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Weaker jobs, weaker innovation. Exploring the temporary employment-product innovation nexus.*

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Abstract

This work explores the relationship between temporary employment and product innovation focusing on five major European economies (France, Germany, Italy, Spain and the Netherlands) observed between 1998 and 2012. Building on the conceptual framework proposed by Kleinknecht et al. (2014), the analysis distinguishes sectors according to their technological characteristics and regimes finding that industries using temporary employment tend to have a weaker product innovation propensity. The negative correlation between temporary employment and innovation is stronger in medium and high-tech sectors, identified using both the "Cumulativeness" proxy stemming from Peneder's classification (Peneder, 2010) as well as distinguishing between different Schumpeterian regimes - Schumpeter Mark I vs II - of knowledge accumulation.

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1 Introduction

In recent years, (external) labour flexibility has been propagated across Europe, aimed at increasing employment and productivity. By favouring the adjustment of labour supply to changing market conditions, greater external flexibility was expected to impact positively on employment. By easing workers' entry and exit, labour market flexibility was expected to foster productivity dynamics, ensuring a better match between the demand for and supply of skills (OECD, 1994 and European Commission, 2007).

After the 2008 crisis, labour market flexibility was on the top of the reform agenda of the governments of Southern Europe, seen as a way of promoting GDP and employment growth.[1] In the meantime, technological competitiveness and innovation emerged as key strategies to promote firm and industry growth. In the wake of the crisis, companies that have managed to maintain (and in some cases to increase) their market share are mostly those firms that have introduced new products or made improvements to the quality and technological content of existing goods. The economic impact of labor flexibility is still a theoretically controversial issue and the related empirical evidence are ambiguous. There is a growing body of literature that analyses the relationship between flexibility and employment dynamics. In a review of these contributions, Vergeer and Kleinknecht (2012) emphasize that a significant part of the available evidence argues for no effect or a negative effect of flexibility on employment. Indeed, several works underline the absence of an explicit outcome (Howell et al., 2007; Baccaro and Rei, 2007; Piasna and Myant, 2017). There is another literature stream that focuses on the linkage between flexibility and productivity; however, its results are not clear-cut. Furthermore, a large number of studies report a negative relation between flexibility and productivity and a small body of work, such as Arvanitis (2005), shows evidence of an insignificant or even positive relationship between flexibility and product innovation (Barbosa and Faria, 2011).[2]

There are two opposing hypotheses about the linkage between flexibility and innovation. First, greater external flexibility may be associated to horizontal (and less hierarchical) organizations where knowledge (and workers) move frequently both within and outside the organization. In this case, external flexibility may spur knowledge flows favouring the diffusion of new ideas with a potentially positive impact on product innovation. Second, it is hypothesized that labour flexibility can reduce innovative competencies by weakening the accumulation of tacit or firm-specific knowledge. The stock of tacit and firm-specific knowledge is vital for the development of innovations and their accumulation depends heavily on long-lasting labour relations and on organizational environments that favour cooperation between workers and employers. In this context, uncertainty about the duration of labour relationships, which is typical of temporary and other flexible labour contracts, can discourage the accumulation of organization-specific knowledge, and of tacit knowledge (embodied by workers), in particular. Similarly, uncertain employment perspectives may have a negative effect on loyalty and cooperation, between employers and employees as well as among employees.

These contrasting hypotheses point to different organizational profiles and/or firms competitive strategies. Some firms rely on innovation and product quality to achieve market success; while others compete by reducing costs (particularly labour cost). Of course, most companies rely on a combination of these two strategies with the relative importance of one or the other depending on a multitude of firm, industry and market-level characteristics. Moreover, a significant heterogeneity may emerge even among firms that rely on innovation and technological competition strategies. The key element is the role played by tacit and firm-specific knowledge and, hence, stable and cooperative labour relationships in different technological regimes (Kleinknecht et al., 2014). In the garage-business model - that is the model proxying the Schumpeter Mark I technological regime -, competition is characterized by continuous firm entry and exit, and by the type of knowledge required for innovations which is general and usually readily available. Conversely, in the routinized-innovation model - that

[1] Assessments of the spread of labour market reforms after the crisis are available, for the OECD economies in Adascalitei et al. (2015) and for Italy in Cirillo and Guarascio (2015). The European cross-country heterogeneity in terms of labor market reforms is analysed by Picot and Tassinari (2017).

[2] In this case, the authors investigate the link between labor market rigidity and innovation.

is, the model proxying the Schumpeter Mark II technological regime which is characterized by high barriers to entry - the development of innovations relies on historically accumulated, firm-specific and idiosyncratic knowledge. As a result, the relationship between labour flexibility and innovation can vary markedly according to the competition strategy (technology vs costs), and the technological regime (Schumpeter Mark I vs Mark II). In addition, the magnitude and direction of the flexibility-innovation nexus can change depending on country-specific structure and institutions.

In Europe, labour flexibility mostly involves reducing worker protection against layoffs and using temporary contracts (Cirillo et al., 2017). Despite neoclassical economists belief (Nickell et al., 2005), it is doubtful whether the push towards flexible labour markets has given rise to significant employment or productivity improvements (Vergeer and Kleinknecht, 2012; Howell et al., 2007; Baccaro and Rei, 2007; Piasna and Myant, 2017; Fana et al., 2016) especially in Southern EU countries. For several decades, sluggish productivity performance in these economies has prevented the expected convergence towards the "core" - Germany and the other Central-Northern EU economies (Landesmann, 2015). There is a group of recent empirical and theoretical contributions that analyses the impact of labour flexibility accounting explicitly for differences in production structures, technological regimes, policy-mixes and macroeconomic conditions (Cirillo and Guarascio, 2015; Dosi et al., 2016). These contributions show that, in the presence of structural weaknesses - i.e identified as the prevalence of low-tech sectors, low-skilled employment and weak aggregate demand - lowering worker protections can even negatively affect productivity dynamics. In this context, the empirical literature provides no clear-cut evidence concerning the relationship between use of temporary contracts, productivity and innovation dynamics. From a policy perspective, the International Monetary Fund claimed recently that labour market regulation is not found to have "...statistically significant effects on total factor productivity" (IMF, 2015). At the same time, there is no consensus on the linkage between labour flexibility and innovation. Nevertheless, most of the reforms (for a review, see Cirillo and Guarascio, 2015) recently implemented in the EU went on reducing restrictions on the use of fixed term contracts so to increase flexibility. As a consequence, the share of temporary contracts has surged, although with differences across European economies. Boeri and Garibaldi (2007) highlight the emergence of dual labour markets and predict an increasing risk of reduced mobility, a worsening wage distribution and a predominance of temporary employment for new entrants (Scherer, 2004).

Given the emergence of temporary employment as a trait peculiar to European labour markets, it is worth exploring whether and how its diffusion has affected European industries structural and technological dynamics. So far, few empirical works have investigated the linkage between temporary contracts and innovation. Also, there are only few studies that explore econometrically the relationship between temporary contracts and product innovation (Zhou et al., 2011; Michie and Sheehan, 2003). This paper tries to contribute to this line of research through an analysis that relies on a rich indutry-level longitudinal database providing information on economic and innovative performance and temporary employment on five major EU economies. Community Innovation Surveys (CIS) data on product innovation are used as indicators of sectoral innovative performances, in line with a large number of studies that use innovation surveys data (Mairesse and Mohnen, 2010). Three research questions are addressed. First, we test whether a relatively more intense use of temporary contracts affects the development of new products in European industries. Second, we test whether the relationship investigated is sensitive to technological regimes (Schumpeter Mark I vs Schumpeter Mark II) and industry characteristics - Low, Med, High Cumulativeness sectors from the classification introduced by (Peneder, 2010). Third, we distinguish between workers' age cohorts, to test whether the impact of temporary employment on innovation changes according to the age cohort. In particular, we look at youth employment, given that young people record the highest share of temporary employment among age cohorts.[3]

The paper is organized as follows. Section 2 discusses the theoretical and empirical literature analysing the relation between labour market institutions and innovation. Section 3 presents the data and provides some

[3]In 2016, the share of young people (15-24 years old) employed with temporary contracts was 72,9% in Spain, 54,7% in Italy, 53,8% in Netherlands, 58,6% in France and 53% in Germany. Source Eurostat LFS.

preliminary evidence, while section 4 describes the econometric strategy and discusses the main results. Section 5 offers some conclusions.

2 Background Literature

A large number of contributions has explored the economic impact of labour market flexibility at both the macro and micro levels. Empirical studies of the association between flexibility and employment dynamics try to figure out the extent to which removing labour market rigidities affects wage determination mechanisms, job search-and-matching processes and productivity dynamics. A large group of comparative analyses has investigated whether similar reforms, aimed at making labour markets more flexible by introducing short term contracts or easing workers entry and exit, have produced differentiated impacts in different socio-economic environments. The works that explicitly addresses the relationship between flexibility and economic performance and, more specifically, innovation dynamics, falls into two main groups. There is a group of international comparative studies based on various indexes, such as the OECD Indicator of Employment Protection Legislation (EPL)[4] and innovation variables (patents, R&D expenditure, productivity growth or product and process innovation). There is another group that provides firm and sector level analyses of the effects of different types of flexible employment on innovation and productivity dynamics. The resulting empirical evidence is not fully conclusive. Indeed, behind such heterogeneous empirical outcomes, different theoretical approaches stand out.

From a neoclassical perspective, rigidities - understood as the combination of open ended contracts, firing restrictions and (too) generous social benefits - can hamper labour market adjustments to shocks hindering the achievement of an optimal equilibrium. Therefore, "stringent layoff regulations increase the cost of firing workers, reducing the productivity threshold at which firms are willing to lay off workers" (Bassanini et al., 2009: p.9). Murphy et al. (2017) further develop the econometric strategy proposed in Bassanini et al. (2009) and focus on the role played by adjustment costs. They claim that firms with a higher propensity for job reallocations demonstrate lower innovation intensity in the presence of stringent labour rules (in particular regulation of temporary employment). If employment subsidies are given, firms hesitate to abandon relatively unproductive opportunities, leading to a fall in the average productivity and aggregate Total Factor Productivity (TFP), as explained by (Lagos, 2006, p.27). Thus, distinct specialization patterns may be linked to labour market rigidity, with low EPL countries specializing in *primary innovation*[5], and high EPL countries focusing on imitative *secondary innovations*[6], which allows them to reduce the risks of paying firing costs (Saint-Paul, 1997, 2002). Several authors, such as Cuñat and Melitz (2012), propose an empirical test of the neoclassical hypothesis about the relationship between labour market institutions and economic performance. They find that countries with relatively more flexible labour markets have comparative advantage in industries with high consumer demand volatility, due to different allocative reactions in the face of micro level shocks. Bartelsman et al. (2008) identify the relatively higher firing costs faced by EU firms as one of the reasons for their weaker innovation performance compared to the US companies, that is, high firing costs are assumed to increase the burden associated to investment failures, thereby reducing the incentive to experiment. Along similar lines, Alesina and Zeira (2006) state that the presence of stricter labour regulations in Europe is a barrier to the achievement of a 'competitive' level of (skill biased) wage inequality and thus direct inefficiently investments on low skill sectors through labour savings technologies, rather than on high skill industries.

The introduction of imperfect information within a neoclassical setting slightly changes the interpretation of the flexibility-innovation relationship. Sticky wages (and eventually rigid firing rules) can improve rather

[4]The EPL measures the level of strictness of labour legislation across countries, in particular, in relation to the cost of dismissing an individual workers or a group of workers employed on various types of contracts. For further details see http://www.oecd.org/els/emp/oecdindicatorsofemploymentprotection.htm

[5]New goods with higher volatility.

[6]Improvement of mature goods with lower levels of volatility and more stable demand.

than weaken productivity dynamics due to their potentially positive correlation to workers' effort (Akerlof and Yellen, 1990; Shapiro and Stiglitz, 1984). In this framework, lower levels of job turnover can increase the value of the job for the worker, favouring loyalty and cooperation, and reducing the risk of moral hazard. Belot et al. (2007) consider the welfare effect of an endogenous level of employment protection and acknowledge the existence of a trade off between flexibility and worker commitment or effort. In approaches that take account of market imperfections, stronger labour laws can help to overcome bounded rationality and coordination problems (Williamson et al., 1975). Storm and Naastepad (2007) point to the importance of regulatory complementarities and observe that as labour flexibility increases, the number of control technologies and supervisory bureaucracies also increases. Riphahn (2004) provides a different interpretation based on a study of German data. The author finds that absenteeism (seen as proxying for workers' effort) is higher in the public than in the private sector. Riphahn explains this difference as due to the stronger protections (against dismissals) characterizing public sector employees. Ichino and Riphahn (2005) extend this finding in an analysis of white collars employees of a large Italian bank. They find that the incidence of absenteeism is more than doubled after workers were granted of protection from dismissal. The relation between job tenure and turnover, on the one side, and innovation, on the other, is important also within an endogenous growth theoretical framework (Acemoglu, 1997). In this setting, human capital and technological change are key drivers of growth. Wasmer (2006) explains that, in a context of equilibrium, stricter EPL, which would suggest more stable employment relationships, could increase the accumulation of workers' skills and have a positive feedback on innovation dynamics. Accordingly, too frequent job turnover can weaken firm-specific human capital accumulation and have a negative impact on firm productivity and innovation (Acharya et al., 2010). In line with this, many researchers agree that employees with temporary contracts are less involved than permanent employees in firm-specific training (Arulampalam and Booth, 1998), since longer work relationships encourage employers to provide training (Booth et al., 2002). Weaker firm-specific human capital accumulation in turn might have a negative impact on firm productivity and innovation.

Theoretical and empirical analyses that adopt an evolutionary approach (Nelson and Winter, 1982) provide a different perspective. In this framework, workers are key actors in the development of the firm's knowledge base and capabilities. By accumulating process-specific experience and (over time) refining their ability to perform tasks and solve problems, workers contribute to the build-up of their company's capabilities. This constitutes the 'learning process' described by several authors (Freeman, 1989; Nelson, 1993; Lundvall, 1992), which is considered one of the crucial elements driving economic and technological change. Using a panel of Italian firms to test how labour market flexibility affects within-firm learning processes, Lucidi and Kleinknecht (2009) argue that the accumulation of firm-specific knowledge and the adoption of innovation-based competitive strategies are hampered by the presence of highly flexible labour. The authors find that the use of flexible personnel is associated with strategies based on cost reductions, and reduces productivity growth. This applies particularly to firms characterized by a Schumpeter-Mark II routinized regime (Kleinknecht and Naastepad, 2005; Kleinknecht et al., 2014), where the accumulation of tacit knowledge is essential for product and process innovation. Similarly, Kleinknecht and Naastepad (2005) find that rising levels of turnover, enabled by temporary contracts and weak firing restrictions, have a negative effect on cohesion and trust while increasing moral hazard and opportunistic behaviour. In a study focusing on institutional heterogeneities (Estevez-Abe et al., 2001), Kleinknecht and Naastepad (2005) highlight that the Anglo Saxon system, characterized traditionally by more flexible labour markets, outperforms the Rhineland model, which is characterized by more 'rigid' labour markets, in terms of job creation, but achieves weaker productivity growth.[7] Greater labour flexibility, associated to a relatively higher probability of being fired is likely to reduce workers' propensity to share their know-how with colleagues, thereby impeding the development of firm-specific knowledge base (Kleinknecht and Naastepad, 2005). At the same time, a higher risk of being fired might encourage workers to disclose firm-specific knowledge to competitors. This

[7]This kind of comparison is proposed also in the studies based on the 'Varieties of capitalisms' approach (Hall and Soskice, 2001).

can lead to a vicious circle in which employers exclude workers from decisions involving strategic information and workers reduce efforts to contribute to firm-specific knowledge accumulation. In addition, labour market flexibility can affect capital-labour relations. The introduction of a greater flexibility might reduce the relative bargaining power of labour due to the employment risk implied by the reduced protections against layoffs or the spread of temporary contracts. In this case, workers will be disinclined to criticize or disagree with managers, which could lead to bad management practices and damage to collective learning. Dosi et al. (1988) underlines the importance of collective learning in technologies where firms' dynamic capabilities depend also on the ability to react to the environment. Cooperation between employers and employees, and the latter's active contribution to knowledge accumulation are crucial for a firm's adaptation and resilience to external shocks. In this sense, the dynamic interplay between workers and organizational practices within firms is addressed in Lazonick's description of the "innovative enterprise" (Lazonick, 2005).[8] More recently, the notion of employee driven innovation has been proposed. This refers to innovation promoted by "multi skilling employees", performing job rotation schemes defined as High Performance Work Systems (HPWS) (Leoni, 2012). In this setting, compared to a human capital framework, workers are not just a production factor; they are a source of creativity (Amabile, 1988). Supporting this proposal, several empirical works show that practices related to the functional flexibility of employees (autonomy, team working, quality circles, suggestion schemes, etc.) are related positively to organizational innovativeness (Michie and Sheehan, 2003; Kleinknecht et al., 2009), but do not complement numerical flexibility, given the potential conflict among different types of workers (Arvanitis, 2005). Interestingly, this result is acknowledged also by authors who detect a negative effect of EPL, such as Scarpetta et al. (2002).

Another strand of literature, that is in line with the approach of this paper, consists of empirical studies of the relationship between numerical flexibility and innovation using temporary contracts to proxy for labour flexibility. Overall, the effect of temporary contracts on innovation and productivity depends on the reason for their use (Arvanitis, 2005). Some scholars observe the presence of non-linear consequences of short term contracts according to their relative contractual weight in the total workforce employed in the unit under scrutiny (Altuzarra and Serrano, 2010; Hirsch and Mueller, 2012). Others highlight a persistent deterrent impact of temporary employment on innovation dynamics. In a recent study of Italian firms, Franceschi and Mariani (2015) show that innovation - measured both by the probability of submitting an annual patent application and by the number of applications per year - decreases when the share of temporary worker rises. This result is explained as firms' short term maximization behaviour. A similar result is found by Lucidi and Kleinknecht (2009), where innovation is taken as a hidden determinant of productivity. Overall, the literature investigating the relationship between innovation and labour flexibility is at an early stage, but one stylized fact can be defined: the magnitude and direction of the flexibility-innovation nexus depends strongly upon the firm's and industry's technological characteristics and technological regimes. Kleinknecht and Naastepad (2005) pioneered these analyses, focusing mostly on firms and adopting a 'Schumpeterian' approach. Kleinknecht and Naastepad (2005), Kleinknecht et al. (2014) and Wachsen and Blind (2016) find that the impact of labour market flexibility impacts differs according to whether the prevalent technological regime is Schumpeter Mark I or Mark II (see above). In the first case, innovation tends to be disruptive and accumulated firm-specific knowledge is less relevant. In the case of Schumpeter Mark II, historically accumulated firm specific (and tacit) knowledge is crucial. In the context of the introduction of product innovations (the type mostly associated to Schumpeter Mark II regimes), workers' creativity based on their on-the-job specific experience is key to the process of technological change. In such environments, Kleinknecht et al. (2009) argue that enduring labour relationships, trust and cooperation between employers and employees, are fundamental ingredients to increase firms' innovative performance. These

[8] We need to distinguish between functional flexibility and numerical and wage flexibility. The former is based on the possibility for workers to assume different roles and responsibilities within the same firm (for a seminal distinction see Beatson, 1995). This internal mobility can facilitate cooperation, increase workers' motivation and engender trust. In a context of incomplete contracts and bounded rationality, employees' participation can facilitate the solution of problems and promote a trial error learning process (Lorenz, 1999).

arguments are significantly in line with the hypotheses made in in the efficiency wage literature (Akerlof and Yellen, 1990). Looking at workers' productivity, the efficiency wage theory hypothesizes that workers' effort is correlated positively to wage levels. Therefore, paying higher than the market-clearing wage will benefit both parties (i.e., both firms and workers) through a productivity-enhancing effect. Overall, work environments protecting workers from uncertainty about job duration and wage levels, and promoting trust and cooperation in the workplace, are expected to push product innovation, particularly in organizations that rely on the accumulation of firm-specific knowledge. Few contributions have explored this linkage at the industry level. Trying to fill this gap, we explore the flexibility-product innovation nexus examining manufacturing and services industries in the five major EU economies (France, Germany, Italy, Spain and the Netherlands). We contribute to the literature in various ways: i) we test whether sectors characterized by relatively higher degrees of flexibility display a different innovation dynamics from that observed in other industries; ii) we check the extent to which the relationships emerging at the aggregate level change when we control for an industry's technological intensity (medium-high vs low tech industries classified according to the Peneder taxonomy) and innovation regimes (Schumpeter Mark I vs Mark II industries classified according to Kleinknecht et al. (2014)'s taxonomy; iii) using the OECD's EPL index, we investigate how country-level heterogeneities interact with sectoral technological characteristics in shaping the relations under investigation.

3 Data, main variables and descriptive evidence

3.1 Sources and main variables

The empirical analysis builds upon a set of independent data sources. Information on economic performance - stemming from the World Input Output Database (WIOD) - are merged with information on innovation dynamics - drawn from four rounds of the Community Innovation Survey (CIS) - and on temporary employment - Labour Force Survey (LFS) database. The analysis focuses on 21 manufacturing and 17 service industries - 2-digit NACE Rev.1 classification - observed in France, Germany, Italy, the Netherlands and Spain over the period 1998-2012.[9] The main variables used in this analysis are reported in Table 1. Industries' innovation output is proxied by the share of firms introducing new products[10]; while R&D expenditure per employee proxies the innovative input. The use of temporary contracts is captured by the share of temporary employees over total (sectoral) employment - this variable is computed for the whole sectoral workforce and separately for young employees (15-34).[11] In addition, we include a variable reporting the sectoral average firm size accounting for industries' market structure and the change in value added capturing economic dynamics. Furthermore, we consider technological intensity of sectors by including, alternatively, the knowledge "cumulativeness" indicator stemming from the Peneder's classification and the Herfindahl-Hirschman index built on firm/sectoral intangible assets intensity.[12] Regarding labour market institutions, the OECD's Employment Protection Index for each considered country is also included. Finally, a set of country dummies is plugged in to control for country-level heterogeneity. [13]

[9]To enable comparison, the innovation and employment variables taken respectively from CIS6 and LFS were converted into Nace Rev.1 using the conversion matrix proposed in Perani and Cirillo (2015).

[10]According to CIS metadata, "Product innovative enterprises" are those who introduced new or significantly improved goods and/or services with respect to their capabilities, user friendliness, components or sub-systems. Changes of a solely aesthetic nature and the simple resale of new goods and services purchased from other enterprises are not considered as innovation.

[11]Note that the Eurostat definition of temporary contracts refers to employees on temporary contracts "that declare themselves as having a fixed term employment contract or a job which will terminate if certain objective criteria are met, such as completion of an assignment or return of the employee who was temporarily replaced". Lisi and Malo (2017) emphasize that the Eurostat definition of temporary employment does not allow to distinguish between fixed-term contracts and temporary agency workers.

[12]The Herfindahl-Hirschman index is built using AMADEUS firm-level data.

[13]Descriptive statistics for the main variables are provided in the Appendix - see Table 5.

Table 1: Main variables

Variable	Description	Unit	Source	Period covered
New products	Share of firms introducing a product new to them and to the market	Share	CIS	1998-2012
New products and processes	Share of firms introducing products and processes new to them and to the market	Share	CIS	1998-2012
R&D	Sectoral R&D expenditure per employee	Thousands euro per employee	CIS	1998-2012
Firm size	Average number of employees in firms	Absolute value	CIS	1998-2012
Value added	Sectoral value added	Compound rate of change	WIOD	2000-2012
Share of temporary employees	Share of temporary employees over total employees	Share	LFS	2002-2010
Share of temporary employees (15-34 years)	Share of temporary employees (15-34) over total employees	Share	LFS	2002-2010
Herfindahl index	Herfindahl index on firm value intangible assets	Index	AMADEUS	2002-2010
Peneder classification	Low, Med, High *Cumulativeness*	Categorical variable	?	time invariant

3.2 Technological heterogeneity of sectors: the Herfindahl-Hirschman index and the Peneder taxonomy

The relationship between technological change and temporary employment might not be homogeneous across sectors. Indeed, sectors display strong differences with respect not only to their production process and technological characteristics but also concerning the skill level of the workforce. In this article, we build on Kleinknecht et al. (2014)'s distinction between two different models of knowledge accumulation and innovation at the sectoral level. We distinguish between an 'entrepreneurial' (or garage business) and a 'routinized' model of innovation characterized by a differentiated role of internal knowledge as an innovation input. The two models are respectively defined Schumpeter Mark I and Schumpeter Mark II (Kleinknecht and Naastepad, 2005, p.2). The Schumpeter Mark I model or "garage business innovation" includes starters in high-tech, niche players in contexts of turbulent competition, and creative destruction; the "routinized innovation" model, or Schumpeter Mark II, includes mature firms with professional R&D laboratories often working in contexts of monopolistic competition or oligopolies where a stable hierarchy of dominant innovators persists. The two regimes are characterised also by different knowledge accumulation processes: in Schumpeter Mark I, general and easily available knowledge is pivotal to support innovation; in Schumpeter Mark II - featured by high barriers to competitors -, innovation-related knowledge is firm-specific, accumulated over time and idiosyncratic due to its linkage with workers and entrepreneurs' experience. These two technological regimes are associated with different types of labour market institutions: Schumpeter Mark I industries are more likely to hire from the external labour markets, while Schumpeter Mark II industries rely mostly on internal labour markets where insiders are well-protected. Such heterogeneity is linked to the differentiated role played by internal knowledge. In the Schumpeter Mark I case, the scarce relevance of tacit and firm-specific knowledge accumulation matches with a high turnover rate and a widespread use of temporary employment. In the Schumpeter Mark II case, where internally accumulated knowledge is crucial to develop new products and processes, industries rely mostly on internal labour markets where insiders are well-protected. To identify such heterogeneity in technological regimes we adopt to different strategies: first, we build an index capturing the degree of concentration of intangible assets (Herfindahl-Hirschman index); second, we rely on the Peneder's indicator of knowledge "cumulativeness". To build the Herfindahl-Hirschman index, we rely on firm-level information from the AMADEUS database reporting information on intangible assets for 21 million companies across Europe. Comparability of enterprises is ensured by national industry codes. Intangible assets in the AMADEUS dataset include operational assets that lack physical substance, such as patents, copyrights, trademarks, franchises and goodwill. As a result, this measure of concentration might work as a valuable proxy to distinguish industries between Schumpeter Mark I and Mark II's regimes.

The Herfindal-Hirschman indicator is computed as follows. Every industry receives a value on a continuous scale between 0 (perfect dispersion of intangible assets) and 1 (perfect concentration of intangible assets). Values closer to zero indicate a Schumpeter Mark I garage business model while values closer to 1 indicate a Schumpeter Mark II model. In order to check the consistency of the measures adopted, Table 6 in the Appendix reports the ranking of sectors according to the highest concentration score in intangible assets. The concentration index is strongly correlated - at the 5% significance level - with the share of firms introducing both product and process

innovations (0.21*) and exclusively product innovations (0.22*), but is not significantly correlated (0.07) to the amount of R&D expenditure per employee. As expected, the degree of concentration of intangible assets is higher in larger firms.

As argued, the second measure adopted to capture sectors' heterogeneity in terms of (innovation-related) knowledge intensity relies on the Peneder (2010)'s classification. The Peneder's classification characterizes sectors according to the following four dimensions: 'creative' and 'adaptive response' to technological changes, technological opportunities, appropriability conditions and cumulativeness of knowledge. More specifically, sectors are ranked according to the prevailing behaviour of firms in terms of creative versus adaptive knowledge generation, intramural R&D versus external acquisition of R&D, appropriability conditions such as patents and other formal and strategic protection methods and cumulativeness of knowledge. For the so-called creative firms, internal sources of innovation (and knowledge) are more important than external sources, while in adaptive firms, external sources prevail. [14] In this analysis, we classify sectors focusing on the relative importance of internal knowledge as a driver of innovation. Relying on the 'degree of cumulativeness' as defined by Peneder (2010), we introduce a categorical variable assuming value 1 if sectors display 'high-cumulativeness', 2 in the case of 'medium-cumulativeness' and 3 in the case of 'low-cumulativeness'. Such ranking refers to the (relative) ability of firms and industries in creating new knowledge and generating innovations relying on their historically accumulated knowledge stock (Peneder, 2010). Therefore, high-cumulativeness industries are expected to more intensively rely on their existing knowledge-stock and to benefit more from increasing returns to knowledge creation as compared to medium and low-cumulativeness ones. (Marlerba and Orsenigo, 1993). The ranking of sectors in terms of innovation expenditure, share of firms declaring to introduce product or process innovations and the cumulativeness criteria stemming from the Peneder's taxonomy is shown in figure 1. The detailed list of sectors according to the Peneder's "cumulativeness" criteria is presented in Appendix table 7 .

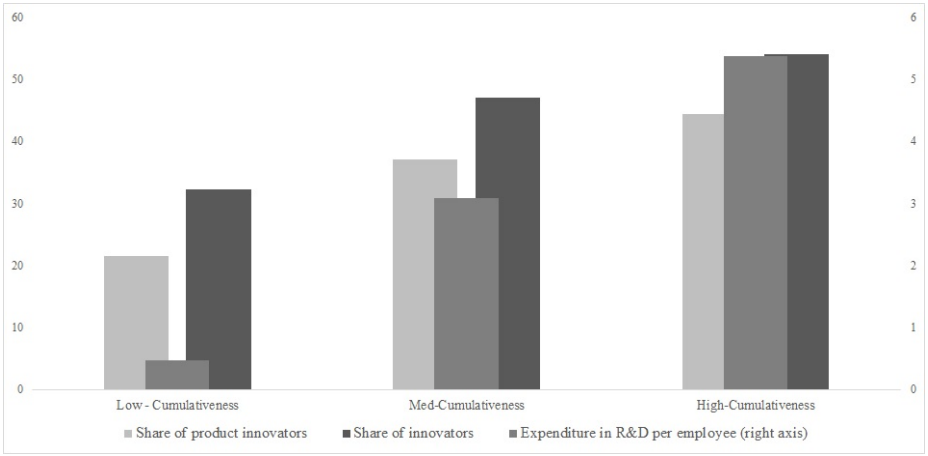

Figure 1: Share of product innovators, innovators and expenditure in R&D by "Cumulativeness"

As figure 1 shows, sectors classified as 'high-cumulativeness' are characterized by a relatively higher shares of firms declaring to introduce product and product and process innovations. Similarly, the (average) R&D expenditure per employee is higher in high-cumulativeness sectors as opposed to med and low-cumulativeness

[14]The Peneder (2010)'s measure of cumulativeness is based on two CIS questions: the first regarding the relative importance of internal versus external sources of information; the second classifies firms depending on whether the firm appears to be a technological leader or follower. Therefore, high-cumulativeness sectors are those ones where firms are classified as "creative" in terms of technology development and internal sources of knowledge are important as well as external sources. High-cumulativeness sectors are also those where "adaptive firms" - namely firms adopting technology from outside - acquire knowledge from external sources. Conversely, sectors are classified as low-cumulativeness if creative firms relying on external sources of information prevail, or if adaptive firms relying equally on internal and external sources of information dominates. The main idea is that if knowledge is highly cumulative, creative firms closer to the technological frontier will more "heavily rely on their own sources of information. Conversely, adaptive firms - more distant from the technological frontier - will have to acquire knowledge for their innovation activities from external sources" (Peneder, 2010, p. 327)

ones.[15]

3.3 Descriptive evidence

In what follows, we provide a preliminary description of our main variables focusing on the relationship between the share of temporary employees and industries' technological intensity - proxied by both the Peneder classification (cumulativeness of knowledge) and the Herfindahl index. Figure 2 highlights the heterogeneity in the distribution of temporary contracts across countries and sectors, along two dimensions. The first concerns country-level differences which are likely to reflect heterogeneities in terms of institutional setting.[16] The second dimension relates to technological heterogeneity classifying industries according to the Peneder (2010)'s classification illustrated above - low, med and high "cumulativeness" sectors. In almost all countries, a sort of polarization emerges- except for the Netherlands- with high shares of temporary employment in both high and low "cumulativeness" sectors. This evidence might be explained pointing to two distinct 'types' of external flexibility. The first type may characterize high-tech sectors employing significant shares of high-skill workers (often having managerial positions) likely to have temporary contracts due to frequent carrer-upgrading related job turnover. The second type refers to organization prevalently employing low-skilled workers exposed to intense turnover due to high substitutability of their skills. This polarization in terms of 'types of flexibility' is quite evident in Germany, France and Italy. In Germany, however, the share of temporary jobs in high "cumulativeness" sectors is high as much as the share of temporary jobs in low "cumulativeness" sectors, while the reverse applies to Spain and the Netherlands, where the share of employees on short-term contracts is higher in low "cumulativeness" industries. The coexistence of these two typologies of temporary employment (2) opens the debate on the differentiated effects of "precariousness" on innovation when industries structural and technological heterogeneities are explicitly accounted for. This descriptive outcome is attributable to different reasons, some of which are related to country specificities, and others to the different types of temporary contracts observable in advanced sectors, where a degree of labour mobility may be related to workers' professional decisions rather than being the result of the firm's strategy to reduce labour costs.

Figure 3 depicts the relationship between temporary employment and new products. The scatter plot distinguishes between countries and macro-sectors according to the Peneder classification (cumulativeness dimension), and distinguishes the degree of concentration of intangible assets expressed by the Herfindahl index, proxied by the size of the bubbles. We observe a generally negative relationship between the two variables. In particular, high and medium-cumulativeness sectors show, on average, a relatively higher share of product innovating firms and a relatively lower share of temporary jobs - this is particularly true in Germany and the Netherlands. In Spain, in turn, the country-level effect seems to prevail given the significant share of temporary employees even in high and medium-high cumulativeness sectors. Overall, industries located in Central-Northern Europe - Germany, France and the Netherlands - have a significantly larger share of product innovators, while Southern European industries - in Spain and Italy - have a higher number of temporary contracts. The average share of temporary contracts is, respectively, 11.12% and 16.25%.

The geographical heterogeneity emerged so far is in line with the evidence reported in Celi et al. (2017). The relative weight of temporary contracts is higher in the South than in Central-Northern Europe. Taken together, this evidence sheds lights on the structural divergence between these areas in relation to both innovativeness and labour market configuration. The econometric analysis that follows aims explaining whether differences in terms of labour market characteristics - i.e. relative intensity in the use of flexible contracts - are and to what

[15] Note that, in this paper, we cluster sectors according to their technological features provided by the Schumpeter and Peneder characterizations (cumulativeness criteria). Thus, our approach differs from Lisi and Malo (2017) where sectors are ranked on the basis of technology-related employees' characteristics - such as the share of workers with a tertiary education or the share of workers engaged in science and technology tasks.

[16] For instance, Spain has the highest shares of temporary employment - almost double that in Germany, France, Italy and the Netherlands. This holds for all Spanish sectors and is probably due to the deep and generalized labor market 'flexibilization' recently put forth in that country.

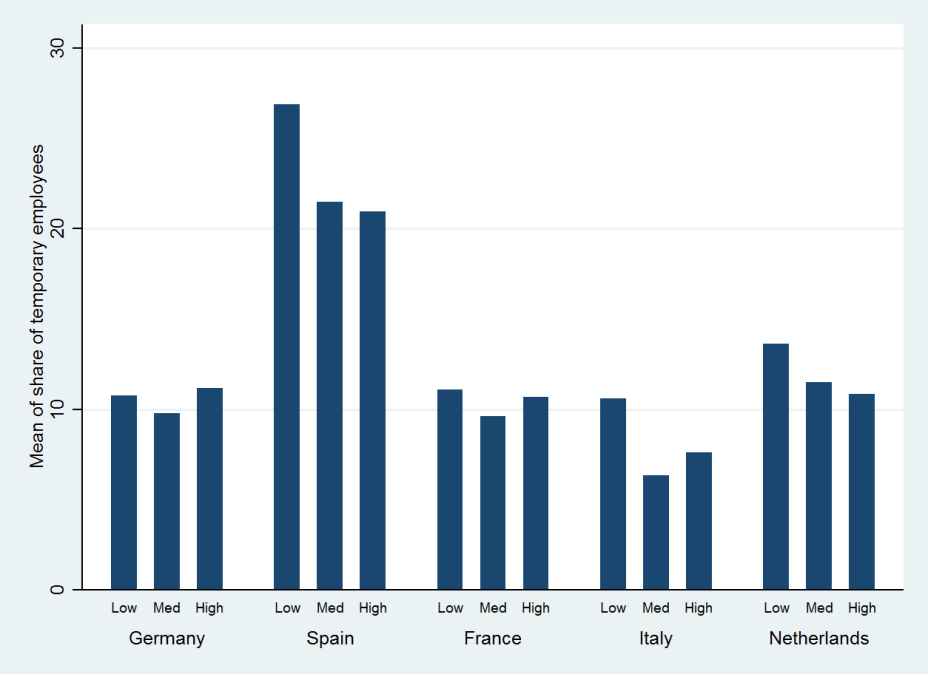

Figure 2: Temporary employment by cumulativeness regimes of sectors and countries

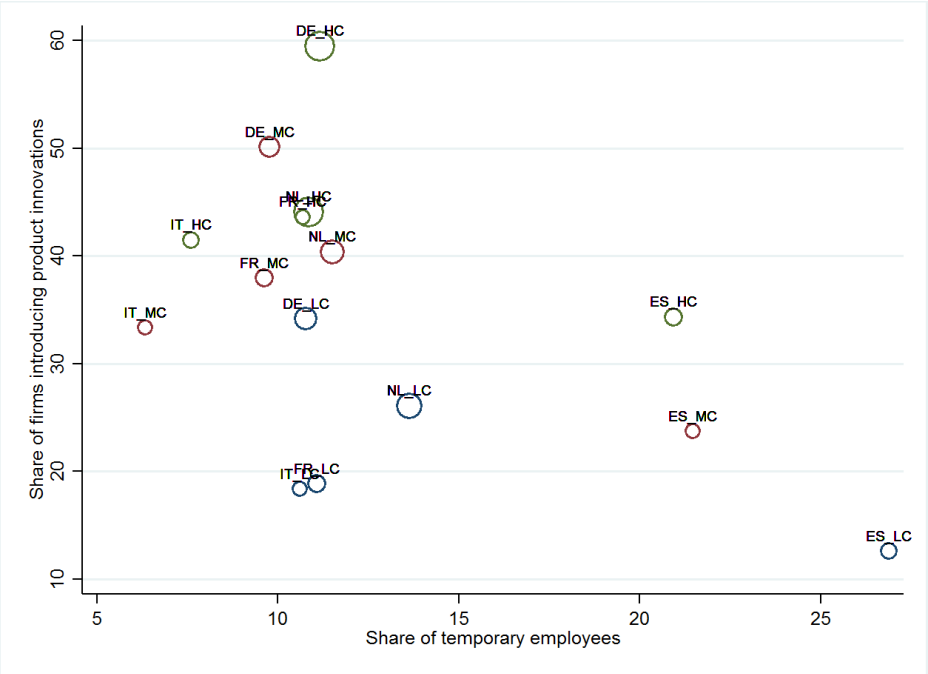

Figure 3: Temporary employment and product innovators by concentration of intangible assets
Note: the diameter of the circles relates to the value of the Herfindal-Hirschmann index on intangible assets while the labels refer to the country-Peneder cumulativeness indicator pairs (LC=low cumulativeness, MC=medium cumulativeness and HC=high cumulativeness)

extent behind the (observed) divergent innovative performance of European industries.

4 Econometric strategy and results

4.1 Empirical strategy

The aim of this work is to investigate, empirically, the relationship between the introduction of new products and the share of temporary jobs accounting explicitly for industries' technological and institutional heterogeneities. Formally, the relationship between innovation and temporary employment can be written as follows:

$$ShareofProdInnov_{ijt} = b_0 + b_1\,\text{ShareTemp}_{ijt} + b_2\,\text{Tech}_{ijt} + b_3\,\text{ShareTemp}_{ijt} * \text{Tech}_{ijt} + b_4\,\text{X}_{ijt} + b_5\,\text{Z}_{ijt} + b_6\,\text{EPL}_{jt} + \epsilon_{ijt} \quad (1)$$

where the share of firms introducing product innovations $ShareofProdinnov_{ijt}$ in sector i at time t in country j is regressed against the share of employees with temporary contracts $ShareTemp_{ijt}$, the share of employees with University degree $\boldsymbol{X}_{ijt}$, a set of industry-level controls $\text{Z}_i jt$ (value added growth, lagged expenditure per employee in R&D) and an 'institutional variable' - the EPL (*Employment Protection Index*) - varying only by country and over time. In order to consider explicitly the heterogeneity of sectoral patterns, we introduce a proxy for technological intensity $Tech_{jit}$ using, alternatively, a dummy reflecting the cumulativeness regime of sectors based on the Peneder (2010)'s taxonomy - low, med, and high-cumulativeness; and a continuous variable reporting the value of the Herfindahl index built on firms' intangible assets data. To identify the impact of industries' technological heterogeneity on the temporary employment-new products relationship we test two distinct specification in which our technological indicators - i.e. the Peneder-based and the Herfindal-Hirschman index - are interacted with the share of temporary jobs. In this way, we can test whether magnitude and direction of the investigated relationship change according to sectoral technological peculiarities.

The time structure of the empirical model is the following. We rely on long lags (3 years) to reduce variables' autoregressive character as well as to control for time/sectoral fixed effects. To soften potential endogeneity problems, we use all regressors at their first lag; in the case of variables expressed in shares, we use the first year of the period. Thus, risk of simultaneity-related endogeneity is reduced considerably and the consistency of the estimation is strengthened. The panel has the following periodization. Innovation variables are drawn from four CIS waves: CIS 3 (1998-2000), CIS 4 (2002-2004), CIS 6 (2006-2008) and CIS 8 (2010-2012); the economic variables are computed (compound average annual rates of variation) for the periods 2000-2002, 2004-2006 and 2008-2010; data on labour contracts (share of temporary employees) and share of workers with a university degree refer to the periods 2002, 2006 and 2010.[17] All the economic variables are deflated using the sector-specific value added deflator from WIOD (base year 2000), corrected for purchasing power parities (using the index provided in Stapel et al. (2004)). Following Guarascio et al. (2015) and Cirillo (2016), we compute compound annual growth rates to approximate the difference in log, for all the economics variables.

4.2 Results

Table 2 reports the results of Model 1's different specifications. In almost all the reported regressions, the coefficient associated to the share of temporary workers is negative and significant[18], suggesting that - on average and holding other factors constant - industries displaying a relatively higher share of temporary jobs

[17] We end up with a three-period time structure. The share of product innovators observed in 2002-2004, 2006-2008 and 2010-2012 is regressed on the share of temporary employment registered in 2002, 2006 and 2010. The other controls (average firm size, expenditure in R&D by employee, sectoral change in value added) are included into the model according to the following periods: 1998-2000, 2002-2004, 2006-2008 for technological variables, 2000-2002, 2004-2006 and 2008-2010 for value added.

[18] It loses its significance in regression (5), where we introduce the interaction term with the Peneder technological dummy and in regression (7) where we introduce a dummy for Southern Europe.

are characterized by a comparatively lower share of firms introducing new products. Turning to the impact of labor market 'rigidities' - regression (2) of table 2 -, it turns out that the EPL variable is always positive and significant, pointing to the presence of a positive correlation between the degree of labour protection and the introduction of new products. In regressions (3) and (4) of Table 2 we explicit technological regimes, using respectively the Peneder (2010)' cumulativeness classification and the Herfindahl index.[19] In the first case (3), we observe that the estimated coefficients of both values (medium and high-cumulativeness) are significant and positive. This suggests that creative sectors, are comparatively more intensive in terms of product innovation as opposed to low-cumulativeness ones where internal knowledge has a marginal role. A similar outcome is obtained in regression (4), where we use the Herfindahl index. Also in this case, we find a positive and significant coefficient. This suggests that as concentration of intangible assets increases, the probability of introducing new products rises as well. These results are in line with our previous reasoning on the role of knowledge and technological regimes. As a further step, we investigate the potential presence of a differentiated impact of temporary employment according to sectors' technological regimes. This is done interacting, alternatively, the share of temporary workers with both Peneder (2010)'s variable categories (medium and high-cumulativeness) as well as with the Herfindal-Hirschman indicator of intangible assets intensity. We obtain different results. In the case of regression (5), including the Peneder dummy for medium and high level of cumulativeness, there are no statistically significant interactions; also in regression (6), where we consider the Herfindal index, the coefficient of the interaction term is negative but statically insignificant. However, the interaction between share of temporary employees and the high-cumulativeness category is negative and significant. This seems to suggest that a relatively intense use of temporary work is associated with a weak dynamics of product innovation even in creative sectors where internal knowledge and organisational routines are crucial for the development of new products and processes. Looking at the other controls, we observe that the coefficient of R&D expenditure is always positive and significant, consistently with standard theories according to which R&D is a key input for marketable innovation. In relation to the role of skills, we find that the coefficient of the share of highly educated workers is positive and significant in four out of eight specifications (columns 2, 4, 6 and 8), confirming the strong correlation between (high) skills and innovation.

Table 3 presents the same model with the focus switched on young temporary workers (15-34 years old). We choose the 15-34 years cohort since the latter has been the most affected by the spreading of temporary employment in Europe (Cirillo et al., 2017). This variable is computed as the ratio between the share of young workers with a temporary contract over the total 15-34 employment at the sectoral level, representing a measure of the degree of flexibility among young workers. The coefficient of the share of temporary employment is always negative and generally (apart from regressions (5) and (7)) significantly different from zero. The coefficient of EPL is positive and significantly different from zero confirming the whole sample model results. The medium and high-cumulativeness categories are always positive and statistically different from zero, as already emerged in table 2. Concerning the interaction terms, we obtain a result similar to the one observed previously. Indeed, all coefficients are negative and when we interact the share of temporary employment with the high cumulativeness dummy, the coefficient is again statistically significant.

Table 4 presents the results using a more general measure of innovation as dependent variable: the shares of firms declaring to have introduced both a product and a process innovation. We performed this further set of regressions to check whether our results are 'product innovation specific' or contrarily apply also to process innovation. Our main findings are supported. The coefficient associated to temporary workers is always negative and almost always significantly different from zero; the coefficients of both intangible assets concentration and cumulativeness levels are positive and significantly different from zero, as well as the interaction term of temporary employment with high cumulativeness Peneder index. Appendix Table 8 and Table 9 reports the results controlling for the institutional setting of different countries, weighting the share of temporary

[19] As explained, the Peneder (2010)'s is a categorical variable thus the coefficients associated to the high and low-cumulativeness modality are interpreted in relation to the omitted one (low-cumulativeness).

employment by the EPL index. Our objective is to consider the specific case of Spain, where the overall index is already low[20]. In this case, the share of temporary workers does not fully capture the concentration of precarious jobs. The weighted procedure allows us to partly control potential bias. Even in this case, we obtain similar and even stronger results for all the main variables investigated.

[20]The case of Spain is counter-intuitive since the country experienced the highest level of short term contracts from eighties. With the Workers' Charter reform in 1984, that essentially allowed the use of temporary contract for any kind of job and without specific constraints, the demand of temporary jobs significantly rose well before the other countries and remained high.

Table 2: Share of temporary employees and innovation (I)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share of firms introducing product innovations							
Average firm size (lagged)	-2.122	-1.585	-2.680	-3.354	-2.608	-3.738	-2.876	-3.748
	(-1.18)	(-0.84)	(-1.17)	(-1.61)	(-1.14)	(-1.73)	(-1.20)	(-1.72)
Expenditure in R&D per employee (lagged)	2.203***	2.087***	1.793***	2.044***	1.665***	2.029***	1.574***	2.025***
	(8.69)	(8.83)	(7.36)	(8.86)	(6.79)	(8.82)	(5.91)	(8.45)
Rate of change of Value Added	0.0554	-0.108	-0.0886	-0.0943	-0.0868	-0.0815	-0.0743	-0.0806
	(0.35)	(-0.71)	(-0.57)	(-0.57)	(-0.55)	(-0.50)	(-0.48)	(-0.49)
Share of workers with tertiary education	0.119	0.189**	0.0375	0.177**	0.0657	0.185**	0.0255	0.183**
	(1.81)	(2.92)	(0.50)	(2.65)	(0.90)	(2.80)	(0.35)	(2.81)
Share of workers with temporary contracts	-0.908***	-0.761***	-0.638***	-0.779***	-0.206	-0.615**	-0.154	-0.613**
	(-6.02)	(-5.41)	(-4.16)	(-5.40)	(-1.35)	(-2.98)	(-1.02)	(-2.97)
Employment Protection Index		16.87***	15.84***	13.23***	16.06***	13.69***	13.91***	13.57***
		(5.36)	(5.37)	(3.85)	(5.76)	(3.99)	(4.74)	(3.83)
Med Cumulativeness			7.813***		14.21**		14.55***	
			(3.55)		(3.18)		(3.35)	
High Cumulativeness			10.57***		22.98***		23.94***	
			(3.85)		(4.78)		(4.98)	
Herfindahl index				11.23**		18.34*		18.31*
				(2.67)		(2.19)		(2.18)
Med Cumulativeness*Share temporary employment					-0.483		-0.478	
					(-1.84)		(-1.86)	
High Cumulativeness*Share temporary employment					-1.012***		-1.019***	
					(-3.84)		(-3.87)	
Herfindahl index*Share of temporary employees						-0.668		-0.667
						(-1.08)		(-1.08)
Southern Europe							-3.044	-0.182
							(-1.43)	(-0.08)
2006	7.816**	4.615	5.259*	4.741	5.476*	4.410	5.827*	4.426
	(2.77)	(1.71)	(2.00)	(1.75)	(2.12)	(1.63)	(2.34)	(1.66)
2008	-0.620	-4.340	-2.807	-4.419	-2.727	-4.691	-2.392	-4.679
	(-0.22)	(-1.58)	(-1.01)	(-1.53)	(-0.99)	(-1.62)	(-0.92)	(-1.64)
Constant	33.33***	23.17***	20.17***	23.35***	13.90***	21.51***	16.15***	21.66***
	(10.57)	(6.73)	(5.69)	(6.84)	(3.73)	(5.72)	(3.79)	(4.92)
N	376	376	376	358	376	358	376	358

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Table 3: Share of temporary employees and innovation (II)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share of firms introducing product innovations							
Average firm size (lagged)	-2.122	-1.585	-2.680	-3.354	-2.608	-3.738	-2.876	-3.748
	(-1.18)	(-0.84)	(-1.17)	(-1.61)	(-1.14)	(-1.73)	(-1.20)	(-1.72)
Expenditure in R&D per employee (lagged)	2.203***	2.087***	1.793***	2.044***	1.665***	2.029***	1.574***	2.025***
	(8.69)	(8.83)	(7.36)	(8.86)	(6.79)	(8.82)	(5.91)	(8.45)
Rate of change of Value Added	0.0554	-0.108	-0.0886	-0.0943	-0.0868	-0.0815	-0.0743	-0.0806
	(0.35)	(-0.71)	(-0.57)	(-0.57)	(-0.55)	(-0.50)	(-0.48)	(-0.49)
Share of workers with tertiary education	0.119	0.189**	0.0375	0.177**	0.0657	0.185**	0.0255	0.183**
	(1.81)	(2.92)	(0.50)	(2.65)	(0.90)	(2.80)	(0.35)	(2.81)
Share of workers with temporary contracts	-0.908***	-0.761***	-0.638***	-0.779***	-0.206	-0.615**	-0.154	-0.613**
	(-6.02)	(-5.41)	(-4.16)	(-5.40)	(-1.35)	(-2.98)	(-1.02)	(-2.97)
Employment Protection Index		16.87***	15.84***	13.23***	16.06***	13.69***	13.91***	13.57***
		(5.36)	(5.37)	(3.85)	(5.76)	(3.99)	(4.74)	(3.83)
Med cumulativeness			7.813***		14.21**		14.55***	
			(3.55)		(3.18)		(3.35)	
High cumulativeness			10.57***		22.98***		23.94***	
			(3.85)		(4.78)		(4.98)	
Herfindahl index				11.23**		18.34*		18.31*
				(2.67)		(2.19)		(2.18)
Med Cumulativeness*Share temporary employment					-0.483		-0.478	
					(-1.84)		(-1.86)	
High Cumulativeness*Share temporary employment					-1.012***		-1.019***	
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Herfindahl index*Share of temporary employees						-0.668		-0.667
						(-1.08)		(-1.08)
Southern Europe							-3.044	-0.182
							(-1.43)	(-0.08)
2006	7.816**	4.615	5.259*	4.741	5.476*	4.410	5.827*	4.426
	(2.77)	(1.71)	(2.00)	(1.75)	(2.12)	(1.63)	(2.34)	(1.66)
2008	-0.620	-4.340	-2.807	-4.419	-2.727	-4.691	-2.392	-4.679
	(-0.22)	(-1.58)	(-1.01)	(-1.53)	(-0.99)	(-1.62)	(-0.92)	(-1.64)
Constant	33.33***	23.17***	20.17***	23.35***	13.90***	21.51***	16.15***	21.66***
	(10.57)	(6.73)	(5.69)	(6.84)	(3.73)	(5.72)	(3.79)	(4.92)
N	376	376	376	358	376	358	376	358

t statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001

Table 4: Share of temporary employees and innovation (III)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Share of firms introducing product innovations							
Average firm size (lagged)	-1.278	-0.342	-1.313	-1.631	-1.165	-2.062	-1.475	-2.113
	(-0.81)	(-0.24)	(-0.75)	(-1.00)	(-0.68)	(-1.21)	(-0.81)	(-1.22)
Expenditure in R&D per employee (lagged)	2.060***	1.854***	1.605***	1.856***	1.490***	1.838***	1.384***	1.819***
	(7.59)	(9.27)	(7.66)	(9.11)	(7.44)	(9.02)	(6.22)	(8.45)
Rate of change of Value Added	-0.0406	-0.304*	-0.279	-0.275	-0.272	-0.262	-0.259	-0.258
	(-0.24)	(-2.05)	(-1.87)	(-1.75)	(-1.89)	(-1.65)	(-1.82)	(-1.63)
Share of workers with tertiary education	0.0489	0.175**	0.0464	0.158*	0.0729	0.166*	0.0268	0.158*
	(0.68)	(2.71)	(0.70)	(2.38)	(1.12)	(2.54)	(0.41)	(2.40)
Share of workers with temporary contracts	-1.032***	-0.767***	-0.656***	-0.774***	-0.251	-0.590**	-0.188	-0.580**
	(-6.47)	(-5.36)	(-4.21)	(-5.30)	(-1.70)	(-2.85)	(-1.29)	(-2.79)
Employment Protection Index		30.54***	29.68***	27.41***	29.87***	27.92***	27.35***	27.32***
		(8.36)	(8.28)	(6.68)	(8.98)	(6.74)	(7.93)	(6.51)
Med cumulativeness			6.966**		11.96**		12.38**	
			(3.30)		(2.90)		(3.07)	
High cumulativeness			9.117***		20.79***		22.00***	
			(3.45)		(4.77)		(5.10)	
Herfindahl index				7.965*		15.96*		15.80*
				(1.98)		(2.08)		(2.04)
Med Cumulativeness*Share temporary employment					-0.368		-0.366	
					(-1.44)		(-1.46)	
High Cumulativeness*Share temporary employment					-0.964***		-0.981***	
					(-3.35)		(-3.33)	
Herfindahl index*Share of temporary employees						-0.751		-0.744
						(-1.29)		(-1.29)
Southern Europe							-3.494	-0.894
							(-1.71)	(-0.43)
2006	6.763*	0.886	1.454	1.105	1.617	0.728	1.989	0.798
	(2.20)	(0.34)	(0.55)	(0.42)	(0.63)	(0.27)	(0.80)	(0.30)
2008	1.574	-4.887	-3.584	-4.702	-3.578	-5.005	-3.192	-4.943
	(0.52)	(-1.73)	(-1.27)	(-1.59)	(-1.29)	(-1.70)	(-1.21)	(-1.71)
Constant	49.38***	30.96***	28.14***	31.18***	22.32***	29.13***	24.94***	29.90***
	(16.10)	(8.95)	(7.45)	(8.98)	(6.09)	(7.57)	(5.87)	(6.65)
N	384	384	384	364	384	364	384	364

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

5 Conclusions

Does labor flexibility affect product innovation? This work addresses such critical question by investigating, empirically, the joint dynamics of new products and temporary employment in European industries. Disentangling the flexibility-innovation nexus is crucial with respect to both theoretical, empirical as well as policy-related debates. Concerning theory, the relationship between labor flexibility and innovation might unfold along significantly heterogeneous directions according to adopted theoretical framework. Following mainstream theories, flexibility is expected to boost employment - i.e. by reducing market rigidities - and productivity - i.e. via a better matching between skills demand and supply. According to evolutionary theories, in turn, flexibility may impact negatively on productivity and innovation by hampering the circulation of firm-specific knowledge; by encouraging cost-based rather than technology and quality-based competitive strategies; as well as by reducing the room for loyalty and cooperation between employers and employees. From an empirical standpoint, there is no conclusive evidence concerning magnitude and direction of the flexibility-innovation relationship. Indeed, significance and characteristics of such relation can vary substantially depending on country (institutions), sector, firms and workers specificities. In terms of policy, the role of labor flexibility and of its impact on workers and firms performance has given rise to an intense (and still ongoing) debate (see Cirillo et al., 2017, for a summary of this debate). Labor flexibility advocates tend to translate mainstream models' predictions - i.e. an expected positive effect of flexibility on employment and companies' productivity - into policy arguments in favor of lowering firing restrictions and diffusing temporary employment. On the contrary, those contrasting such policies emphasize the misalignment between (mainstream) theoretical predictions and real trends - i.e. for example, the poor employment and productivity performance vis a vis the intense labor market flexibilization in Southern Europe.

This work add to all dimensions (theory, empirics and policy) of the discussion on the innovation effects of labor market flexibility. The key findings can be wrapped up as follows. First of all, the use of temporary employment in European industries - used as a proxy of external flexibility - turns out to be negatively associated to the introduction of new products irrespective of the empirical model adopted. Secondly, these findings contrast significantly with mainstream theories' predictions; while giving support to theories - as the evolutionary ones (Kleinknecht et al., 2014) - pointing to a potentially negative flexibility-innovation relationship. On similar lines, the coefficient associated to the EPL indicator suggest a positive effect of labor market rigidities on product innovation in industries. Moving to technological regimes, it emerges how the negative correlation between temporary employment and product innovation holds also in case of 'knowledge intensive' sectors. This relationship holds identifying sectors both as 'Schumpeter Mark II' according to Kleinknecht et al. (2014)'s classification as well as using the Peneder's taxonomy with reference to 'high-cumulativeness' sectors. Not less relevantly, these results are confirmed by a number of robustness check: i) using the share of young (15-34 years) temporary workers as a proxy of external flexibility; ii) using as dependent variable the share of firms introducing both process and product innovation so to exclude 'type of innovation-driven' results; iii) controlling for the role of Spain given the peculiarities of this country in terms of labor market institutions and flexibility.

This work provides relevant implications for European labor and innovation policies. Overall, the identification of a negative relationship between temporary employment and innovation highlights a (potentially harmful) innovation-related side effect of labor market flexibilization. In other words, the push towards flexibilization seems to contrast with the (frequently declared) intention of European policy makers to spread innovation in firms and industries. In addition, the result of the empirical model point to a potentially 'structural effect' of external labor market flexibility. That is, a relatively more intense use of temporary contracts seems to penalize innovation not only on average but also in those industries structurally characterized by a more stronger propensity towards product innovation. Therefore, these findings suggest to consider an additional element of cautiousness in case European policy makers intend to further flexibilize labor markets in the next future.

6 References

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A Appendix

Table 5: Descriptive statistics by main variables

	mean	sd	min	max
Share of temporary workers	13.27	8.70	1.79	70.02
Share of temporary workers (15-34 years old)	24.87	11.37	4.42	71.87
New products	32.92	18.63	0.07	93.40
New products and processes	44.02	18.64	0.25	94.56
Average firm size	0.28	0.82	0.00	12.93
Share of workers with tertiary education	23.60	17.17	0.80	86.25
Rate of change of Value Added	0.89	7.91	-42.94	46.91
R&D per employee	2.76	4.83	0.00	33.17
Herfindahl index	0.27	0.26	0.00	1.00
N		760		

Table 6: High-concentrated sectors by country

Country	**Macro sector**	**NACE 2 digit sector**	**Herfindal Index**
Germany	Manufacturing	Basic metals	0.87
		Rubber and plastic products	0.85
		Other non-metallic mineral products	0.80
	Services	Air transport	1.00
		Post and telecommunications	0.87
		Activities related to financial intermediation	0.68
Spain	Manufacturing	Other non-metallic mineral products	0.75
		Coke, refined petroleum products and nuclear fuel	0.56
		Food products and beveradges	0.32
	Services	Air transport	0.48
		Supporting and auxiliary transport activities	0.37
		Other business activities	0.32
France	Manufacturing	Rubber and plastic products	0.52
		Manufacturing NEC	0.52
		Coke, refined petroleum products and nuclear fuel	0.32
	Services	Post and telecommunications	0.94
		Air transport	0.66
		Land transport and transport via pipelines	0.49
Italy	Manufacturing	Other non-metallic mineral products	0.39
		Basic metals	0.37
		Other transport equipment	0.33
	Services	Post and telecommunications	0.86
		Air transport	0.59
		Water transport	0.34
Netherlands	Manufacturing	Other transport equipment	0.99
		Electrical machinery and apparatus n.e.c	0.90
		Fabricated metal products	0.86
	Services	Air transport	0.93
		Post and telecommunications	0.90
		Computer and related activities	0.59

Table 7: Sectors' classification according to "Cumulativeness of knowledge"

Sectors	**Peneder classification**	**Cumulativeness**
Food products, beverages	Med-low	Low
Tobacco products	Med-low	Low
Textiles	Med-high	Med
Wearing apparel	Low	Low
Leather, -products, footwear	Low	Low
Wood, -products, cork	Med	Low
Pulp/paper, -products	Med	Med
Publishing, reproduction	Med-low	Low
Ref. petroleum, nucl. fuel	Med-high	Med
Chemicals	Med-high	High
Rubber and plastics	Med-high	Med
Mineral products	Med-high	Med
Basic metals	Med-high	High
Fabricated metal products	Med	Low
Machinery, nec.	High	High
Computers, office machinery	High	Med
Electrical equipment, nec.	High	High
Communication technology	High	High
Precision instruments	High	High
Motor vehicles	Med-high	High
Other transport equipment	Med-high	Med
Manufacturing nec.	Med	Med
Recycling	Low	Low
Electricity and gas	Med-low	Low
Water supply	Med-low	Low
Wholesale trade	Low	Low
Land transport, pipelines	Low	Low
Water transport	Low	Low
Air transport	Med	Low
Auxiliary transport services	Low	Low
Post, telecommunications	Med-high	Med
Financial intermediation	Med	High
Insurance, pension funding	Med-low	High
Auxiliary financial services	Low	Low
Computer services	High	High
Research and development	High	High
Other business services	Med	High

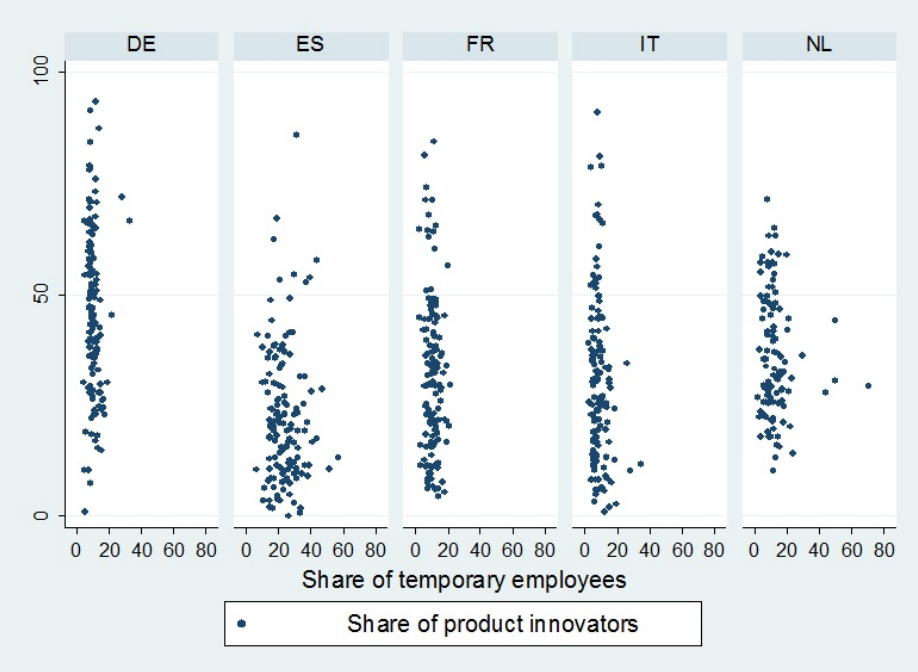

Figure 4: Product innovators and temporary employment by time

Table 8: Share of temporary employment and innovation (weighted)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Share of firms introducing product innovations						
Average firm size (lagged)	-1.679	-2.805	-3.408	-2.636	-3.308	-2.969	-3.332
	(-0.95)	(-1.29)	(-1.75)	(-1.25)	(-1.71)	(-1.32)	(-1.70)
Expenditure in R\&D per employee (lagged)	2.118***	1.828***	2.077***	1.728***	2.036***	1.590***	2.016***
	(9.18)	(7.67)	(9.23)	(7.25)	(9.14)	(6.17)	(8.71)
Rate of change of Value Added	-0.0838	-0.0614	-0.0917	-0.0725	-0.0607	-0.0702	-0.0609
	(-0.55)	(-0.39)	(-0.57)	(-0.46)	(-0.38)	(-0.45)	(-0.38)
Share of workers with tertiary education	0.219***	0.0710	0.211**	0.0952	0.212**	0.0431	0.204**
	(3.39)	(0.98)	(3.18)	(1.29)	(3.23)	(0.59)	(3.15)
Share of workers with temporary contracts (weighted)	-0.337***	-0.302***	-0.311***	-0.208***	-0.236***	-0.175***	-0.232***
	(-9.40)	(-8.18)	(-8.45)	(-4.90)	(-4.51)	(-4.26)	(-4.55)
Med cumulativeness		7.620***		11.00**		11.44***	
		(3.47)		(3.11)		(3.38)	
High Cumulativeness		10.14***		16.33***		17.51***	
		(3.83)		(4.27)		(4.57)	
Herfindahl index			11.86**		18.62***		18.12**
			(3.17)		(3.48)		(3.24)
Med Cumulativeness*Share temporary employment				-0.110		-0.105	
				(-1.55)		(-1.54)	
High Cumulativeness*Share temporary employment				-0.214**		-0.215**	
				(-3.22)		(-3.18)	
Herfindahl index*Share of temporary employees					-0.339*		-0.327*
					(-2.30)		(-2.12)
Southern Europe						-4.231*	-0.915
						(-2.13)	(-0.44)
2006	6.182*	6.847**	5.585*	7.031**	5.247*	7.123**	5.266*
	(2.37)	(2.65)	(2.18)	(2.74)	(2.05)	(2.82)	(2.06)
2008	-2.969	-1.477	-3.731	-1.657	-3.947	-1.624	-3.956
	(-1.13)	(-0.55)	(-1.39)	(-0.63)	(-1.47)	(-0.64)	(-1.48)
Constant	31.54***	28.57***	28.95***	25.34***	27.43***	26.95***	27.95***
	(11.95)	(10.21)	(9.78)	(8.11)	(8.70)	(8.39)	(7.77)
N	376	376	358	376	358	376	358

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001

Table 9: Share of product innovators and temporary employment (15-34) weighted

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Share of firms introducing product innovations (weighted)						
Average firm size (lagged)	-0.971	-2.366	-2.819	-2.283	-2.290	-2.824	-2.443
	(-0.54)	(-1.06)	(-1.42)	(-1.04)	(-1.17)	(-1.18)	(-1.20)
Expenditure in R\textbackslash\&D per employee (lagged)	2.316***	2.001***	2.259***	1.959***	2.204***	1.745***	2.134***
	(9.83)	(7.99)	(9.83)	(7.89)	(9.63)	(6.46)	(8.92)
Rate of change of Value Added	-0.123	-0.0868	-0.128	-0.0913	-0.0953	-0.0901	-0.0991
	(-0.77)	(-0.54)	(-0.76)	(-0.56)	(-0.58)	(-0.57)	(-0.61)
Share of workers with tertiary education	0.210**	0.0646	0.200**	0.0782	0.191**	0.0149	0.173**
	(3.27)	(0.91)	(3.02)	(1.10)	(2.88)	(0.22)	(2.67)
Share of workers 15-34 with temporary contracts (weighted)	-0.205***	-0.184***	-0.187***	-0.130***	-0.135***	-0.111***	-0.135***
	(-8.38)	(-7.31)	(-7.42)	(-4.69)	(-4.04)	(-4.11)	(-4.02)
Med cumulativeness		8.778***		12.05**		12.43**	
		(3.93)		(2.96)		(3.24)	
High Cumulativeness		10.25***		16.12***		17.37***	
		(3.66)		(3.78)		(4.11)	
Herfindahl index			12.35**		22.22***		19.98**
			(3.30)		(3.44)		(2.92)
Med Cumulativeness*Share temporary employment 15-34				-0.0599		-0.0558	
				(-1.22)		(-1.20)	
High Cumulativeness*Share temporary employment 15-34				-0.111*		-0.108*	
				(-2.27)		(-2.21)	
Herfindahl index*Share of temporary employees					-0.232*		-0.200
					(-2.24)		(-1.86)
Southern Europe						-5.810**	-2.750
						(-2.84)	(-1.27)
2006	6.178*	6.799*	5.579*	6.868*	5.348*	6.989**	5.409*
	(2.23)	(2.49)	(2.06)	(2.53)	(1.97)	(2.64)	(2.02)
2008	-1.966	-0.574	-2.840	-0.768	-2.907	-0.938	-3.030
	(-0.71)	(-0.21)	(-1.02)	(-0.28)	(-1.04)	(-0.35)	(-1.09)
Constant	31.99***	28.75***	29.18***	25.72***	27.01***	28.26***	28.83***
	(11.17)	(9.55)	(9.16)	(7.88)	(7.92)	(8.54)	(7.35)
N	378	378	360	378	360	378	360

t statistics in parentheses

* p<0.05, ** p<0.01, *** p<0.001