of wages through the increasing workers' bargaining power that the former induces. Employment growth may be thus interpreted also in our framework as a proxy of labour market tightness, which is expected to impact positively on wages.

Second, a two-way link might also affect the relationship between offshoring processes and wage growth. Higher wage increases which come at the expense of profits are likely to push firms to pursue offshoring strategies with the aim of curbing workers' wage claims. It follows that a reverse causality issue may emerge between income distribution dynamics and firms' delocalization strategies (Barthelemy and Geyer, 2001). The wage equation proposed in the recursive model allows to avoid this potential simultaneity-related source of endogeneity taking the first lag of the offshoring indicators as covariates. This strategy allows us to assess the robustness of the result emerged from the previous model estimation, i.e. an overall negative impact of offshoring on wage dynamics (especially strong with regard to low-tech offshoring) and a positive effect on profits.

Finally, since we failed to find a significant autonomous (i.e. labour cost-indipendent) impact of union density on profits in the model developed in the previous chapter, we drop the sectoral union membership rate as covariate from the profit equation, including it in the wage equation only. Furthermore, this adjustment is coherent with the determination of wage and profit dynamics as the result of a two-step bargaining mechanism, according to which wages are fundamentally settled in the first step on the basis of the negotiation position of workers as shaped by trade unions' strength.

In the next sections we briefly present the wage and profit equation which make up the recursive model and the econometric strategy we follow to achieve the identification of structural parameters in the regressions.

3. A Sequential Model

3.1 The wage equation

The log-linear equation for the determination of wage dynamics in the recursive model is the following:

$$log(W_{ijt}) = \alpha_1 log(EMPE_{ijt-1}) + \alpha_2 log(NM_{ijt}) + \alpha_3 log(PROC_{ijt}) + \alpha_4 log(OFFSH_{ijt-1}) + \alpha_5 log(UD_{ijt}) + u_{ij} + \varepsilon_{ijt}$$

where i, j and t identify, respectively, industry, country and time.

W stands wage per worked hour and $EMPE$ for employment, while NM and $PROC$ represent our innovation proxies capturing the different effects of technological change. In particular the former stands for the share of firms introducing innovation aiming to open up new markets whilst the latter

[80] Furthermore, a potential circular mechanism of causation between wage and productivity growth might theoretically occur, arising endogeneity problems which would affect the robustness of the empirical analysis (see Appendix, Table A.1). For the model developed in this chapter this is no longer a cause of concern.

for the share of firms introducing process innovation in the sector. It is worth noting that the use of these new variables allows us to account for the heterogeneous (i.e. technology-driven and cost-based) competitive strategies pursued by industries (Pianta, 2001) and to assess, at the same time, the robustness of our previous results (see Chapter 3) concerning the impact of different firms' innovative efforts on wage dynamics.

The role of international fragmentation of production is captured by $OFFSH$, which stands for the offshoring variables.[81] We measure offshoring process with several different offshoring indicators; on the one hand, we use both a broad and a narrow offshoring proxy, as introduced by Feenstra and Hanson (1996, 1999), to capture the general impact of delocalization strategies on wages. On the other hand, we follow Guarascio et al. (2015) distinguishing between high- and low-tech offshoring strategy on the basis of the technological content of intermediate input flows.[82]

Finally, UD stands for union density – i.e. the union membership rate at industry level – proxying labour market institutions role and notably trade union action; u controls for time-invariant fixed effects and ε represents the residuals.

We follow the strategy pursued for the previous model taking the first difference of the equation to get rid of time-invariant components (thereby reducing potential endogeneity bias) and we obtain the following final formulation for the wage equation:

$$\Delta log(W_{ijt}) = \alpha_1 \Delta log(EMPE_{ijt-1}) + \alpha_2 \Delta log(NM_{ijt}) + \alpha_3 \Delta log(PROC_{ijt}) + \alpha_4 \Delta log(OFFSH_{ijt-1}) + \alpha_5 \Delta log(UD_{ijt}) + \Delta \varepsilon_{ijt}$$

The variables regarding wages and employment are computed as compound annual average rate of change which proxies the difference in logarithmic terms. The innovation variables, although proxied by share of firms in the sector, capture the changing innovative efforts of firms over time and can thus be conceived as intrinsically dynamic. Similarly, union density refers to the first year of every time period, while offshoring variable is computed as the simple difference between the last and the first year of each time period.

3.2 The profit equation

The profit equation does not present major changes with respect to the one introduced for the model presented in Chapter 3, the main difference being the absence of union density as covariate.[83] The log-linear specification of profits in the recursive model is thus the following:

$$log(PROF_{ijt}) = \alpha_1 log(W_{ijt}) + \alpha_2 log(PROD_{ijt}) + \alpha_3 log(NP_{ijt}) + \alpha_4 log(MACH_{ijt}) + \alpha_5 log(OFFSH_{ijt}) + u_{ij} + \varepsilon_{ijt}$$

where *i* stands for industry, *j* for country and *t* for time.

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[81] Values of all the offshoring variables have been multiplied by 100.

[82] The broad offshoring indicator considers the evolution of the ratio between the expenditure for the imported intermediate inputs from whatever foreign industries and the money spent to purchase the overall amount of intermediate inputs used in production. On the contrary, narrow offshoring indicator accounts for the fragmentation of production within industries as it is measured by the ratio between the expenditure of a given industry for the intermediate inputs imported from foreign industries of the same kind and total intermediate inputs purchased to produce. With regard to the distinction between high-tech and low-tech offshoring strategies, we built the related indicators relying on the Revised Pavitt taxonomy developed by Bogliacino and Pianta (2010, 2016); it follows that the technological strategy which drives the offshoring process is identified according to the nature of knowledge, patterns of innovation and market structure of foreign source industries from which the inflow of imported intermediate inputs originates. In particular, high-tech (low-tech) offshoring variable measures the evolution of a ratio which has, at the numerator, the expenditure of a given industry in the acquisition of intermediate inputs imported from foreign Science based or Specialized suppliers (Scale and information intensive and Supplier dominated) industries and, at the denominator, the expenditure for purchasing the overall intermediate inputs used for production.

[83] As already stated, union density seemed to have no autonomous impact on profits in the simultaneous model presented in Chapter 3.

Gross profits, indicated by $PROF$, are realized as residual after the fixing of wages (W) on the labour market. Moreover, $PROD$ stands for labour productivity performance of industries, while diffent kinds of innovation strategies are still accounted for by NP and $MACH$, which stand for the introduction of new products and the expenditure in new machinery and equipment, respectively. Lastly, $OFFSH$ stands for the offshoring indicator, whilst time-invariant (sectoral and country) fixed effects and residuals are captured by u and ε.

Differentiating the equation to get rid of time-invariant unobservable effects, we obtain the following final specification of profit equation:

$$\Delta log(PROF_{ijt}) = \alpha_1 \Delta log(W_{ijt}) + \alpha_2 \Delta \log(PROD_{ijt}) + \alpha_3 \Delta log(NP_{ijt}) + \alpha_4 \Delta log(MACH_{ijt}) + \alpha_5 \Delta log(OFFSH_{ijt}) + \Delta \varepsilon_{ijt}$$

where wage, profit and productivity variables are computed as compound annual average rate of change which proxies the difference in logarithmic terms. The innovation variables proxying technological and cost competitiveness strategy are measured by share of firms introducing new products and by expenditure for new machinery per employee, while the variation of offshoring variable is computed as the simple difference between the last and the first year of each time period.[84]

3.3 Data and econometric strategy

The empirical analysis is performed using the Sectoral Innovation Database (SID), which includes industry-level data at two-digit NACE Rev. 1 classification for 21 manufacturing and 17 service sectors for six major European countries – France (FR), Germany (DE), Italy (IT), the Netherlands (NL), Spain (ES) and the United Kingdom (UK). The time span covered by the dataset is 1994-2014. A comprehensive description of the dataset is reported in the final Appendix of the SID database.

As regards the econometric strategy, the techniques adopted to empirically estimate the wage and profit equation in the recursive model largely relies on the same panel data techniques employed to estimate the simultaneous model presented in Chapter 3. Nonetheless, some key elements of novelty are introduced to assure the reliability of our specification in the context of two-step bargaining procedure.

First, we develop a recursive rather than a simultaneous model, i.e. a system of equations characterized by unidirectional dependency among the endogenous variables. Notably, we build a two-equation system such that, for given values of exogenous variables (namely technological change, globalization and labour market institutions), endogenous variables (namely rate of growth of wages and gross profits) are determined sequentially rather than jointly. This strategy allows to avoid any simultaneity-related endogeneity bias which might arise between our dependent and explanatory variables.

Second, we rely on a lag structure allowing independent variables to have time to unfold their effect in terms of income distribution. Notably, the temporal structure of the panel is such that, except for the last period (for which limits associated to CIS data availability prevent the possibility of accounting for a time lag), innovation variables refer to a lagged period as compared to dependent economic variables (i.e. wages and profits); similarly, union density refers to the first year of each period the dependent variables are computed on.[85] Most important, we take the first lag of employment rate of variation as well as offshoring variables in the wage equation, acknowledging the potential endogeneity bias which might stemming from the simultaneity between these latter variables and wage dynamics. For example, higher wages in one sector may be the reason for increasing employment in that sector according to an equilibrium price mechanism, i.e. growing wages might signal that labour demand is greater than labour supply inducing growing labour compensation and a market reallocation process of labour supply towards that sector. On the other

[84] We remind that our panel is composed by five time periods (1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014) and all the economic and offshoring variables are computed accordingly.

[85] See the temporal structure of the dataset – reported in the final Appendix on the SID database – for further details.

hand, wage pressure is likely to constitute a powerful incentive in pursuing offshoring strategies with the aim of reducing labour cost. Our choice to include lagged employment and offshoring variables is designed to address this source of endogeneity.

Third, we differentiate the equations to get rid of any time-invariant individual effects. Considering that the latter may have a simultaneous impact on both the dependent variable and the regressors, first-differencing removes this source of endogeneity. Furthermore, we calculate long differences with two- to five-years lags, softening considerably the autoregressive character of variables.

Fourth, we include a set of time, country and sectoral dummies as additional control, with the aim of reducing the potential endogeneity bias which may stem from other sources of observable heterogeneity. On the one hand, time dummies essentially control for business cycle; otherwise, time-specific effects would be captured by the error term raising endogeneity problems. On the other hand, country and sectoral dummies are included to control for the overall institutional features which contribute to shape national and sectoral systems of innovation (Freeman, 1995; Malerba, 2002). Notably, Pavitt dummies account for technological trajectories of industries avoiding any risk of multicollinearity otherwise induced by the inclusion of several sector-specific dummies.[86]

Fifth, estimations are performed using the weighted least squares (WLS) estimator, accounting for the unequal size according to which industry data are grouped – otherwise, consistency of the estimated coefficients would be affected (Wooldridge, 2002). We prefer to use the number of employees in the sectors – as observed in the first year of each economic period – as weights rather than industries' value added, since the former does not depend on price variation.

Sixth, all the estimations are performed using Huber-White standard errors – i.e. heteroskedasticity- and autocorrelation-robust standard errors – since industry-level data are usually affected by heteroskedasticity, as confirmed by the Breusch-Pagan and White test's results reported in Appendix.[87]

Finally, since common institutional and economic factors may impact simultaneously on the variation rate of both wages and profits may occur – affecting regressions' stochastic disturbances – in the next section we also report estimations using the Seemingly unrelated regression estimator (SURE), which exploits correlation among regression equations' residuals to gain efficiency (Zellner, 1962).[88]

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[86] We do not include the manufacturing dummy in the wage equation as we want test properly the potential distributive role played by the growth rate of employment, which already controls for the structural change process that has led to the decline of the relative weight of the manufacturing sector in modern economies. experimented by advanced economies toward service-based economic system. The inclusion of the manufacturing dummy does not substantially change the results anyway, as shown by Table A.2 in Appendix.

[87] Robustness checks concerning the wage equation of the recursive model are provided in Appendix, Table A.1; they broadly confirm the appropriateness of our estimation strategy.

[88] More formally, in matrix notation a system of structural equations may be written as $\mathbf{\Gamma y} = \mathbf{Bx} + \boldsymbol{\varepsilon}$, where $\mathbf{y}$ is a vector of the n endogenous variables, $\mathbf{x}$ is a vector of the k exogenous variables, $\boldsymbol{\varepsilon}$ is a vector of the n stochastic disturbances, $\mathbf{\Gamma}$ is a $n \times n$ matrix of the coefficients associated to the n endogenous variables and $\mathbf{B}$ is a $n \times k$ matrix of the coefficients on the k exogenous variables. If $\mathbf{\Gamma}$ is a triangular matrix (i.e. it has only zeroes above the principal diagonal) we refer to the system as 'recursive'. That's the reason why this kind of model is also called 'triangular'. Moreover, define $\mathbf{\Sigma}$ to be the variance-covariance matrix of the stochastic disturbance terms. If $\mathbf{\Gamma}$ is a triangular matrix and in addition $\mathbf{\Sigma}$ is a diagonal matrix (i.e. the disturbances across the different equations are – contemporaneously – uncorrelated), the system is called 'diagonally recursive'; in this case, OLS is an appropriate estimator for each single equation of the system – it yields consistent and (asymptotically) efficient estimates –, since there is no correlation between the explanatory variables in any one equation and that equation's stochastic disturbances. If a system is recursive but not diagonally recursive, namely $\mathbf{\Gamma}$ is a triangular matrix but $\mathbf{\Sigma}$ is not a diagonal matrix, the system is called 'seemingly unrelated' and the Seemingly Unrelated Regressions (SUR) method of estimation is more appropriate (more efficient) than OLS (Zellner, 1962). See Wooldridge (2002).

4. Results of the sequential model

The results of the empirical estimation of the recursive two-equation model are reported in Table 1 and Table 2, which respectively provide the empirically estimated specification of the wage equation and the profit equation. Moreover, Table 3 shows the outcome of the wage-profit recursive system estimated using the SURE model.

4.1 The estimated wage equation

Table 1 provides estimation results for the wage equation in the recursive model. Consistently with our theoretical framework, the first key finding emerging from column 1 and 2 – reporting our baseline models – concerns the always positive and strongly significant impact of (lagged) employment dynamics on wages. This result is also confirmed for all the next columns, suggesting the crucial relevance of the structural "Goodwin effect" to understand income distribution patterns of industries. Mainly, it provides support to a conflictual interpretation about the forces which rule the growth rate of wage and profit; accordingly, wage dynamics is the outcome of social conflict shaped by the strength of workers in labour market, which in turn depends positively on the employment growth rate of the sector.

Furthermore, the distinction between the distributive impact on wages of a technology-driven and cost-based competitiveness strategy seems confirmed. The former is proxied by the share of firms introducing innovation to open up new markets and its impact on wages is found to be always positive and significant, giving support to the results of previous model (see Table 5). Conversely, industries' innovative efforts aimed at reducing production costs is captured by the share of firms introducing process innovation, whose coefficient turns out to be negative and significant in column 1, 3, 5 and negative but not significant in column 2, 4 and 6. However, this latter outcome seems due to the inclusion of country dummies, which in turn emerge jointly not significant, as shown by the p-value of the F-test reported in the same table.[89]

Similarly, union density has a positive and strongly significant impact on wages in column 1, 3 and 5, while its coefficient turns out not significant when country dummies are included (column 2, 4 and 6); however, country dummies are jointly not significant (the p-value of the F-test is constantly above 0,20). Hence, we argue that the specifications reported in column 1, 3 and 5 of Table 1 are the most reliable.[90]

In addition, Table 1 accounts for different offshoring indicators (taken at first lag) to assess properly the impact of international fragmentation of production on the rate of variation of wages. As expected, from column 1 and 2 the coefficients of broad offshoring variable – which captures the extent to which industries are involved in global trade flows of intermediate inputs – turn out to be negative and significant, regardless the lag structure applied and the dummies we account for. Conversely, the offshoring proxy used in column 3 and 4, namely the narrow offshoring indicator – accounting for the level of international fragmentation of production within industries –, appears to have no significant impact on wages, although presenting a negative coefficient.[91]

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[89] Table A.2 in Appendix provides the results of the estimated wage regression without the inclusion of country dummies (since they are not significant). The results largely confirm the ones reported in Table 5, although the negative coefficient related to process innovations loses significance when the manufacturing dummy is included.

[90] See Appendix, Table A.2.

[91] An explanation that we could provide is that offshoring exerts a general downward pressure on labor costs and this effect is captured by the broad offshoring indicator which accounts for any form of delocalization of production, as it encompasses the inflows of imported intermediate inputs from whatever foreign industry. The narrow offshoring indicator takes into account only the fragmentation of production within industries and therefore represents a more specific form of productive internationalization; the latter, although it has a negative impact on wages, is probably a better proxy for tracking production fragmentation and measuring the involvement of industries in global value chains, but – compared with the broad offshoring indicator – it incompletely captures the negative impact that delocalization processes have on wage growth.

Finally, the distinction between high- and low-tech offshoring indicators is introduced in column 5 and 6. As already found in previous model, both variables show a negative coefficient, but only the low-tech offshoring one – capturing the imports of intermediate inputs from Scale intensive and Supplier dominated foreign sectors – turns out to be significant, giving further prominence to the technological dimension of offshoring strategies. Growing acquisition of foreign intermediate inputs – especially from industries specialized in not-knowledge-intensive productions – seems having labour cost reduction as main effect. These findings confirm our expectations and support the idea that globalization has provided firms with additional tools to carry out social dumping strategies; in other terms, the delocalization of labour-intensive tasks to labour-abundant countries with lower wages (labour substitution effect) or the growing credibility of future massive layoffs (firing threat effect) seem to constitute key elements of modern capitalism able to curb workers' wage claims.

4.2 The estimated profit equation

Table 2 reports the estimation results of the profit equation of the recursive model. There are minor differences with respect to the previously estimated profit equation (see Chapter 3, Section 5), suggesting the reliability of our findings. The conflictual relationship between profits and wages is reaffirmed as wage growth always shows a significant and negative coefficient, while labour productivity performance of industries presents a strongly significant and positive impact on capital compensation.[92]

Industries which rely more on a technological competitiveness strategy achieve higher profit growth rate, as it is demonstrated by the fact that the coefficient of our product innovation proxy is positive and significant in every specification. Conversely, the introduction of new processes (proxied by the expenditure in new machinery) appears not significant – maybe due to the absence of any (labour cost-) independent impact of this covariate on profit growth. This confirms the relevance of differentiating the innovative efforts of firms to examine their asymmetric outcomes in terms of income distribution.

Interesting results emerge from the analysis of the impact of offshoring variables. Profits turn out to be significantly higher in industries pursuing more intensely narrow offshoring processes, while the broad offshoring indicator shows a positive but not significant effect on profit growth.[93] As theoretically discussed, offshoring provides industries with new flows of intermediate inputs from abroad, allows them to be involved in the global trade of instrumental goods and improve their technological competitiveness.

We deepen the technological aspects of offshoring strategies and of their impact on profit growth in column 5 and 6 of Table 2. As already done in previous estimations, we exploit the revised Pavitt taxonomy proposed by Bogliacino and Pianta (2010, 2016) to distinguish offshoring processes according to the technological nature of the foreign industries from which the inflow of imported intermediate inputs come from.[94] Notably, columns 5 and 6 confirm a significant positive impact of high-tech offshoring only on profit growth.[95] This finding suggests that the technological aspects of

[92] Table A.3 in Appendix reports several robustness checks concerning the exogeneity of wage growth and labour productivity growth in the profit equation. The endogeneity tests do not reject the hypothesis of exogeneity of the regressors, supporting the robustness of our results.

[93] Since the opposite was true for wages (i.e. the negative impact of broad offshoring on wage growth is significant, while the negative effect exerted by narrow offshoring on wage growth turns out not significant), one explanation might be that the impact of the broad offshoring on profits is captured by wage growth as a regressor in the profit equation.

[94] We remind that the high-tech offshoring indicator captures the growth of the ratio between the expenditure for the acquisition of intermediate inputs produced by Science based and Specialized suppliers foreign industries over the total intermediate inputs purchased by a given industry; conversely, the low-tech offshoring indicator computes the growing amount of intermediate inputs imported from Scale intensive and Supplier dominated foreign industries over the total intermediate inputs used for production by a given industry.

[95] We argued that cost-based offshoring strategies may not having any role but reducing wages (an effect already accounted for by wage regressor), while technology-driven delocalization is found to increase profits because it supplies

industries' growing involvement in global value chains play a key role for both competitiveness and profitability, beyond the already addressed 'cost reduction channel'.

4.3 The sequential wage-profit SURE model

Table 3 presents the results of the recursive system on wage and profit growth estimated using the Seemingly Unrelated Regression Estimation (SURE) model. This method takes advantage of the cross-correlation correlation between the error terms to gain efficiency (Zellner, 1962). Since industries are exposed to common external factors which may impact on both dependent variables simultaneously, we perform the estimation of the recursive model exploiting this more efficient estimator to assess the robustness of our previous findings about the determinants of wage and profit dynamics.

The results in Table 3 largely confirms the findings turned out from the WLS estimation of the wage and profit equation provided respectively in Table 1 and Table 2. The distributive conflict between wages and profits is confirmed by all the specifications, as the negative coefficient of wage growth in the profit equation is always significant. Moreover, labour productivity growth controls for those factors associated to the growth of industries – e.g. capital investment, better organizational skills and higher levels of education of workers – and it is constantly associated to higher profitability.

Consistently with our previous findings, the structural "Goodwin" effect captured by the employment growth in the wage equation always has a positive and significant coefficient, meaning that industries whose growth rate in occupational terms is greater tend to pay higher wages. According to the theoretical framework we proposed, this is due because, on the one hand, growing sectors drive the process of structural change of the economies and their development has positive repercussions on wage levels; on the other hand, employment growth rate is a proxy of labour market tightness, which in turn may foster workers' bargaining strength and increase and labour compensation.

The product innovation proxy included in the profit equation, i.e. share of firms introducing product innovation in the sector, always shows a positive coefficient, although only significant in the second and fourth specification of the SURE models. On the other hand, the impact of new machinery expenditure on profit growth is always positive as well, but its effect is significant in the first and third specifications only, which do not account for the full set of dummy variables. Hence, looking at the most robust specifications, we conclude that industries which experiment a higher profit growth are those which more intensely pursue a technological competitiveness strategy based on the making of new products.

With regard to the impact of technological change on wage growth, the product innovation proxy included in the wage regressions, i.e. the share of firms introducing innovations to open new markets or increase market share, shows a positive and significant coefficient in every specification. Conversely, the negative relationship found in Table 1 between process innovations and wage growth seems not confirmed, as the regressor related to the share of firms introducing process innovation in the sector has not a significant impact on wage dynamics.

According to the SURE models reported in the first and third columns of Table 3, industries with higher union density experiment a relatively higher rate of growth of wages. However, the union density coefficient turns out not significant in the regression equations which include the full set of dummy variables (especially country dummies). This prevents the possibility to clearly identify the impact of unionization on wage growth, albeit suggesting the relevance of country-specific labour market institutions on income distribution dynamics.

Results concerning the impact of offshoring variables in wage and profits dynamics largely confirm our previous findings. The strongly asymmetric effect of internationalization of production on labour and capital compensation emerges clearly from the first and second estimated models reported in Table 3. On the one hand, industries populated by the most internationalized firms,

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industries with not-domestically produced intermediate inputs, improving production conditions and making new sources of knowledge available to them.

pursuing intensely offshoring strategies, experiment higher growth rate of profit (out narrow offshoring indicator always shows a positive and significant coefficient in the profit equation). On the other hand, the coefficient of broad offshoring indicator included in the wage regression is negative and significant, meaning that delocalization processes rise the threat against workers and their wage demands.

Finally, in the last two specifications reported in the third and fourth pair of columns of Table 3 we introduce the distinction between low- and high-tech offshoring processes, relying on the technological nature of the foreign industries the imported intermediate inputs come from. The coefficients of both low- and high-tech offshoring result positive in the profit equation, while the opposite occurs in the wage equation, in which both indicators have a negative sign. Curiously, the only difference with respect to the findings in Table 1 and Table 2 consists in the greater effect that low-tech offshoring (as compared to the high-tech one) has in promoting profit growth; indeed, while the low-tech offshoring regressor is significant in the profit equation, high-tech offshoring coefficient is not. On the other side, no meaningful novelties are found with respect to the wage equation; industries which more intensely pursue low-tech offshoring strategies are successful in pushing down wages significantly.

Table 1. The estimated wage equation of the recursive model

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔWages	(5) ΔWages	(6) ΔWages
ΔEmployment (first lag)	0.138*** (0.0429)	0.110*** (0.0415)	0.142*** (0.0437)	0.113*** (0.0420)	0.134*** (0.0424)	0.109*** (0.0417)
Share of firms aiming to open up new markets	0.0590*** (0.0125)	0.0727*** (0.0211)	0.0506*** (0.0130)	0.0602*** (0.0203)	0.0592*** (0.0126)	0.0700*** (0.0210)
Share of firms introducing process innovation	-0.0425*** (0.0148)	-0.0350 (0.0214)	-0.0450*** (0.0147)	-0.0336 (0.0215)	-0.0452*** (0.0149)	-0.0341 (0.0215)
Union density	0.0541*** (0.0133)	-0.00442 (0.0220)	0.0534*** (0.0133)	-0.00494 (0.0219)	0.0546*** (0.0132)	-0.00419 (0.0218)
ΔBroad offshoring (first lag)	-0.187** (8.358)	-0.221** (8.705)				
ΔNarrow offshoring (first lag)			-0.0532 (0.132)	-0.0518 (0.143)		
ΔOffshoring HT (first lag)					-0.0593 (0.105)	-0.0613 (0.121)
ΔOffshoring LT (first lag)					-0.333** (0.147)	-0.383*** (0.145)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Pavitt dummies	No	Yes***	No	Yes**	No	Yes***
Country dummies	No	Yes**	No	Yes**	No	Yes**
F-test country dummies	-	0.2005	-	0.2434	-	0.2426
Observations	652	652	652	652	652	652
R-squared	0.351	0.388	0.346	0.381	0.354	0.391

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the share of firms innovating with the aim of opening up new markets and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

Table 2. The estimated profit equation of the recursive model

	(1) ΔProfits	(2) ΔProfits	(3) ΔProfits	(4) ΔProfits	(5) ΔProfits	(6) ΔProfits
ΔWages	-0.279***	-0.289***	-0.252***	-0.269***	-0.273***	-0.283***
	(0.0944)	(0.0931)	(0.0938)	(0.0929)	(0.0944)	(0.0938)
Share of firms introducing	0.0719***	0.0627**	0.0606**	0.0543*	0.0610**	0.0547*
product innovation	(0.0275)	(0.0307)	(0.0271)	(0.0304)	(0.0287)	(0.0319)
Expenditure in new mach.	0.418	0.600	0.489	0.629	0.503	0.670
and equipment per emp.	(0.760)	(0.766)	(0.752)	(0.758)	(0.762)	(0.767)
ΔProductivity	0.415***	0.437***	0.398***	0.427***	0.411***	0.434***
	(0.106)	(0.104)	(0.105)	(0.102)	(0.107)	(0.105)
ΔBroad offshoring	0.103	0.155				
	(14.32)	(14.82)				
ΔNarrow offshoring			0.814***	0.788***		
			(0.251)	(0.253)		
ΔOffshoring HT					0.545*	0.548*
					(0.282)	(0.282)
ΔOffshoring LT					-0.0718	0.0204
					(0.187)	(0.187)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	Yes*	Yes**	Yes*	Yes**	Yes*	Yes**
Pavitt dummies	No	Yes***	No	Yes***	No	Yes***
Country dummies	No	Yes**	No	Yes***	No	Yes***
F-test country dummies	-	0.0011	-	0.0011	-	0.0011
Observations	838	838	833	833	831	831
R-squared	0.115	0.155	0.131	0.170	0.123	0.163

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to product innovation and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel.

Table 3. The estimated recursive wage-profit model (SURE model)

	SURE (1)		SURE (2)		SURE (3)		SURE (4)	
	ΔProfits	ΔWages	ΔProfits	ΔWages	ΔProfits	ΔWages	ΔProfits	ΔWages
ΔWages	-0.316***		-0.300***		-0.339***		-0.318***	
	(0.0882)		(0.0886)		(0.0883)		(0.0888)	
ΔProductivity	0.204***		0.221***		0.220***		0.239***	
	(0.0662)		(0.0705)		(0.0671)		(0.0706)	
Share of firms introducing	0.0381		0.0491**		0.0341		0.0464*	
product innovation	(0.0233)		(0.0241)		(0.0232)		(0.0240)	
Expenditure in new mach.	0.467*		0.412		0.456*		0.399	
and equipment per emp.	(0.273)		(0.286)		(0.271)		(0.285)	
ΔNarrow offshoring	0.392**		0.395**					
	(0.163)		(0.162)					
ΔEmployment (first lag)		0.0845**		0.0723*		0.0868**		0.0744**
		(0.0372)		(0.0377)		(0.0372)		(0.0377)
Share of firms aiming to		0.0310**		0.0387*		0.0314**		0.0377*
open up new markets		(0.0156)		(0.0197)		(0.0155)		(0.0196)
Share of firms introducing		-0.00500		0.00578		-0.0105		0.00392
process innovation		(0.0185)		(0.0230)		(0.0183)		(0.0227)
Union density		0.0441***		-0.0143		0.0443***		-0.0147
		(0.0140)		(0.0228)		(0.0141)		(0.0228)
ΔBroad offshoring (first lag)		-0.143**		-0.176***				
		(6.317)		(6.310)				
ΔOffshoring HT					0.0492		0.127	
					(0.196)		(0.205)	
ΔOffshoring LT					0.289**		0.377**	
					(0.145)		(0.149)	
ΔOffshoring HT (first lag)						-0.0302		-0.0653
						(0.104)		(0.104)
ΔOffshoring LT (first lag)						-0.188**		-0.212**
						(0.0954)		(0.0943)
Time dummies	Yes*	Yes***	Yes*	Yes***	Yes*	Yes**	Yes*	Yes***
Manufacturing dummy	Yes***	No	Yes***	No	Yes***	No	Yes***	No
Pavitt dummies	No	No	Yes*	Yes***	No	No	Yes**	Yes***
Country dummies	No	No	Yes***	Yes***	No	No	Yes***	Yes***
Observations	579	579	579	579	578	578	578	578
R-squared	0.098	0.169	0.131	0.207	0.099	0.167	0.136	0.204

Note: Seemingly Unrelated Regression Equations (SURE) model; * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the share of firms introducing product innovation, the one introducing process innovation, the one aiming to open up new markets and expenditure in new machinery present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

5. Conclusions

Following an approach which combines a Neo-Schumpeterian perspective on the dynamics of technological change and a Post-Keynesian approach on the conflictual relationship between capital and labour income, in this chapter we built on Bogliacino, Guarascio and Cirillo (2018) to present a sequential model on wage and profit setting.

According to the proposed framework, wage and profit growth represent the outcome of a two-step bargaining process, where wages are set out in the labour market on the basis of the workers' bargaining power; the latter is defined by employment growth (which proxies a reserve army distribution function resembling the one proposed in Goodwin's growth cycle model), different proxies of product and process innovation, several offshoring indicators and union density. Profits are then realized as residual on the basis of previously determined wages, labour productivity growth, different proxies of product and process innovation and various offshoring indicators.

Contrary to the simultaneous model present in the previous chapter, in the two-equation system here developed there is not a simultaneous (two-way) but a sequential (one-way) relationship between the distributive variables (i.e. growth rate of wages and profits); furthermore, a lag structure has been introduced to avoid simultaneity-related endogeneity bias. In other words, in the light of the results stemming from a different specification of the wage and profit equation, the results of the sequential model also provide the possibility to check the robustness of the findings of the simultaneous model presented in Chapter 3.

In this regard, a strongly negative relationship between wage and profit dynamics is always found, confirming previous evidence. Product innovation is positively associated to increasing profits as well as rising wages, while the introduction of new production processes seems to have no impact on profits other than through a reduction of wages; however, the negative impact of process innovations on wage growth (as shown by the WLS estimation of the wage regression) is not confirmed by the results of the model estimated using the SURE model. Offshoring processes are confirmed as drivers of profits while represent a reliable firms' weapon to reduce labour costs. Moreover, when we distinguish between high- and low-tech offshoring strategies an asymmetric impact of offshoring on wage and profit growth is reaffirmed; whether low-tech offshoring is found as the most detrimental for wages, the relative prominence of high-tech and low-tech strategies for profit growth turns out to be sensitive to the estimation technique used. Concerning the role of trade unions, we find that industries in which union density is greater tend to pay higher wages, although this finding is partially questioned when we control for country dummies capturing the whole institutional features of national labour markets. Finally, employment dynamics shows a significant and positive impact on wages, suggesting that – on the one hand – industries which drive the structural change process tend to pay higher wages compared to declining sectors, and that – on the other hand – increasing labour market tightness improves workers' negotiation position in accordance with a "Goodwin effect";

In conclusion, we try to outline the overall picture which emerged from theoretical and empirical analysis presented in the last two chapters of the present work.

First, social bargaining on income distribution refers to a conflictual reality shaped by power relations far from any theoretical approach claiming an alleged harmonious (i.e. marginal productivity-led) distributive mechanism.

Second, labour productivity growth – a variable including a series of factors which foster value added growth, such as capital investment, organizational improvements and skill upgrading of workers – appears always positively correlated with the dynamics of both distributive components, emerging as an element of major relevance whose dividends provide room for wage and profit increases.

Third, technology plays a key role in driving distributional patterns of industries and the distinction between product and process innovation is crucial to shed light on the impact that different competitiveness strategies – i.e. technology-driven and cost-based one – have on wage and profit dynamics. On the one hand, the introduction of new products tends to be associated with higher labour and capital compensation; in line with a Schumpeterian model of market competition, innovation creates "rents" of which workers benefit from according to their bargaining power (Van Reenen 1996). On the other hand, process innovation – as proxied by an embodied technical change indicator (namely, the expenditure for new machinery and equipment) – has the reduction of labour cost as main consequence.

Fourth, globalization has substantial effect in terms of income distribution and its technological dimension cannot be disregard. Notably, the international fragmentation of production – especially the one that occurs within industries as captured by the narrow offshoring indicator – emerges as a firms' powerful strategy to reduce wages, narrowing workers' claims through the credible threat of delocalization of production and consequent job destruction. In particular, low-tech offshoring strategies seem associate to lower wage growth. Conversely, knowledge-oriented offshoring strategies – i.e. the acquisition of intermediate inputs imported from technologically advanced foreign industries – allow sectors to enrich their stock of technological and organizational knowledge and increase in this way their profitability.

Fifth, even though the empirical evidence cannot be considered conclusive, the long-run generalized decline of unionization did not vanish the role of trade unions; our investigation has demonstrated that union density still represents a factor which contributes – together with the other country-specific institutional features of labour market – to support workers' bargaining power and thus the growth rate of wages.

Finally, heterogeneity turns out to be a crucial element affecting the set of relationships inquired, confirming the need to adopt a structural perspective to investigate the changing forces which shape the long-run dynamics of income distribution.

Appendix of Chapter 4

This Appendix reports several robustness checks related to the recursive wage-profit model estimated in Section 4 of the present chapter.

A.1 The wage equation: robustness checks

The tables reported in this part of the Appendix aim to provide robustness checks related to the estimations results shown in Table 1 of the main text, i.e. regarding the WLS estimation of the wage equation in the recursive model.

In Table A.1 we focus on the baseline wage equation providing a series of diagnostic tests to check the reliability of the estimated regression.[96] We start testing the heteroskedasticity of the residuals of the wage equation. First, we perform the Breusch-Pagan test performing a Weighted Least Squares estimation, i.e. the approach we use in the present work for the equation by equation estimations since we deal with industry-level data. Moreover, we also perform the White test, although it only applies to estimations performed with standard OLS method. As expected, both tests strongly reject the null hypothesis of homoskedasticity, confirming that the variance of the error term differs across observations and thus supporting our choice to estimate the wage equation using heteroskedasticity- and autocorrelation-robust standard errors.

Moreover, we test the serial correlation of residuals applying the test proposed by Cumby and Huizinga (1990, 1992) and developed for STATA by Baum and Schaffer (2013); as above mentioned, this test can be used in several circumstances in which other tests like the Box-Pierce/Ljung-Box test, the Durbin's h-test or the Breusch-Godfrey test are not applicable. The null hypothesis of the test is that residuals are serially uncorrelated. Since we use a first-difference estimator with dummy variables, we do not expect to face autocorrelation problems. Indeed, the Cumby and Huizinga test does not reject the null hypothesis of serially uncorrelated residuals of the estimated wage equation.

We use the Variance Inflation Factor (VIF) to test for multicollinearity problems. In particular we apply the VIF test to the specification reported in column 6 of Table 1, that is the one including all the right-hand-side regressors we account for in the analysis and the full set of dummy variables. The VIF value is equal to 3.33, below 4 and much below 10 (the thresholds usually taken as reference in the literature). Hence, we conclude that multicollinearity is not a cause for concern.

Finally, we remind that Table 1 reported in Section 4 of the main text has shown that country dummies are jointly not significant in the wage regression of the recursive model. Therefore, Table A.2 provides the estimation results of the latter regression without the inclusion of such dummies. The results largely confirm the significant role played by the right-hand-side regressors we have identified as determinants of the wage dynamics. In particular, they show that industries with higher union density tend to pay higher wages. These findings are consistent with the ones reported in column 1, 3 and 5 of Table 1 (as well as the results of the wage equation estimated in Chapter 3, Section 5), although the negative coefficient related to process innovations loses significance when the manufacturing dummy is included.

[96] The baseline wage equation we are referring to is the specification reported in the first and second column of Table 1 in Section 4 (depend variable: growth rate of wages; regressors: employment growth rate (first lag), share of firms introducing innovation with the aim of opening new markets, share of firms introducing process innovation, union density, growth rate of broad offshoring (first lag), time, Pavitt and country dummies).

Table A.1 Robustness checks for the wage equation in the recursive model

Heteroskedasticity (Breusch-Pagan test)
WLS regression (time, Pavitt and country dummies included)
Ho: constant variance (homoskedasticity)
F(16, 828) = 11.40
Prob > F = 0.0000
Heteroskedasticity (White test)
OLS regression (time, Pavitt and country dummies included)
Ho: homoskedasticity
Ha: unrestricted heteroskedasticity
chi2(121) = 241.56
Prob > chi2 = 0.0000
Autocorrelation of residuals (Cumby-Huizinga test)
WLS regression (time dummies included)
H0: variable is MA process up to order q (with q = 0: serially uncorrelated)
HA: serial correlation present at specified lags >q
chi2 = 1.837
p-value = 0.1753
Multicollinearity – specification of Table 1, column 6 (Variance Inflation Factor)
WLS regression (time, Pavitt and country dummies included)
Mean VIF = 3.33

Table A.2 The estimated wage equation in the recursive model without country dummies and controlling for manufacturing dummy

	(1) ΔWages	(2) ΔWages	(3) ΔWages	(4) ΔWages	(5) ΔWages	(6) ΔWages
ΔEmployment (first lag)	0.121*** (0.0405)	0.0781** (0.0390)	0.128*** (0.0416)	0.0776** (0.0389)	0.117*** (0.0403)	0.0750* (0.0391)
Share of firms aiming to open up new markets	0.0576*** (0.0126)	0.0599*** (0.0127)	0.0479*** (0.0133)	0.0520*** (0.0131)	0.0578*** (0.0128)	0.0605*** (0.0128)
Share of firms introducing process innovation	-0.0338** (0.0165)	-0.0178 (0.0178)	-0.0355** (0.0164)	-0.0174 (0.0178)	-0.0358** (0.0167)	-0.0196 (0.0181)
Union density	0.0341** (0.0162)	0.0358** (0.0160)	0.0345** (0.0162)	0.0364** (0.0160)	0.0345** (0.0160)	0.0362** (0.0159)
ΔBroad offshoring (first lag)	-0.214*** (8.225)	-0.172** (7.866)				
ΔNarrow offshoring (first lag)			-0.0464 (0.135)	0.00182 (0.133)		
ΔOffshoring HT (first lag)					-0.0576 (0.109)	-0.0354 (0.108)
ΔOffshoring LT (first lag)					-0.384*** (0.145)	-0.337** (0.140)
Time dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Pavitt dummies	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
Manufacturing dummy	No	Yes***	No	Yes***	No	Yes***
Observations	652	652	652	652	652	652
R-squared	0.372	0.381	0.366	0.377	0.376	0.385

Note: Weighted least squares (WLS) with robust standard errors in brackets and weighted data (weights are sector- and time-specific numbers of employees). * significant at 10%, ** significant at 5%, *** significant at 1%. Variables referring to the share of firms innovating with the aim of opening up new markets and share of firms introducing process innovation present a lag (except for the last period) according to the time structure of the panel; union density is lagged as it refers to the first year of each time period.

A.2 The profit equation: robustness checks

In this part of the Appendix we report the results of several endogeneity tests concerning the profit equation estimated in Table 2 of Section 4 of the present chapter.[97] In particular, we check whether our findings stemming from the estimated profit equation of our recursive wage-profit system is affected by endogeneity problems due to reverse causality between profit growth (dependent variable) and wage and labour productivity dynamics (independent variables).

Four post-estimation tests are performed exploiting different techniques and using different combinations of instruments to check the exogeneity of wage growth and labour productivity growth. The results are reported in Table A.3, which is structured as follows: the first column shows the test performed, the second column the variables whose exogeneity is to be checked, the third column the variables used as instruments, the fourth column the estimator employed for the diagnostic test, the fifth column the results concerning the relevance and validity of the instruments, the sixth column the results of the endogeneity tests performed and the last column summarizes the final outcome.

The tests shown in the Table A.3 are those which do not present any problems in terms of relevance and validity of the instruments; in other words, we present the results of the most meaningful tests according to the F-test and overidentification test reported in the fifth column.

The first and third test are performed using the *ivreg2* Stata's command developed by Baum et al. (2007). Regarding the results of the first stage, both tests reject the null hypothesis of underidentification, while they do not reject the null hypothesis on overidentifying restrictions, suggesting the relevance and validity of instruments. Moreover, both tests do not reject the null hypothesis of wage and labour productivity growth exogeneity.

The other tests, i.e. the Wooldridge's robust score test and robust regression-based test, provide the same conclusion. The F-statistic related to the first stage regressions (concerning the wage growth and labour productivity growth respectively) are well above the "rule of thumb" of 10, which would be the lower threshold to consider the weakness of instruments not an issue (Staiger and Stock, 1997); in addition, the test of overidentifying restrictions do not reject the null hypothesis regarding the validity of instruments. Finally, the null hypothesis of exogeneity of both wage growth and labour productivity growth is not rejected, providing support to the econometric strategy we followed and to the reliability of the results we achieved.

[97] The specification of the profit equation we are referring to is the following. Depend variable: growth rate of profits; regressors: growth rate of wages, share of firms introducing product innovation in the sector, expenditure in new machinery and equipment, labour productivity growth, Pavitt and country dummies (results do not change considerably if the growth rate of narrow offshoring is included among regressors).

Table A.3 Baseline profit equation: endogeneity tests

Test	Endogenous variable(s)	Instruments	Estimator	Test F (first stage) and overidentification tests	Final test (second stage) and endogeneity tests	Result
Endogeneity test after 2sls	**Wages and productivity**	Lagged RVEXPVA, lagged RVA, QCLE, QCWO, QEUN	2SLS weighted, with robust s.e. (*ivreg2* Stata's command)	Underidentification test (Kleibergen-Paap rk LM statistic) = 10.208. Chi-sq(4) P-val = 0.0371 Hansen J statistic (overidentification test of all instruments) = 4.672. Chi-sq(3) P-val = 0.1974	Ho: variables are exogenous. Endogeneity test (difference of two Sargan-Hansen statistics) = 3.669. Chi-sq(2) P-val = 0.1597	***exogenous***
Wooldridge's robust score test and robust regression-based test after 2sls	**Wages and productivity**	QMAN, QCLE, QCWO	2SLS with robust s.e. (*ivregress 2sls* Stata's command)	First-stage regressions (wages) F(9, 702) = 18.47. Prob > F = 0.0000 First-stage regressions (productivity) F(9, 702) = 44.53. Prob > F = 0.0000 Test of overidentifying restrictions: Score chi2(1) = 0.359221 (P-val = 0.5489)	Tests of endogeneity Ho: variables are exogenous Wooldridge's (1995) robust score chi2(2) = 3.98847 (P-val = 0.1361). Robust regression F(2,698) = 2.02535 (P-val = 0.1327).	***exogenous*** ***exogenous***
Endogeneity test after 2sls	**Wages and productivity**	Lagged RVEXPVA, lagged RVA, QCLE, QCWO, size (first lag)	2SLS weighted, with robust s.e. (*ivreg2* Stata's command)	Underidentification test (Kleibergen-Paap rk LM statistic) = 9.783. Chi-sq(4) P-val = 0.0443 Hansen J statistic (overidentification test of all instruments) = 3.623. Chi-sq(3) P-val = 0.3051	Ho: variables are exogenous Endogeneity test (difference of two Sargan-Hansen statistics) = 3.220. Chi-sq(2) P-val = 0.1999	***exogenous***

Note: RVA=growth rate of value added; RVEXPVA=growth rate of the ratio between exports and value added; QMAN=share of managers; QCLE=share of clerks; QCWO=share of craft workers; QEUN=share of precarious workers; size=average firm size. Variables referring to the share of managers, clerks, craft and manual workers over the total number of employees in the sector, as well as size and the share of precarious workers (computer as the sum of part-time and fixed-term workers) over the total number of employees in the sector, present a lag (except for the last period) according to the time structure of the panel. Variables referring to the economic performance of sectors (growth rates of value added and exports over value added) are computed as the average annual rate of change over five periods (1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014) according to the time structure of the panel. See the final Appendix on the SID database.

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Appendix on the SID database

1. The Sectoral Innovation Database

The Sectoral Innovation Database (SID), developed at the University of Urbino (Pianta et al., 2018), is an industry-level database which accounts for 38 manufacturing and service sectors – classified according to the two-digit NACE Rev. 1 classification – of six major European countries (France, Germany, Italy, the Netherlands, Spain and the United Kindgom), representing the 75% of the entire EU28's GDP. The time span covered by the database is 1994-2014.[98]

Table A.1 shows the list of sectors included in the SID database. The 21 manufacturing and 17 service sectors (first column) are classified according to the two-digit NACE Rev. 1 classification (second and third column). The third column reports the Revised Pavitt class to which each industry belongs, while the final (fifth) column refers to the aggregation of sectors in high- and low-tech clusters. To fulfill the requisite conditions for comparability, all the data from 2008 onwards have been converted into NACE Rev. 1 using the conversion matrix provided by Perani and Cirillo (2015).[99] All data refer to total activities of industries.

Table A.1 List of sectors

Nr.	Sectors (Nace Rev. 1)	Nace codes	Revised Pavitt class	High-tech / Low-tech *
	Manufacturing sectors			
1	FOOD PRODUCTS, BEVERAGES AND TOBACCO	15-16	SD	LT
2	TEXTILES	17	SD	LT
3	WEARING APPAREL, DRESSING AND DYEING OF FUR	18	SD	LT
4	LEATHER AND LEATHER PRODUCTS AND FOOTWEAR	19	SD	LT
5	WOOD AND PRODUCTS OF WOOD AND CORK	20	SD	LT
6	PULP, PAPER AND PAPER PRODUCTS	21	SI	LT
7	PRINTING AND PUBLISHING	22	SI	LT
8	COKE, REFINED PETROLEUM PRODUCTS AND NUCLEAR FUEL	23	SI	LT
9	CHEMICALS AND CHEMICAL PRODUCTS	24	SB	HT
10	RUBBER AND PLASTICS PRODUCTS	25	SI	LT
11	OTHER NON-METALLIC MINERAL PRODUCTS	26	SI	LT
12	BASIC METALS	27	SI	LT
13	FABRICATED METAL PRODUCTS (EXCEPT MACHINERY AND EQUIPMENT)	28	SD	LT
14	MACHINERY AND EQUIPMENT, N.E.C.	29	SS	HT
15	OFFICE, ACCOUNTING AND COMPUTING MACHINERY	30	SB	HT
16	ELECTRICAL MACHINERY AND APPARATUS, NEC	31	SS	HT
17	RADIO, TELEVISION AND COMMUNICATION EQUIPMENT	32	SB	HT
18	MEDICAL, PRECISION AND OPTICAL INSTRUMENTS	33	SB	HT
19	MOTOR VEHICLES, TRAILERS AND SEMI-TRAILERS	34	SI	LT
20	OTHER TRANSPORT EQUIPMENT	35	SS	HT
21	MANUFACTURING NC AND RECYCLING	36-37	SD	LT

[98] The selection of countries and sectors has been made in order to avoid limitations in access to data (due to the low number of firms in a given sector of a given country, or to the policies on data release by National Statistical Institutes).
[99] Since the conversion procedure might result in some data distortions, implausibly large values (in absolute terms) which appeared for some industries have been excluded.

	Service sectors			
22	SALE, MAINTENANCE AND REPAIR OF MOTOR VEHICLES; RETAIL SALE OF FUEL	50	SD	LT
23	WHOLESALE, TRADE & COMMISSION EXCL. MOTOR VEHICLES	51	SD	LT
24	RETAIL TRADE EXCL. MOTOR VEHICLES; REPAIR OF HOUSEHOLD GOODS	52	SD	LT
25	HOTELS AND RESTAURANTS	55	SD	LT
26	LAND TRANSPORT	60	SD	LT
27	SEA TRANSPORT	61	SD	LT
28	AIR TRANSPORT	62	SD	LT
29	SUPPORTING AND AUXILIARY TRANSPORT ACTIVITIES	63	SD	LT
30	POST AND TELECOMMUNICATIONS	64	SB	HT
31	FINANCIAL INTERMEDIATION (EXCEPT INSURANCE AND PENSION FUNDING)	65	SI	LT
32	INSURANCE AND PENSION FUNDING (EXCEPT COMPULSORY SOCIAL SECURITY)	66	SI	LT
33	ACTIVITIES RELATED TO FINANCIAL INTERMEDIATION	67	SI	LT
34	REAL ESTATE ACTIVITIES	70	SS	HT
35	RENTING OF MACHINERY AND EQUIPMENT	71	SS	HT
36	COMPUTER AND RELATED ACTIVITIES	72	SB	HT
37	RESEARCH AND DEVELOPMENT	73	SB	HT
38	OTHER BUSINESS ACTIVITIES	74	SS	HT

* The high- and low-tech classification is made relying on the Revised Pavitt taxonomy for manufacturing and service sectors (Bogliacino and Pianta 2010, 2016). Industries belonging to Science Based (SB) and Specialized Suppliers (SS) are included in the high-tech group while Supplier Dominated (SD) and Scale and Information Intensive (SI) in the low-tech one.

2. The Revised Pavitt Taxonomy

Pavitt (1984) focused on the structure of the markets and on the nature, sources and appropriability of innovation to conceptualize the existence of four different technology-based classes, according to which classify manufacturing industries. Bogliacino and Pianta (2010, 2016) investigated the relationships between innovation patterns and economic performance of service industries and provided a Revised Pavitt Taxonomy which extends the original Pavitt classification to the latter sectors. Here we report a brief description of the four classes of industries classified according to the Revised Pavitt Taxonomy.

(a) Science-Based industries (SB) include sectors where innovation is based on advances in science and R&D (such as the pharmaceuticals, electronics, computer services) where research laboratories are important, leading to intense product innovation and a high propensity to patent.

(b) Specialised Supplier industries (SS) include the sectors producing machinery and equipment; their products are new processes for other industries. R&D is present but an important innovative input comes from tacit knowledge and design skills embodied in the labour force. Average firm size is small and innovation is carried out in close relation with customers.

(c) Scale and Information Intensive industries (SI) include sectors (such as the automotive sector and financial services) characterized by large economies of scale and oligopolistic markets where technological change is usually incremental. New processes (often related to information technology) shape the organisation of production and coexist with new product development.

(d) Supplier Dominated industries (SD) include traditional sectors (such as food, textile, retail services) where internal innovative activities are less relevant, small firms are prevalent and technological change is mainly introduced through the inputs and machinery provided by suppliers from other industries. Firms in this group do not carry out much R&D or other innovative activities.

Source: Bogliacino and Pianta (2016, p. 157).

3. The variables

The SID merges five different sources of data to include information on the following items: first, the technological trajectories of industries and their structural evolution as shaped by the innovative efforts pursued by firms belonging to them; second, the economic performance of sectors mainly in terms of employment, productivity and value added; third, the distributive patterns of industries, i.e. their income distribution dynamics; fourth, the evolution of the components of effective demand, which essentially contribute to drive the growth and decline of industries and thus the changing composition of the economies; fifth, the ongoing industries' involvement in processes of internationalization of production on a global scale (i.e. along hierarchical global value chains stemming from different offshoring strategies); sixth, the labour market institutions (namely union density), the spreading of non-standard, precarious work and the occupational structure of industries. Let us briefly discuss the variables included in the database, reporting the data source from which they are drawn.

Innovation variables

The SID includes a set of variables coming from the Community Innovation Surveys (CIS) collected by Eurostat and related to the innovative efforts pursued by industries; this data source is essential as it provides information which allows to disentangle the complexity regarding the process of technological change.

All data concerning the innovation variables are drawn from the following five European Community Innovation Surveys (CIS) collected by Eurostat: CIS 2 (1994-1996), CIS 3 (1998-2000), CIS 4 (2002-2004), CIS 7 (2008-2010) and CIS 9 (2012-2014). As shown below, the latter five survey waves are therefore matched with economic, productive structure and labour market data at industry level.

Notably, the SID encompasses a set of proxies enabling the distinction between input and output of innovation and between product and process innovation. In this way our database provides information which allows to capture the dominant competitiveness strategy of industries along with their technological trajectories.

Economic and distributive variables

A series of variables concerning the economic performance of sectors in terms of gross output, value added, employment and productivity growth, as well as variables on the distributive patterns of industries (i.e. on the dynamics of labour and capital compensation) are present. The main sources for these data are the Structural Analysis Database (STAN) provided by the OECD and the Socio Economic Accounts (SEA) released by the World Input-Output Database (WIOD) (Timmer et al., 2015, 2016).

Demand variables

Another data source provided by WIOD, i.e. the World Input-Output Tables (WIOT), has been fundamental for the construction of demand and offshoring variables. We start discussing briefly the former. The growth of aggregate demand is largely recognized as crucial for understanding the development and decline of industries over time; this awareness raises the need to disentangle the role of different components of effective demand to assess properly the growth patterns of sectors and suggest policy recommendations. The SID accomplishes this task reporting industry-level data for total (final and intermediate) demand, domestic demand, exports, imports and investment (proxied by gross fixed capital formation).

In particular, the variable of domestic final demand has been computed in the following way: for each industry of a given country we computed the sum of four sources of final demand coming from that country, namely final consumption expenditure by households, final consumption expenditure by non-profit organizations serving households (NPISH), final consumption expenditure by government and gross fixed capital formation.

As regards exports, for each industry of a given country we computed the sum of both intermediate and final flows of goods (expressed in monetary terms) produced by that industry and directed abroad, i.e. bought by any other industry of any other country in the world.

Offshoring variables

The SID includes data on the industries' evolution with respect to their involvement in the process of internationalization of production on a global scale (i.e. on production offshoring). Indeed, industry-level data are particularly suitable to study the modern trajectories of international trade, increasingly marked by the strategic localization of production plants and the selection of suppliers, as well as by the sales and purchases of intermediate inputs and their technological content. A full set of offshoring indicators accounting for the modern fragmentation of production spurred by globalization has thus been constructed exploiting the World Input-Output Tables (WIOT) provided by WIOD.[100]

Table A.2 summarizes the extent to which the dynamics of different kinds of offshoring processes are correlated, reporting the correlation matrix – i.e. the normalized variance and covariance matrix – of the offshoring variables' variations computed for all countries over the period and a test on their linear correlation.

Table A.2 Correlation matrix of offshoring indicators' variations
(whole sample: DE, IT, FR, ES, NL, UK; 1995-2014)

	Broad offsh. (% change)	*Narrow offsh. (% change)*	*HT offsh. (% change)*	*LT offsh. (% change)*
Broad offsh. (% change)	1			
Narrow offsh. (% change)	0,6882 *	1		
HT offsh. (% change)	0,5868 *	0,5242 *	1	
LT offsh. (% change)	0,7536 *	0,5933 *	0,1359 *	1

Source: Our elaboration on Sectoral Innovation Database.
Note: the percentage variations are computed for the following five periods: 1996-2000, 2000-2003, 2003-2008, 2008-2012, 2012-2014. The star (*) refers to the Pearson correlation coefficient, testing if it is significantly different from zero at a significance level of 1%.

Labour market variables

The SID provides information on the labour market dynamics of industries including a set of indicators which capture the design of labour market institutions, their evolution over time as well as task-related occupational trends.

Exploiting the ICTWSS database (Visser, 2016) we built an industry-level indicator of union density to assess the role of trade unions, conceived as key actors which are expected to shape the distributive dynamics of sectors. Since union density data are only available at an aggregated level of sectoral classification, we implemented the methodology followed by Guschanski and Onaran (2016, 2017, 2018): on the one hand, we linearly interpolate the series between available years; on the other, for certain individual industries we extrapolate missing data computing the union density growth rate on the basis of the data available for the next higher level of aggregation (which may even be country-level union density data whether data at higher level of disaggregation are not available). For example, we extrapolate data for individual manufacturing sectors using the growth rate of the total manufacturing union density (or, if the latter is not available, we use the country-level union density

[100] Section 4 of Chapter 1 of the present work illustrates the offshoring variables included in the SID database and the procedure we followed for their construction.

rate of growth) (see Guschanski and Onaran, 2017, p. 11). Unfortunately, such procedure inevitably reduces the inter-industry variability of union density data and questions to some extent its reliability, without allowing to fully account for various economic events or shifts in policy orientation that affect industrial relations and the power balance between capital and labour. However, we argue that the relevance accorded to the union density variable by our empirical analysis suggests its ability in capturing the role of wage bargaining institutions on income distribution dynamics.

Furthermore, given the broad restructuring processes which involved the labour market regulation in the last three decades, fixed-term employment contracts have spread and the employment protection legislation experienced a general downtrend. The SID now accounts for this phenomenon including a proxy of the worker "precariousness" – i.e. the share of workers who have a part time job and/or a fixed term employment contract at sectoral level –, that we built on data from the Labour Force Survey (LFS) provided by Eurostat.

Data from LFS have been exploited also to trace the occupational structure of industries over time. Drawing from this source, the SID includes data on employment dynamics for four task-related groups – Managers, Clerks, Craft and Manual workers –, reporting also their share over total employment. These data are the result of a clustering procedure carried out on the basis of the nine professional categories of the International Standard Classification of Occupations (ISCO). Unfortunately, task-related data are not available for the Netherlands.

Table A.3 shows the grouping of professional categories included in the SID with respect to the ISCO 1-digit classes.

Table A.3 The professional groups

Professional groups	ISCO 1-digit classes
Managers	Managers, senior officials and legislators
	Professionals
	Technicians and associate professionals
Clerks	Clerks
	Service and sales workers
Craft workers	Skilled agricultural and fishery workers
	Craft and related trade workers
Manual workers	Plant and machine operators and assemblers
	Elementary occupations

Source: Cirillo (2017).

The list of variables and the unit of measure
The first column of Table A.4 reports the list of variables included in the SID database that have been exploited to perform the empirical analyses of the present work. The measurement unit of the variables (as used empirically in the analysis) as well as the sources from which they are drawn are reported in the second and third column, respectively.

Table A.4 List of variables

Variable	Unit	Source
Rate of growth of value added	Annual rate of growth	SID – (WIOD-SEA)
Rate of growth of domestic final demand	Annual rate of growth	SID – (WIOT)
Rate of growth of exports	Annual rate of growth	SID – (WIOT)
Rate of growth of wages	Annual rate of growth	SID – (OECD-STAN)
Rate of growth of profits	Annual rate of growth	SID – (OECD-STAN)
Rate of growth of productivity	Annual rate of growth	SID – (OECD-STAN/WIOD-SEA)
Rate of growth of employment	Annual rate of growth	SID – (OECD-STAN/WIOD-SEA)
R&D expenditure per employee	Thousands euros/employee	SID – (EUROSTAT-CIS)
New machinery exp. per employee	Thousands euros/employee	SID – (EUROSTAT-CIS)
Turnover due to product innovation	Share	SID – (EUROSTAT-CIS)
Share of firms introducing new products	Share	SID – (EUROSTAT-CIS)
Share of firms introducing new processes	Share	SID – (EUROSTAT-CIS)
Share of firms innovating to open new markets	Share	SID – (EUROSTAT-CIS)
Rate of growth of broad offshoring	Simple difference	SID – (WIOT)
Rate of growth of narrow offshoring	Simple difference	SID – (WIOT)
Rate of growth of high-tech offshoring	Simple difference	SID – (WIOT)
Rate of growth of low-tech offshoring	Simple difference	SID – (WIOT)
Union density	Share	SID – (ICTWSS)
Share of managers	Share	SID – (EUROSTAT-LFS)
Share of clerks	Share	SID – (EUROSTAT-LFS)
Share of craft workers	Share	SID – (EUROSTAT-LFS)
Share of manual workers	Share	SID – (EUROSTAT-LFS)

Source: Sectoral Innovation Database.
Note: Rate of growth are compound average annual rate of growth computed over two to five years periods (1996-2000; 2000-2003; 2003-2008; 2008-2012; 2012-2014). Offshoring variables are computed as the simple difference between the value assumed in the last year and the one assumed in the first year of each of the five periods.

4. The time structure of the database

The dataset is a panel over five periods covering a time span from 1994 to 2014. The time structure of the panel is the following:[101]

- *Economic, demand and offshoring variables* are computed for the periods 1996-2000, 2000-2003, 2003-2008, 2008-2012 and 2012-2014. For economic, distributive and demand variables we compute the compound annual growth rate that approximates the difference in logarithmic terms, while for the offshoring indicators we take the simple difference.
- *Innovation variables* are taken from five waves of innovation survey: the first wave (CIS 2) refers to 1994-1996 and is linked to the first period of economic variables; the second wave (CIS 3) spans 1998-2000 and is linked to the second period of economic variables; the third wave (CIS 4) refers to 2002-2004 and is linked to the third period of economic variables); the fourth wave (CIS 7) spans 2008-2010 and is linked to the fourth period of economic variables; the fifth wave (CIS 9) refers to 2012-2014 and is linked to the fifth period of economic variables.[102]

5. Data deflation methodology

The monetary innovation variables – namely the expenditure in research and development and in new machinery and equipment – have been deflated (base year 2000) using the aggregate value added deflator provided by OECD-STAN, while the value added and demand variables – namely domestic final demand and exports – have been deflated (base year 2000) using the sectoral value added deflators provided by WIOD-SEA.

All the monetary variables have been converted in euros and adjusted for PPP using the index provided in Stapel et al. (2004, p. 5).

[101] The temporal structure of the database is firstly due to the frequency according to which Eurostat collects the innovation surveys and makes them available. Secondly, the surveys' innovation-related questions are partially changed over the time, forcing us to select consistently the CIS containing the variables of our interest. Finally, we matched the economic and innovation variables so that the latter are lagged relative to the former, bearing in mind the time needed by technological efforts to display their effects. For more details, see the final Appendix on the SID database.

[102] The variable related to the expenditure for new machinery and equipment contains missing values for the first two CIS waves by construction. However, missing values are homogeneously distributed across countries in service industries. Unfortunately, the variable related to the turnover due to innovation contains, by construction, missing values for Germany and the Netherlands in the second CIS wave and for France in the third CIS wave.