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Employment protection and labour productivity growth in the EU: skill-specific effects during and after the Great Recession

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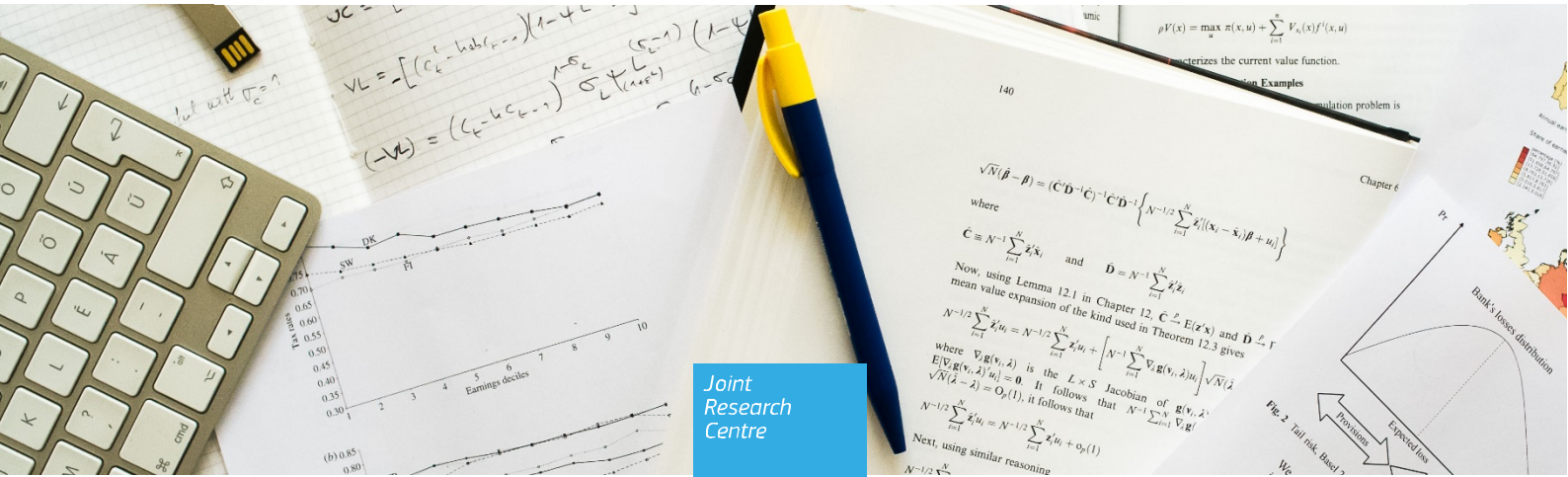

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Executive summary

The Great Recession (2008-2009) brought with it a generalised consensus among economists and policymakers at large on the need to improve the flexibility of labour markets with a view to restoring unemployment to pre-crisis levels and combatting long-term unemployment. Concerns surrounding the negative implications of too stringent labour market regulations were voiced already before the crisis: "Excessive job protection makes it costly for firms to restructure and also reduces the incentives for the employee to exert effort and to move to higher productivity jobs" (OECD, 2008). This view was recently reiterated: "when job protection is too high […], efficient job allocation and innovation are likely to suffer. Hence, overly strict dismissal regulation tends to reduce productivity growth and increase the duration of unemployment spells" (OECD, 2020). The recent episodes of Covid-19 have further underlined the importance of the ability to withstand and reduce the impact of various shocks.

In this paper we evaluate the importance of potentially too stringent labour protection regulations in the EU by evaluating the varying responses of labour productivity during and after the Great Recession in countries with different stringency of the regulations. We consider not only the whole period 2008-2017, but also subsamples of the crisis and recovery periods that have different patterns. Using the cross-sectional and panel model frameworks, we exploit the country-sector variation in labour productivity coupled with the OECD indicators on the strictness of employment protection legislation (EPL) while conditioning on a wide set of additional controls.

First, we study the effect of EPL on labour productivity's resilience — i.e., on changes in labour productivity during the crisis and the recovery path — to the financial crisis by conditioning the long run changes in productivity on the pre-crisis levels of EPL. During recessions, stricter EPL might lead to greater labour hoarding, thus on one hand hurting productivity growth. However, on the other hand, stricter EPL might induce rises in labour productivity observed in the recovery period, as costly dismissals during the crisis might provide incentives for employers to invest in physical capital and/or training. Second, by distinguishing between the short and long-term impacts of changes in EPL, we find support for the view that, upon a negative shock, EPL is binding over short periods, preventing an optimal reallocation of factors of production, thus potentially leading to an inefficiently large amount of labour, and in turn, decreasing productivity, whereas, over longer time horizons, firms facing relatively large levels of EPL may find it optimal to increase their investment in capital in order to reduce their susceptibility to such shocks and labour overhang. Third, we break down our analysis between high- and low-skill intensive industries based on several metrics. This distinction is important because not only can firms react under negative shocks differently with respect to qualified versus unqualified workers — due to unequal searching and hiring/firing costs —, but also because workers of differing skills and education might be unequally informed and able to exercise their rights. Fourth, we explore the potentially nonlinear impact of EPL by testing if overly strict employment protection regulation might be harmful.

Overall, we find that, during the crisis, stricter labour protection reduces labour productivity growth in sectors with a large share of workers with tertiary education, whereas this effect is negligible or positive in sectors where workers with secondary or only primary education are more prevalent, respectively. We establish that overly strict regulation is more harmful, whereas its moderate level can be even beneficial in regular (non-crisis) times. In the long run, we document that an increase in EPL stimulates employers to substitute labour with capital, partially mitigating the overall negative effect on labour productivity growth.

In general, our findings are in line with previous studies establishing that stricter EPL hurts productivity growth, especially during the period of crisis, whereas less binding EPL is associated with greater labour productivity growth, at least up to some point. Indeed, our results confirm that there exists some room for improving productivity growth by adopting a less stringent EPL framework, especially in countries with very strict EPL regulations. However, we also find that the predominant part of such positive effect is retained only for about three years, whereas the long-term impact of EPL is conditional on the specific skill/education distribution of workers across sectors, with higher education associated with a stronger positive effect attributable to decreasing EPL.

Our results point to several policy-relevant messages. First, the EPL design should take into account not only its level, but also sectoral specificities, especially in terms of the varying distribution of demanded skills across industries. In particular, overly stringent EPL is especially harmful for productivity growth in sectors employing a relatively more skilled workforce. Second, the simultaneous reduction of EPL together with the promotion of education and skills is important to foster labour productivity growth in high-skilled sectors, especially in countries where EPL is very binding. Third, moderate levels of EPL might not be productivity-harming in the long run, since it stimulates the substitution of labour for capital. This effect needs to be balanced against the negative shorter-term effects.

At the same time, the established dependence of the impact of EPL on productivity growth on the education levels of the workforce and the share of permanent contracts might also hint that the less educated workforce is more easily dismissed, especially during the crisis period, as they also tend to work more based on temporary contracts. This might indicate either insufficient legislative regulation for less educated workers or their inability to understand and exploit their rights.

Employment protection and labour productivity growth in the EU: skill-specific effects during and after the Great Recession

Igor Fedotenkov[1] Virmantas Kvedaras[2] and Miguel Sanchez-Martinez[3]

Abstract

The paper investigates the relationship between employment protection legislation (EPL hereafter) and labour productivity growth in the EU in the context of the Great Recession. We consider the crisis and recovery periods, evaluate the relevance of both levels and changes in EPL for productivity growth, establish the presence of some nonlinearities, and explore the conditioning role played by the skills of the labour force, captured by different levels of education. We find that stricter labour protection reduces labour productivity growth in sectors with a large share of workers with tertiary education, whereas this effect is negligible or positive in sectors where workers with secondary or only primary education are more prevalent, respectively. We establish that overly strict regulation is more harmful, whereas its moderate level can be even beneficial in regular (non-crisis) times. In the long run, we document that an increase in EPL stimulates employers to substitute labour with capital, partially mitigating the overall negative effect on labour productivity growth. We provide several hypotheses that could explain our findings and discuss potential policy implications supported by a back-of-the-envelope calculation.

JEL classification: E24, I25, J24, J88.

Keywords: Labour productivity, employment protection legislation, skills, education, Great Recession.

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1. Introduction

The Great Recession (2008-2009) brought with it a generalised consensus among economists and policymakers at large on the need to improve the flexibility of labour markets with a view to restoring unemployment to pre-crisis levels and combatting long-term unemployment (OECD, 2013a). In fact, concerns surrounding the negative implications of too stringent labour market regulations were voiced even before the crisis, especially by key international institutions such as the Organisation for Economic Co-operation and Development (OECD), which started collecting indicators to capture the extent of employment protection in its member countries. When these indicators started being compiled, it was already believed that "the stringency of employment protection legislation (EPL), matters for innovation and productivity, too. Excessive job protection makes it costly for firms to restructure and also reduces the incentives for the employee to exert effort and to move to higher productivity jobs" (OECD, 2008). In a very recent contribution, this view is reiterated: "when job protection is too high [...], efficient job allocation and innovation are likely to suffer. Hence, overly strict dismissal regulation tends to reduce productivity growth and increase the duration of unemployment spells" (OECD, 2020).

In the context of the Great Recession, and in the specific context of European Union (EU) Member States, the focus of policy and applied research has been on those countries that had been hardest hit by the crisis, mostly in the periphery. As an example, the OECD (2016) provides an overview of the lessons learned for the case of Greece in terms of macroeconomic outcomes after the plethora of structural reforms the country undertook since 2010. It is estimated that EPL reforms, and in particular the relaxation of some of the most stringent elements of job protection, have had a substantial impact on Greek Gross Domestic Product (GDP) through their impact on productivity growth. Similar studies are available for Italy and Spain too. For the former, a similar analysis also found a positive and non-negligible effect of employment protection reforms on GDP, mainly through the employment generation channel in this case (OECDa, 2015). For Spain, the reforms implemented in 2012, which reduced the stringency of job protection legislation, have been shown to have contributed to 'wage moderation and increased hiring on permanent contracts' (OECD, 2013b). [4] An evaluation of the effects of such reforms on other outcomes, such as productivity growth, that takes into account the resilience aspect, is conditional on the skill level of workers, and focuses on EU Member States — as we do in this study — is, however, absent.

This paper contributes to the extant literature in several respects. First, we study the effect of EPL on labour productivity's resilience to the financial crisis — i.e., on changes in labour productivity during the crisis and the recovery path — based on EU data. This is the first attempt, to our knowledge, at examining this issue in the context of the Great Recession and specifically for the EU. The choice of the Great Recession as the focus of our analysis is of special interest. During recessions, stricter EPL might lead to greater labour hoarding, thus on one hand hurting productivity growth. However, on the other hand, stricter EPL might induce rises in labour productivity observed in the recovery period, as costly dismissals during the crisis might provide incentives for employers to invest in physical capital and/or training. Second, we provide a novel analysis of both the short and long-term impacts of changes in EPL, relating them to their impact on productivity growth at different time horizons. We find support for the view that, upon a negative shock, EPL is binding over short periods, preventing an optimal reallocation of factors

[4] The OECD has also investigated the effects of EPL at the regional level, finding that they are negative overall, and especially detrimental to productivity growth in lagging regions (OECD, 2013c).

of production, thus potentially leading to an inefficiently large amount of labour, and in turn, decreasing productivity, whereas, over longer time horizons, firms facing relatively large levels of EPL may find it optimal to increase their investment in capital in order to reduce their susceptibility to such shocks and labour overhang. Third, we break down our analysis between high- and low-skill intensive industries based on several metrics. This distinction is important because not only can firms react under negative shocks differently with respect to qualified versus unqualified workers — due to unequal searching and hiring/firing costs —, but also because workers of differing skills and education might be unequally informed and able to exercise their rights (see, e.g., Meager et al., 2002, Denvir et al., 2013, and OECD, 2019). Fourth, we explore the potentially nonlinear impact of EPL by testing if overly strict employment protection regulation might be harmful. Fifth, we evaluate how the importance of the different channels affecting productivity growth differ between the crisis and regular times. Sixth, relying on a simple back-of-an-envelope calculation, we provide a comparative analysis of the effects of EPL across the EU Member States we analyse, indicating which countries — chiefly depending on their industrial structure and labour skill composition — could be most affected by EPL changes in terms of labour productivity growth.

The paper is organized as follows. Section 2 provides a thorough overview of the most relevant literature. . Section 3 presents the data used in the analyses and discusses important methodological considerations in the empirical approach. It also provides a motivation for the paper based on a number of empirical regularities observed in the data. Section 4 presents the econometric specifications in detail. Section 5 discusses the main empirical results. Section 6 provides robustness and further impact analyses. In Section 7, a comparative analysis across EU Member States of the effects of EPL based on our econometric results is carried out. Finally, section 8 contains concluding remarks.

2. Literature Review

Regarding impacts other than on employment, the idea that curtailing EPL invariably leads to better economic outcomes hinges on the assumption that it increases employment without reducing innovation and productivity growth (Vergeer & Kleinknecht, 2014). From a theoretical standpoint, the net effect of EPL on productivity growth can take, in principle, a negative or positive sign. The main arguments supporting the first view are centred around the higher firing costs imposed by higher EPL and include: i) EPL might reduce the productivity-enhancing reallocation of labour [5], ii) EPL might also reduce incentives to invest in cost-saving innovation, iii) EPL might provide incentives to invest in lower return, less risky projects, iv) asymmetrically softer EPL for temporary contracts, as compared with regular ones, might encourage employers to rely more on workers with temporary contracts, who tend to be less productive, v) EPL might hamper job turnover and lead to an increase in the mismatch between the qualifications required by firms, which change across time, and those possessed by their workers (OECD, 2015, Berton et al. (2017)).[6] By contrast, arguments pointing to a positive relationship between EPL and productivity growth relate mainly to incentives on the side of firms to invest in human capital and incentives on the side of workers to exert more effort: i) EPL might induce firms to invest in training programs for its workers, partly to avoid large lay-offs, ii) EPL can signal that workers are more unlikely to get laid off, which in turn can result in more commitment to the firm, iii) EPL conditions power relations

[5] These reallocations could take the form of, for instance, employment flows from declining to growing sectors, or from inefficient firms within a sector to more efficient or innovative ones.

[6] For detailed theoretical discussions of each of these arguments see, for example, Poschke (2009), Tresse & Scarpetta (2004), Bentolila et al. (1994), Damiani et al. (2016), Jacquier (2015), Saint-Paul (2002), and Breschi & Lissoni (2009).

between employers and their employees, with stronger EPL potentially leading to a more equitable power dynamic and thus higher wages and likely reduced worker turnover, iv) EPL reduces job turnover and hence increases familiarity between workers and thus might lead to more efficient teamwork, v) EPL might lead to greater innovation through a *selection* effect in which only the firms which can bear the cost of more stringent worker rights regulations thrive.[7]

In response to these theoretical contributions, an extensive body of empirical literature has developed in parallel to investigate which of these forces governing the relationship between EPL and productivity growth may dominate. The two types of productivity measures generally analysed are total factor productivity (TFP) and labour productivity, chiefly depending on the level of granularity of the available data. In the next paragraphs we provide a succinct summary of the most important contributions to the topic analysed in this paper, in order of proximity to our analysis.

Arguably, the study closest to ours in scope is Van der Vorst (2019). This author uses the same data sources as we do in this paper, namely EU KLEMS for productivity at the sectoral level and OECD data for EPL at the national level, to investigate the impact of EPL on both TFP and labour productivity growth. In the same vein, he also distinguishes between low-skilled and high-skilled sectors. However, besides these similarities, there are a number of key differences, chiefly including a different classification of industries according to the skill level of the labour force, disparate data and time dimensions, and different econometric model specifications.[8] In addition, there exist important qualitative differences worth highlighting. First, as opposed to us, he does not analyse the impact of changes in EPL over time and thus does not differentiate between long-term and short-term impacts. Second, this author does not account for potential endogeneity of the EPL indicator after the Great Recession, whereas we explicitly investigate this aspect. Third, he distinguishes between low-skilled and high-skilled sectors using a simple dummy variable,[9] whereas we use a finer set of underlying variables to measure the skill intensity of industries, highlighting in addition the varying impact of EPL policies conditionally on three educational levels. Fourth, this author does not cover temporary workers, which might lead to biased inference due to omitted relevant variables. Fifth, he only analyses EU15 countries and the US, whereas we cover all those EU-27 Member States that are members of the OECD (plus the United Kingdom). Sixth, there is a key difference regarding the goal of both papers; while Van der Vorst's (2019) analysis is aimed at obtaining general conclusions on the relationship between EPL and productivity growth, our main goal is instead to investigate this link in the context of a crisis and the periods surrounding it, with a view to drawing lessons that can be applied to other economic recessions such as the COVID-19 crisis. We thus focus more on what EPL implies in terms of the *resilience* of labour productivity growth in different sectors to a recessionary shock. Nevertheless, despite these data and methodological differences, our main findings are broadly in line with those reported in Van der Vorst (2019), namely that stricter EPL policy is more binding in sectors dominated by high-skilled workers.[10]

[7] For detailed theoretical discussions of each of these arguments see, for example, Belot, et al. (2007), Kleinknecht (2017), Stam, et al. (2019), Vergeer and Kleinknecht (2010).

[8] As an example, whereas Van Der Vorst uses the 2017 release of the EU KLEMS dataset, we use the latest 2019 release. There are major differences in the historical series between these two releases owing to underlying data revisions for many countries. A detailed discussion of the precise differences between his and our contribution is beyond the scope of this paper.

[9] Van der Vorst's definition of the dummy variable is sector-specific but does not have a country-specific component. By contrast, our approach allows for both sector- and country-specific skill levels.

[10] Cimicelli et al. (2020) find that job deregulation has larger effects (i.e., is more binding) in industries characterized by a higher 'natural' propensity to regularly adjust the workforce. However, the link between natural employment turnover rates and the

A seminal contribution in the literature on the relationship between productivity growth and EPL in the presence of business cycle shocks is Bassanini et al. (2009), who examine the impact of EPL on TFP by resorting to cross-country and time variation in both variables. Like us, they use data from OECD countries to classify industries according to their *natural* degree of net employment flows to find that more stringent dismissal regulations have a greater negative impact on those sectors where layoff restrictions are more likely to be binding. An instrumental variable approach is adopted in order to calculate the industry layoff propensity. The authors delve further into the effects of different types of employment regulation and observe that regulations concerning temporary contracts do not bear a significant effect on TFP growth.[11] Although similar in nature, our main analysis focuses on labour productivity growth[12] and breaks industries down according to the skill intensity of the labour force instead, distinguishing in addition between the recession and recovery periods.[13] Contrary to Bassanini et al. (2009), we find a significant influence of EPL on productivity growth not only for regular but also for temporary contracts.[14]

Many examinations focus solely on the impact of regulations related to temporary contracts. A paper belonging to this strand of literature, conceived along very similar lines as the one in Bassanini et al. (2009), is Lisi (2013). Focusing on data for the EU, this author also inspects the impact of labour market policies surrounding temporary employment protection, albeit with a different empirical strategy than previous cross-country studies. This approach consists of exploiting a particular difference-in-difference assumption. This author confirms, for the case of temporary contracts, the widely found result for regular contracts that EPL reduces labour productivity growth more in those industries requiring a greater employment reallocation. Moreover, he obtains the more general result that the use of temporary contracts has a negative, even if small in magnitude, effect on labour productivity, which is fully consistent with our findings.

In a follow-up paper, Lisi and Malo (2017) endeavour to analyse whether the impact of temporary employment differs across sectors according to the sectors' skill intensity. Consistent with expectations, and our own results related to tertiary education, they find that temporary employment damages productivity across all sectors, and especially in relatively more skilled sectors. They show that this result is robust to different classifications of sectors according to skills and productivity measures. The main policy implication following from their analysis is that labour regulation should be designed to address the use of temporary employment as a flexible way to enter the market, rather than as a structurally cheaper form of labour. These findings are very close to ours, albeit we focus on overall EPL as opposed to temporary employment only.

Damiani et al. (2016) corroborate the negative correlation between the share of temporary employment and TFP growth for a panel of 15 EU countries, especially in sectors with higher propensity to hire

focus of our paper, namely the skill intensity of sectors, is unexplored by these authors. Investigating this interplay constitutes a potentially fruitful avenue for future research.

[11] In a related paper, Bassanini and Garnero (2012) test the hypothesis that laxer EPL might lead to reduced efficiency of the worker reallocation process, thereby potentially harming industry-specific human capital. They show that the effect of dismissal regulations on separations is essentially confined to those leading to job findings within the same industry, which suggests that it is unlikely that the human capital destruction channel is at play. This adds further evidence in favour of a negative effect of more stringent EPL on productivity growth.

[12] In terms of skill relevance, the results for TFP are similar as revealed in the section on robustness analyses.

[13] In addition, our analysis circumscribes to EU Member States only, as opposed to all OECD countries.

[14] However, some similarity between the two studies is retained, since in the case of temporary contracts, the only significantly negative effect is observed for tertiary education-intensive sectors while, for regular contracts, the impact is significant (and of varying signs) at all educational levels.

transitory workers, further demonstrating that the deregulation of temporary employment deters on-the-job training and the acquisition of firm-specific competencies.

Another study utilizing an industry-level panel of EU countries to analyse the effect of temporary employment protection is Jacquier (2015). The data are drawn from the same sources as ours, namely the OECD's EPL and EU KLEMS for the industry-level economic variables. Using a two-stage regression procedure, the author shows, first, that temporary employment has an unconditional, significantly negative impact on TFP and, second, that lowering employment protection on temporary jobs, conditional on employment protection on regular contracts being high, creates a surge in temporary employment that is detrimental to productivity performance.

From a more policy-oriented angle and with a wider scope, Rincon-Aznar and Siebert (2012) examine the impact of EPL in European countries on TFP, wage growth, and employment. They find that stricter EPL reduces both TFP and wage growth, while leaving employment broadly unchanged. In addition, contrary to the results of other contributions, they show that service sector industries are less affected by EPL than manufacturing, that industries dominated by large firms are affected to a greater extent than those dominated by smaller firms, and that hours worked per employee increase with EPL.[15] Their results point to the existence of important policy trade-offs in terms of EPL, implying that reforms of the labour market need to progress with caution.

Beyond the EU context, Van Schaik and Van de Klundert (2010) analyse the role of labour market institutions as a driver of productivity growth in a panel of 21 OECD economies over the period 1960-2005. The relatively long time dimension allows the authors to find that the impact of employment protection is qualitatively different before and after 1980. The authors attribute this to technological change being mostly driven by imitation in the first sub-period, implying that incumbent workers were important in generating productivity growth and hence that the effect of EPL was more muted. By contrast, in the second sub-period, product and process innovation became the predominant factor, meaning that excessive protection of insider workers may hamper needed flexibility in terms of labour force adjustments, thereby reducing productivity growth.

Relevant studies based on data for individual countries include Autor et al. (2007), Vergeer et al. (2015) and Bjuggren (2018). The first authors exploit U.S.-state level data on wrongful-discharge protections over thirty years to examine their impact on employment flows and TFP. They find that the adoption of wrongful-discharge protections, a special type of employment protection, reduce employment flows and firm entry rates, while leading to a rise in capital deepening and a decline in total factor productivity. However, their analysis also shows evidence of strong employment growth following the adoption of dismissal protections, which runs counter to conventional wisdom. Moreover, analysis of plant-level data provides evidence of capital deepening and a decline in total factor productivity following the introduction of wrongful-discharge protections. In the second study, the relationship between labour flexibility and productivity is analysed through the lenses of the degree to which the former affects the commitment of workers and their training as well as the style of management. Using firm-level and survey data from the Netherlands, the authors find a negative relationship between flexible personnel and labour productivity growth, adding one further insight, namely that the relationship is moderated by the type of

[15] The lower impact of EPL in smaller firms might be due to workers in these types of firms exhibiting lower market power (Heywood et al. (2018)).

innovation regime.[16] The third study uses micro data on Swedish firms and a quasi-natural experiment on labour law change to study the effect of employment protection rules on labour productivity. In line with most results in the literature, it is found that increased labour market flexibility increases labour productivity, with these rises being driven mainly by the older and the smallest firms.[17]

A recent in-depth survey of empirical works on the interplay between supply-side labour market reforms, innovation and productivity is offered in Kleinknecht (2020). After reviewing the most relevant evidence, the author concludes that the negative impact of more flexible labour relations is significant in medium-high and high-tech sectors characterized by a high 'cumulativeness' of knowledge, while in low-tech sectors, where cumulativeness of knowledge is low, there is little or no effect. The empirical contributions collected in this paper differ in scope and working definitions from ours. In particular, the handful of papers reviewed that are closest to ours in nature focus on drivers other than strictly EPL. Buchele and Christiansen (1999) examine the role of a composite index, consisting of several indicators other than EPL, as the main explanatory variable.[18] Auer et al. (2005) analyse employment tenure, defined as the length of time that workers remain in their present jobs or remain self-employed. The authors argue that job tenure bears some relationship with EPL, but do not explicitly carry out an analysis of the impact that the latter may have on productivity through its impact on job tenure. Pieroni and Pompei (2008) examine the link between labour market flexibility and innovation, where the former is defined in terms of job turnover and the latter is proxied by patents. Their results do not thus pertain to the effect of EPL on productivity. Sanchez and Toharia (2000) build a model of efficiency wages and empirically test it using Spanish data. They find that that the introduction of temporary contracts has an impact on wage formation, reducing the real wage cost. The most important departure with respect to our analysis is that they define labour market flexibility as the share of employees with temporary contracts, whereas only the effects on wages are analysed, and not the direct impact of this share on productivity. Besides these key differences, there are also the usual dissimilarities in terms of data sources and periods used in their econometric analyses. Rather than focusing on the impact of the temporality of jobs and employment turnover on productivity through its impact on innovation performance, which is the main focal point in Kleinknecht (2020), we concentrate instead on how EPL and labour productivity growth are interwoven.

3. Data, methodology, and motivation

3.1. Data and methodological issues

We focus on labour productivity growth performance during and after the Great Recession by using data for the period 2008-2017.[19] We further split the data into the recession episode (2008-2012) and the

[16] Although not strictly the same as EPL, labour flexibility as defined by these scholars is very highly negatively correlated with EPL.

[17] Note this author only studies the effect of EPL on productivity levels, not growth rates.

[18] These indicators include median job tenure, the share of administrative/managerial workers, collecting bargaining coverage, unemployment insurance replacement rate and public expenditures on social protection.

[19] The primary focus on labour productivity growth, instead of TFP growth - which is only considered in the robustness section - is motivated by the fact that, by definition, employment protection legislation is more closely related to labour and wages. In addition, labour productivity growth is generally agreed to, one, be the most important determinant of long-term welfare, two, be better measured than TFP.

recovery period (2013-2017). We analyse all those EU27 Member States that are also members of the OECD, augmenting the list of countries with the UK.[20] Our analysis is performed at the country-sector level. We use the NACE[21] sector split by considering thirteen aggregate sectors specified in Appendix A, Table 7.[22]

Our data are of annual frequency and come from various sources. Labour productivity is calculated as output (gross value added), expressed in real terms, per unit of labour input, expressed in hours. These data are taken from the EU KLEMS2019 release.[23] This database is also used for retrieving data on capital at the sectoral level, which is used for the calculation of capital-labour ratios.

The OECD provides data on the strictness of EPL for regular and temporary contracts,[24] with greater values of EPL corresponding to stricter regulation and a less flexible labour market. We explore various dimensions of EPL in our models by considering both jointly and separately the EPL strictness indicators for regular and temporary contracts. In a first step, we use the sum of the two indexes;[25] although some studies find dissimilar effects on productivity between the two indexes (see Bassanini et al. 2009), in the main analysis we opt to aggregate the two indexes due to the limited number of observations and because the statistical hypothesis of equal coefficients cannot be rejected.[26] Furthermore, including the two indexes separately with the related additional interaction terms into the regression specifications would greatly increase the number of parameters, rendering less precise estimates. Nevertheless, in a second step, we provide a robustness check for our aggregate results by including these two indexes separately in Table 4. [27] In the robustness analysis reported in Table 11, we also explore if the share of temporary workers has any additional influence on our main results.

All data on the skills of workers are derived from the EU Labour Force Survey (LFS). In order to examine the conditioning effect of skills, we use education and occupation characteristics of workers as proxies of labour skills in a specific sector. For education, we separate between the share of workers with primary, secondary, and tertiary education, which are mutually exclusive categories. To account for the usual age restrictions found in the literature, we calculate the share of secondary workers from those who are older than 15, whereas we set the age threshold to 25 when considering tertiary education. Apart from a few robustness checks, we typically use primary education as the control group in our estimations. Occupation data from the EU LFS are used to derive the share of white- and blue-collar workers in different sectors.[28] Blue-collar workers are used again as the baseline in the estimations. As both types of proxies for

[20] The list of countries with all available data is: AUT, BEL, CZE, DNK, FIN, FRA, DEU, GRC, HUN, IRL, ITA, NLD, POL, PRT, SVK, ESP, SWE, and GBR.

[21] The statistical classification of economic activities in the European Community, which is abbreviated as NACE deriving from the French Nomenclature statistique des activités économiques dans la Communauté européenne.

[22] Due to well-known measurement issues, non-market industries as well as the real estate sector are left out of the analysis. The results remain very similar if we also drop the financial and insurance activities sector.

23 For more information, visit www.euklems.net

[24] In particular, The OECD (1999, p. 49) considers EPL to refer "to all types of employment protection measures, whether grounded primarily in legislation, court rulings, collectively bargained conditions of employment or customary practice".

[25] See Appendix B Figure 7 in Appendix B illustrating its dynamics in countries under investigation.

[26] In particular, in Table 4 we test the hypothesis that the coefficients corresponding to EPL for regular contracts and its interactions with other variables are equal to the corresponding coefficients for temporary contracts.

[27] Note that the specifications looking only at separate regressions, with only regular or temporary EPL indicator included, might be susceptible to estimation biases due to their inter-correlation. Hence, we will consider only regression equations where both regular and temporary EPL indicators are included.

[28] The classification is based on the International Standard Classification of Occupations: 1-5 are considered white collar occupations, whereas 6-7 are blue collar occupations (see, e.g., https://www.eurofound.europa.eu/surveys/ewcs/2005/classification).

workers' skills yield qualitatively similar results and insights, and since the occupation-based proxy becomes insignificant when both are included jointly, we use hereafter the education-based shares in our main estimations.

The earlier discussed EPL data are at the country level, which prevents us from the inclusion of fixed country effects in our econometric models due to an identification problem, namely that EPL would be collinear with fixed country effects. However, whenever we are not interested in the impact of EPL as such but in the conditional influence of EPL identified through the usage of certain interactions of EPL with other sector-specific indicators — e.g. education levels in different sectors —, we also control for fixed country effects. In every case, fixed sector effects are always included.

Given that fixed country effects are absent in the main regression specifications, we aim at compensating that by controlling for a large number of potential additional country-specific variables. First, as an indicator of economic development, we use GDP per capita based on purchasing power parity (PPP) from the World Bank Development Indicators. Second, in order to account for the quality of institutions, we further control for corruption, rule of law and government effectiveness indicators, which are provided by the World Bank Worldwide Governance Indicators.[29] Third, in extended model specifications, we also treat Eastern and Western EU countries separately.[30] This is carried out by including a dummy variable, which equals 1 if the country is Eastern European, and zero otherwise. Fourth, in a few models, we control for the Economic Sentiment Index provided by the European Commission. Finally, we control for the size of the shadow economy by using data from Medina and Schneider (2019), which is expressed in terms of percentage of GDP. Summary statistics of all the variables used in the analysis are presented in Appendix A, Table 8.

The control variables we use to reflect the level of economic development, quality of institutions and the size of shadow economy are highly correlated. This leads to a large variance of the estimated parameters. Therefore, in most of our regression specifications, we substitute them with the two significant principal components that explain about 94% of the total variance of these variables.[31]

3.2. Motivation

In this section, we aim at motivating our research questions by presenting several figures using country-sector-level data. First, we provide a few scatterplots of economy-wide average yearly productivity growth in the whole post-crisis period against the EPL values observed in the year immediately before the crisis (2007). Three cases are considered using different EPL indicators, namely each EPL indicator for regular and temporary contracts separately, and the sum of these two. Second, using only the latter, we plot the same relationships separately for different economic sectors. Third, we hypothesise that the differences observed in the different sectors might be linked to the corresponding labour skills in these

[29] These variables are bounded between -2.5 and 2.5 with larger values corresponding to better institutions.

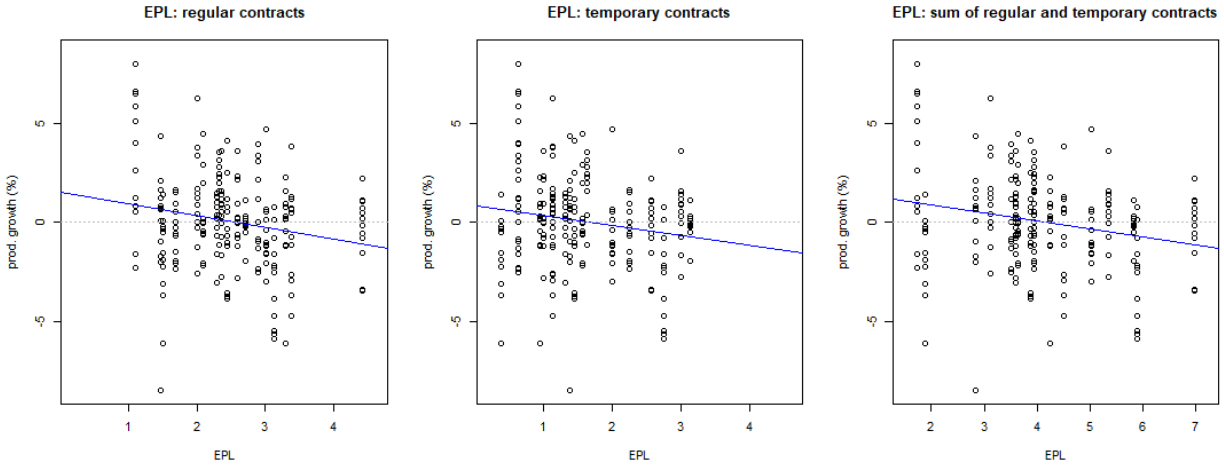
[30] List of countries from Eastern Europe: CZE, HUN, POL, SVK. List of countries from Western Europe: AUT, BEL, DNK, FIN, FRA, DEU, GRC, IRL, ITA, NLD, ESP, PRT, SWE, GBR.

[31] In absolute terms, the first principal component is about equally loaded by all variables, whereas the second one is dominated by the GDP per capita variable. Note that, to avoid simultaneity-induced endogeneity, we use the pre-crisis period values of these economic variables in our estimations.

sectors, illustrating the relationship between EPL and labour productivity growth by conditioning on education levels.

Since economic policy changes generally gain momentum after crisis episodes (see, e.g., OECD (2019)), we fix the pre-crisis EPL level when considering its potential impact on productivity growth in the aftermath of the Great Recession; this aims at avoiding or reducing the potential endogeneity bias induced by simultaneity or reversed causality from productivity growth to changes in EPL policy. Figure 1 plots annual average labour productivity growth in 2008-2017 at country-sector level against the 2007 EPL levels. We distinguish the three EPL indicators discussed earlier in three panels and draw the estimated linear relationships in blue. It should be noted that, in the plots of this section, labour productivity growth rates are adjusted for sector-specific averages, whereas sector fixed effects (FE) will be used later in the econometric estimations to control for sector specificity.[32]

Figure 1: Productivity growth and EPL.



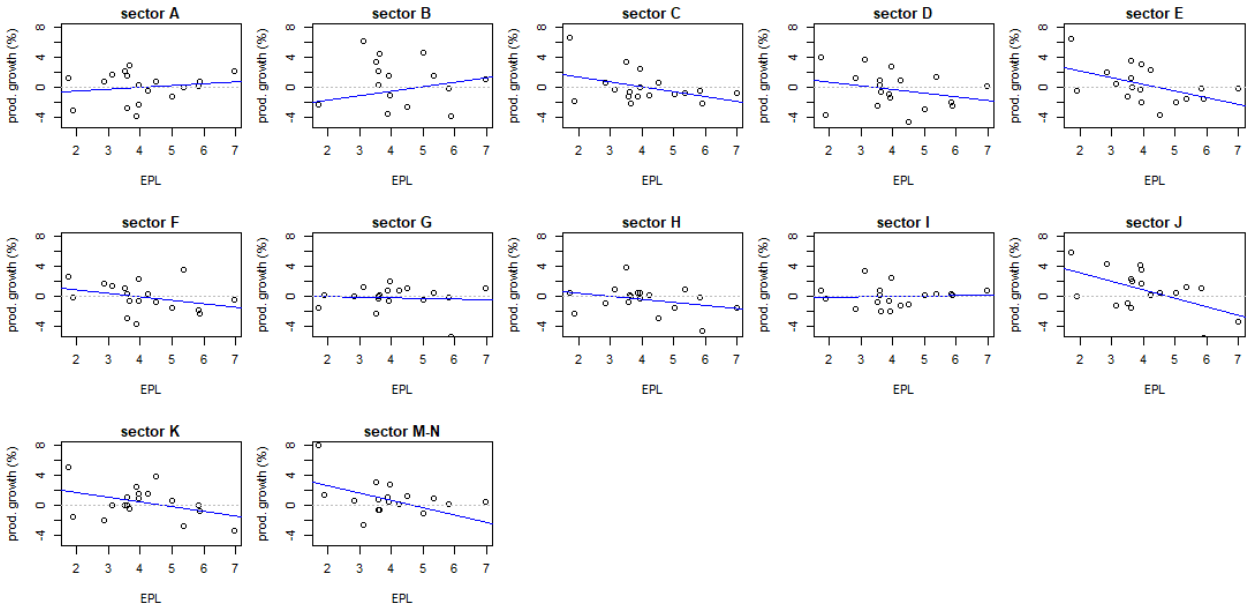
Note: Average annual labour productivity growth during 2008-2017 (vertical axis), adjusted for sector-specific means, and EPL in 2007 (horizontal axis)

A slightly negative relationship appears in all three cases that needs to be further analysed. As the slope of the linear equations in the left and middle panels of Figure 1 is rather similar, in the main econometric specifications we use the sum of the EPL indexes for regular and temporary contracts (right-hand-side panel of Figure 1). This summed index not only accounts for both indicators in a simple way, but also leads to slightly lower heteroscedasticity.[33]

The figures above pool all sectors together, but different sectors might have diverse responses to EPL depending on their specific characteristics. Figure 2 plots the same relationships as Figure 1, but for all sectors under consideration separately.[34]

[32] Random effects (RE) of both sectors and countries will also be explored in the robustness section.
[33] The use of a weighted average - relying on the share of workers with regular and temporary contracts - will also be considered in the robustness section.
[34] A table with sector codes can be found in Appendix A, Table 7.

Figure 2: Average labour productivity growth (2008-2017) and EPL (in 2007) by sectors.

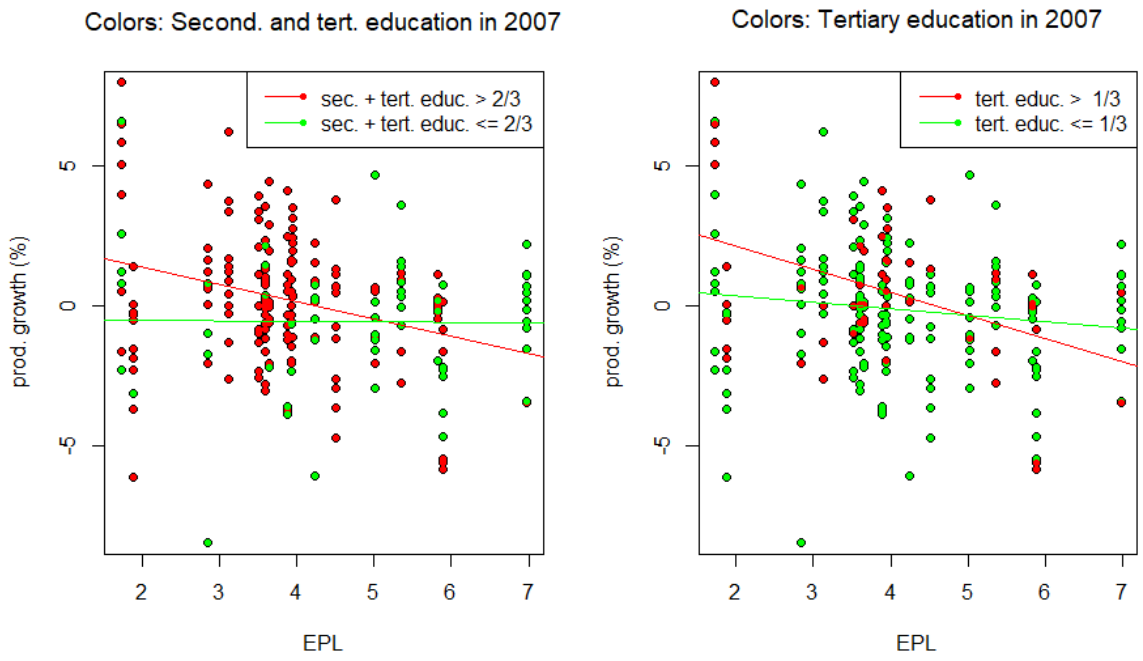


Note: Sectors here are defined by the classification of economic activities as described in Table 7 of Appendix A.

Figure 2 shows that the link between EPL and labour productivity growth differs substantially across sectors. In most cases, we observe a negative relation between EPL and labour productivity growth. Nevertheless, in a handful of activities such as Agriculture (sector A) and Mining & quarrying (sector B), the relationship is positive. Furthermore, Accommodation and food services (sector I) and Wholesale and retail trade (sector G) activities exhibit very weak correlation, if any. A salient characteristic of these sectors is the relatively low skill level of their workforce. Motivated by this observation, we will augment our econometric models with several control variables to account for differences in the skill of workers across sectors.

In Figure 3, we focus on the potential role of skills as a conditioning element in the relationship between EPL and labour productivity growth, using education as the relevant proxy for skills. To illustrate this, we define simple thresholds where we distinguish between industries with a share of workers with at least secondary education above two-thirds, and industries with a share of workers with tertiary education above one-third (left and right panels of Figure 3, respectively). The red and green lines, representing higher and lower education levels, respectively, reveal the conditional impact of EPL on labour productivity.

Figure 3: The link between productivity growth and EPL and the role played by education.



Note: One dot corresponds to a country-sector pair

The left panel in Figure 3 is consistent with the observations in Figure 2: country-sector pairs that predominantly employ a relatively less qualified workforce are likely to benefit somewhat from stricter EPL policy in terms of labour productivity growth (a positively sloped green line in the left panel of Figure 3), whereas EPL correlates negatively with productivity in sectors relying on more educated employees (in red colour *ibidem*). Similar observations are obtained in the right panel of Figure 3, which compares tertiary education to lower education levels (primary and secondary taken together). We again observe that, in country-sector pairs characterised by a larger share of employees with tertiary education, the relationship between EPL and labour productivity growth is more negatively sloped. Both panels thus show that the link between productivity growth and EPL is negative and steeper for greater education levels.

4. Econometric approach

Our econometric specification corresponds quite closely to the figures presented before, while extending the underlying relationships with additional controls. First, to allow for the possibility of a differing impact over time, we include, besides the EPL level in 2007, its short- and long-term changes over time. Second, we further augment the model with many additional country and country-sector-specific factors (or their principal components), mostly aiming to compensate for the absence of country fixed effects.[35] In order

[35] Country-fixed effects are not included in order to avoid collinearity with the country-level EPL indicator.

to avoid potential endogeneity of the post-crisis EPL level to the crisis event, the values for all explanatory variables are fixed at their pre-crisis level (i.e., their values in 2007).[36]

Let $EPL_{c,t0}$ denote the level of the EPL indicator observed in country c in the pre-crisis period t_0 (equal to 2007). The two additional dynamic terms included in the model are the three year and seven-year differences, denoted by $\Delta_h EPL_{c,t0} = EPL_{c,t0} - EPL_{c,t0-h}$, $h \in \{3,7\}$, respectively. These particular values for h were selected relying on their statistical significance, with the seven-year horizon being approximately equal to the average business cycle length in the EU (see, e.g. Giannone et al., 2010). Additional country-sector specific controls and sector-specific fixed effects are denoted by $x_{s,c,t0}$ and α_s, respectively.

To capture the varying influence of EPL on labour productivity conditionally on education levels (primary, secondary, and tertiary), we augment the baseline specification with the interaction terms $EPL_{c,t0}$ x $S2_{s,c,t0}$ and $EPL_{c,t0}$ x $S3_{s,c,t0}$, where $S2_{s,c,t0}$ and $S3_{s,c,t0}$ stand for the shares of workers in sector s of country c in year t_0 with secondary and tertiary education, respectively. Note that, in the specifications containing such interactions, the unconditional $EPL_{c,t0}$ term is associated with the effects for the share of workers with primary education only, which thus serves as the baseline level by construction.[37]

Average yearly labour productivity growth is our dependent variable. Similar empirical results are obtained using both the arithmetic and geometric averages, but the former is more widespread in the literature and thus is used also in our base estimations, leaving the results using the geometric average for robustness checks. We will distinguish between three periods, p: the whole 2008-2017 period ($p=0$), the 2008-2012 recession period ($p=1$), and the 2013-2017 recovery period ($p=2$). Consequently, average yearly labour productivity growth during period p will be denoted hereafter by $\bar{y}_{s,c,p}$. Our main econometric specification is thus as follows:

$$\bar{y}_{s,c,p} = \alpha_s + \beta_0 EPL_{c,t0} + \beta_1 EPL_{c,t0} \text{ x } S2_{s,c,t0} + \beta_2 EPL_{c,t0} \text{ x } S3_{s,c,t0} + \beta_3 \Delta_3 EPL_{c,t0} + \beta_4 \Delta_7 EPL_{c,t0} + \theta' x_{s,c,t0} + \varepsilon_{s,c,p}, \quad (1)$$

where $\varepsilon_{s,c,p}$ corresponds to the i.i.d. error term.[38]

Here, we exploit only the cross-sectional variation, while analysing the effects of EPL on productivity growth over relatively long time periods — akin to a long-differences approach — rather than looking at year-by-year fluctuations. [39] Since the values of all control variables are from the pre-crisis period (i.e., t_0 = 2007) while the dependent variable is the average growth rate for different post-crisis periods, we are effectively investigating the predictive performance of EPL.

It is worth noting that the unconditional shares of workers with secondary and tertiary education (*S2* and *S3*) are included in $x_{s,c,t0}$. It should also be pointed out that eq. (1) does not explicitly include the share of workers with primary education (*S1*), because the shares are perfectly collinear (add up to one). This implies that, although allowing for the inference about the direction of the EPL influence on labour

[36] It is unlikely that the pre-crisis EPL policy could have been influenced by the anticipation of the crisis, since there is consensus that the exact timing of the crisis was essentially unpredictable *ex ante*.

[37] An occupation-based proxy for skills is also used in the robustness section in a similar way, but it is omitted from the specification presented in this section due to its insignificance when considered jointly with education level.

[38] Interaction terms of educational levels with changes in EPL were also investigated in our analysis but were not statistically significant and are not covered here to simplify the presentation.

[39] A (dynamic) panel specification with a joint sector-country cross-sectional dimension estimated using the Generalized Method of Moments estimator will be explored later on, too.

productivity, eq. (1) is a certain reduced representation of the underlying structure where all the education shares are present.[40]

In the next section, we show the main empirical results using the ordinary least squares estimator[41] and consider several alternative specifications to Equation (1), including partial representations, alternative skill indicators, and various sets of control variables. In all the cases presented hereafter, sector fixed effects are always included and statistical inference is obtained relying on heteroscedasticity-robust standard errors.[42]

5. Results

Our empirical study is divided into six building blocks examining different aspects at an increasing level of complexity. First, using rudimentary specifications we analyse the central question of whether EPL and its changes over time significantly affected labour productivity growth during the entire 2008-2017 period. Second, we explore the role of skills have in influencing the impact of EPL on productivity using education levels as a proxy of skills. Third, by splitting the entire sample period, we study the specific effect of EPL during the crisis (2008-2012) and recovery (2013-2017) episodes. Fourth, we evaluate if significant differences in the impact on productivity emerge when distinguishing between the EPL that applies to temporary versus regular contracts. Fifth, we extensively evaluate the importance of potential nonlinearity of the EPL impact. Sixth, by considering a (dynamic) panel model, we go beyond the crisis episode to explore whether (and to what extent) our main findings established using the financial crisis episode are significant also in more general settings.

The significance of EPL

Table 1 presents the basic results, corresponding to the estimation of eq. (1) without any interaction terms:

Table 1: Estimation results for the baseline specification. Dependent variable: average labour productivity growth in 2008-2017.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Level: $EPL_{c,2007}$	-0.0040***		-0.0018	0.0014	-0.0029*	-0.0022	-0.0001
	(0.0014)		(0.0013)	(0.0073)	(0.0015)	(0.0014)	(0.0084)
Short-term change: $\Delta_3 EPL_{c,2007}$		-0.0449***	-0.0418***	-0.0441***	-0.0353*	-0.0401**	-0.0355*
		(0.0148)	(0.0142)	(0.0142)	(0.0179)	(0.0158)	(0.0197)
Long-term change: $\Delta_7 EPL_{c,2007}$		0.0103***	0.0088***	0.0088***	0.0077***	0.0087***	0.0077***
		(0.0023)	(0.0023)	(0.0023)	(0.0028)	(0.0023)	(0.0027)

[40] In Appendix C, we explicate these relationships, whereas the RIDGE regression-based estimation, which identifies the underlying parameters of all shares at the cost of a certain estimation bias, is also presented in the robustness analysis (section 5).

[41] The ridge regression (shrinkage) estimator of the ridge regression, the restricted maximum likelihood estimator of the mixed effects model, and the generalized method of moments of the dynamic panel specification will be employed later on in the respective robustness studies.

[42] In particular, in the main estimations we apply the MacKinnon and White (1985) heteroscedasticity-consistent estimator (the so-called HC1) that adjusts for degrees of freedom and is the most commonly used robust standard error estimator (see, e.g., Hausman and Palmer, 2012). Robustness to a number of alternative corrections will be explored in the robustness check section referring to the results provided in Table 11 (see Appendix B).

Level squared: $(EPL_{c,2007})^2$				-0.0004 (0.0008)			-0.0003 (0.0009)
Share of permanent workers: $Perm_{c,2007}$					-0.0204 (0.0289)		-0.0171 (0.0301)
Economic sentiment index: $ESI_{s,c,2007}$						-0.0001 (0.0002)	-0.0001 (0.0002)
Sector-specific FE	+	+	+	+	+	+	+
R^2	0.1891	0.2496	0.2592	0.2604	0.2604	0.2604	0.2626
R^2-adjusted	0.1411	0.2013	0.1850	0.2049	0.2050	0.2032	0.1973
Degrees of Freedom	203	202	201	200	200	194	192

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

When considered separately in columns (1) and (2) of Table 1, both the EPL level and its changes over time are highly statistically significant. The EPL level in column (1) is significant, which is in line with the previously discussed literature. However, EPL in levels fails to be significant in column (3), where levels and changes are included jointly, potentially suggesting that the permanent impact, i.e., of the EPL level, might be insignificant whenever the temporary effects (of EPL changes) are taken into account. Nevertheless, the signs of all coefficients are retained also in this case. However, the economic effects of EPL changes may not be immediate, since they may only be realized after some time. For example, the related literature suggests that greater EPL may lead to capital deepening, thereby positively affecting labour productivity growth in the longer run (see, for instance, Cingano et al., 2016). However, capital accumulation is a relatively slow process, and this impact can thus only be observed with a certain lag. Furthermore, labour market effects may also not be immediate; both employers and employees may need some time to adjust to the new rules. This motivated our inclusion of shorter- and longer-term changes in EPL, aimed at capturing these distinct processes. Our empirical estimates indeed suggest that the short-run changes in EPL, captured by $\Delta_3 EPL_{c,2007}$ term, are associated with lower productivity growth, thus implying that variations in EPL are more binding in terms of productivity growth in the short term. However, longer-run effects, captured by the $\Delta_7 EPL_{c,2007}$ term, have a positive effect, thus partially softening the overall temporary impact. This might be potentially explained by the fact that stricter EPL stimulates the substitution of labour for capital and vice versa, which is in line with the findings in the literature.

In columns (4)-(6), we further evaluate the potential importance of simple non-linear EPL effects (a quadratic term added to column (4)), the share of the permanent workers (see column (5)), and the state of the business cycle, as captured by the economic sentiment indicator[43] in column (6). A straightforward augmentation of the basic model, given in column (3), with these additional variables does not result in their significant contribution neither when added one-by-one nor jointly (see column (7) for the latter). Nevertheless, an additional subtler and more comprehensive analysis to be provided later on will point to the presence of some nonlinearities, including also interactions with the share of permanent workers.

[43] We use the Economic Sentiment Indicators (see https://ec.europa.eu/info/business-economy-euro/indicators-statistics/economic-databases/business-and-consumer-surveys_en).

Productivity growth and EPL: the role of education

The results in the last section reveal a negative overall dependence between EPL and labour productivity growth. However, they were obtained from a baseline specification of eq. (1), which omits interaction terms and various controls. Next, we explore whether the link between EPL and productivity growth varies across sectors with different worker skills as captured by the share of workers with different education levels. To study this aspect, we augment eq. (1) by including interaction terms of EPL with the share of employees with secondary (*S2*) and tertiary (*S3*) education. We also retain both the level and the short- and long-term changes of the EPL indicator, since, as we will see, they remain significant in almost all equations to be considered in what follows.

Table 2 presents the estimation results of model specifications of an increasing level of complexity and detail. Models corresponding to Columns (1) and (2) are similar to the specifications presented on the left and right panels of Figure 3, respectively. Column (1) extends the previous model with a joint secondary and tertiary education indicator (*S2+S3*) and its interaction with EPL, whereas Column (2) only adds the share of tertiary education, *S3,* (both its level and the respective interaction with EPL).[44] It should be noted that the control groups — associated with the unconditional EPL parameter (see Appendix C for details) — in this case consist of the remaining workers with, respectively: i) less than secondary education in Column (1), and ii) less than tertiary education in Column (2).

Table 2: Dependent variable: average labour productivity growth in 2008-2017.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.0521*** (0.0165)**	**-0.0457*** (0.0156)**	**-0.0625*** (0.0190)**	**-0.0940*** (0.0219)**	**-0.0102*** (0.0205)**	**-0.0069** (0.0022)**		**-0.0903*** (0.0242)**
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0081*** (0.0023)**	**0.0089*** (0.0023)**	**0.0083*** (0.0023)**	**0.0055* (0.0032)**	**0.0074** (0.0031)**	**0.0057* (0.0033)**		**0.0056* (0.0033)**
Level: $EPL_{c,2007}$	**0.0129** (0.0055)**	**0.0028 (0.0022)**	**0.0117* (0.0057)**	**0.0204*** (0.0070)**	**0.0181*** (0.0072)**	**0.0207*** (0.0074)**		**0.0183 (0.0120)**
Interaction with joint second and tertiary education: $EPL_{c,2007}$ x ($S2_{s,c,2007}$ + $S3_{s,c,2007}$)	**-0.0214*** (0.0071)**							
Interaction with tertiary education: $EPL_{c,2007}$ x $S3_{s,c,2007}$		**-0.0207*** (0.0073)**	**-0.0291*** (0.0091)**	**-0.0313*** (0.0087)**	**-0.0295*** (0.0083)**	**-0.0237** (0.0095)**	**-0.0286** (0.0093)**	**-0.0304*** (0.0092)**
Interaction with secondary education: $EPL_{c,2007}$ x $S2_{s,c,2007}$			**-0.0127 (0.0087)**	**-0.0233* (0.0116)**	**-0.0200* (0.0115)**	**-0.0275** (0.0117)**	**-0.0305* (0.0155)**	**-0.0194 (0.0128)**
Secondary and tertiary educ.: ($S2_{s,c,2007}$ + $S3_{s,c,2007}$)	0.1193** (0.0462)							
Tertiary educ.: $S3_{s,c,2007}$		0.0782* (0.0412)	0.1238** (0.0583)	0.1684*** (0.0569)	0.1546*** (0.0553)	0.1365** (0.0643)	0.1573** (0.0616)	0.1594*** (0.0606)

[44] Notice that, although point estimates of *S2* and *S3* were different (see Table 2, starting from Column (3) onwards), we could not reject the hypothesis of their equality at the usual significance levels, which encouraged us to consider the (restricted) case of their sum.

Secondary educ.: $S2_{s,c,2007}$			0.0769 (0.0498)	0.1153 (0.0698)	0.0951 (0.0681)	0.1397* (0.0709)	0.1338 (0.0842)	0.0904 (0.0757)
Eastern Europe dummy				0.0526*** (0.0135)	0.0467*** (0.0136)	0.0302** (0.0134)		0.0486*** (0.0138)
GDP per capita (logarithm)				0.0698*** (0.0179)				
Shadow economy in GDP				-0.0003 (0.0007)				
Control of corruption				0.0111 (0.0089)				
Rule of law				-0.0104 (0.0135)				
Government effectiveness				-0.0097 (0.0106)				
First principal component of macro/institutional controls					-0.0078*** (0.0022)	-0.0050** (0.0022)		-0.0081*** (0.0022)
Second principal component of macro/institutional controls					-0.0194*** (0.0059)	-0.0128* (0.0066)		-0.0204*** (0.0064)
Capital-to-labour growth rate: $\Delta\log(k_{s,c,2008\text{-}2017})$,						0.1252*** (0.0397)		
Level squared: $(EPL_{c,2007})^2$								-0.0002 (0.0010)
Share of permanent workers: $Perm_{c,2007}$								0.0333 (0.0324)
Economic sentiment index: $ESI_{s,c,2007}$								-0.0001 (0.0002)
Sector-specific FE	+	+	+	+	+	+	+	+
Country-specific FE	-	-	-	-	-	-	+	-
R^2	0.3138	0.2964	0.3244	0.4009	0.3912	0.4079	0.4452	0.3975
R^2-adjusted	0.2586	0.2399	0.2627	0.3256	0.3253	0.3352	0.3482	0.3193
Degrees of Freedom	199	199	197	191	194	179	183	185

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

In Column (1), all variables under consideration are highly significant. The coefficient of the interaction term of EPL with the joint indicator (*S2+S3*) is significantly negative, revealing that a stricter EPL policy adversely influences labour productivity in sectors relying predominantly on a more highly educated labour force. On the contrary, the EPL level without an interaction ($EPL_{c,2007}$), which captures the impact of EPL in low-skill intensive industries, has a positive and significant coefficient.[45] These findings are

[45] Potential explanations are as follows. First, less educated persons might be less able and keen to defend their rights (Meager et al., 2002) and, at the same time, firms face relatively smaller costs of firing unskilled employees because of their lower wage rate while also having a better possibility to substitute the less skilled workforce with capital (Griliches, 1969). Hence, in sectors relying more on less educated employees, the *cleansing* effect induced by a crisis leads to a larger reduction of labour hoarding — that was induced by the EPL during the pre-crisis period —, which leads to a productivity increase ceteris paribus. Second, the increased unemployment rate and the reduced employment possibilities across all sectors exert during the crisis a downward pressure on the reservation wage also of the more skilled persons. Hence, firms that previously foresaw higher firing costs of

aligned with the observations in Figure 3 (left panel). Similar results follow in Columns (2) and (3) that include either tertiary only or secondary and tertiary education levels, respectively. The negative impact of the interaction with tertiary education remains always significant.

In Column (4), we further account for the level of economic development, measured by GDP per capita in 2007 (in PPP), the size of shadow economy in 2007 (as a percentage of GDP), indicators for the control of corruption, government effectiveness, as well as the rule of law, and a dummy variable for Eastern European countries. The coefficients associated with our variables of interest remain highly significant. However, we find that the control variables capturing the quality of institutions are insignificant. It is important to note that as their number is rather large and they are highly correlated with each other, the estimates from these models can be susceptible to multicollinearity-induced insignificance of coefficients.[46] Therefore, in Column (5), we replace the extensive list of macroeconomic and institutional control variables with only two significant principal components, keeping the remaining part of the specification the same as in Column (4). Column (5) indicates that the values of the coefficient estimates linked to the main variables of interest remain quite similar, with a slight increase in significance. At the same time, the explanatory power in terms of adjusted R^2 is highly similar in Columns (4) and (5). Hence, we conclude that these two principal components are good substitutes for the five country-level variables, and we use them in the more heavily parameterized specifications that follow hereafter.[47]

Column (6) augments further the previous country-level list of controls with the growth rate of the capital-labour ratio in each country-sector pair during the post-crisis period. Contrary to the other explanatory variables, whose values are fixed at their 2007 level, the capital deepening variable is more likely to suffer from endogeneity problems due to its being measured for the post-crisis period.[48] Nevertheless, all coefficients of interest remain barely affected, except that of the long-run change impact ($\Delta_7 EPL_{2007}$), which remains positive but becomes somewhat smaller and less significant. This is consistent with the interpretation that EPL changes over relatively long periods might be inducing, at least partially, a certain capital deepening effect. Since both the capital-labour ratio and the EPL long-run change variables account for the same process, the latter necessarily becomes less significant.

Next, in Column (7) we evaluate if the five country-level variables - or the respective principal components - used previously account well for country specificity in comparison with the country fixed effects. In this column, we include fixed country effects and thus do without all country-level variables, including the EPL indicators (without interactions). Only the effects of sector-level variables and EPL interactions with sector-specific variables remain identifiable, with their coefficients being quite similar to those obtained in the previous specifications. Hence, we conclude that the included country-level controls seem to account well for unobserved country-level heterogeneity.

Finally, in Column (8) we augment the key specification of column (5) with the same three additional variables as in column (7) of Table 1. As in Table 1, they remain insignificant also here.

more skilled persons due to their higher wages now might start substituting unskilled workforce with the more skilled employees (Pollmann-Schult, 2005), which can also lead to an increase in productivity.

[46] Correlation coefficient for different pairs of institutional variables range from 0.8 to 0.96.

[47] This diminishes the potential increase in variance of estimators as induced by the multicollinearity of the discussed variables.

[48] The inclusion of the values for 2007 produces insignificant estimates for the capital-labour variable.

These results yield several important economic insights that we summarize hereafter. First, the significant negative and positive coefficients of short- and long-term changes[49] (see the first two rows in Table 2) are consistent with our initial expectations regarding the role of labour hoarding and labour substitution with capital, correspondingly. The interpretation is straightforward. Greater EPL increases the employers' costs of firing employees, which becomes especially relevant in the presence of negative shocks. This in turn distorts firms' production choices (Cingano et al. 2016) and labour reallocation (Scarpetta, 2014). Therefore, initially, over short-term periods, greater EPL negatively affects labour productivity growth by leading to inefficient labour choices by firms, whereas, over longer periods, firms aim at reducing their vulnerability to shocks by investing in more capital-intensive technology. However, despite their differing window of impact, both these effects are temporary in our estimations and disappear altogether after about a single business cycle.

Second, the long-term impact of EPL - linked to its level and not its changes over time - is strongly conditional on the level of education of the workforce in a given sector. First, note that, as expected, the coefficients capturing the unconditional effects of tertiary and secondary education (see *S2* and *S3* without interactions) are positive and tend to be higher and more significant for tertiary education, because more skilled workers tend to be more productive. However, the conditional impact, captured by the interaction of educational levels with EPL, is different. In particular, our estimates suggest that sectors relying more heavily on tertiary, and to a lesser extent, secondary, education experience a significant reduction in labour productivity growth due to stricter EPL, whereas sectors characterized by a lower average level of education of the workforce are found to even benefit from stricter EPL in terms of productivity growth.

There are several potential explanations for why higher shares of more skilled/educated workers are related to lower productivity growth under stricter EPL. First, from the workers' perspective, low-educated employees may be unaware of changes in labour protection, or they may not be capable of taking advantage of these changes when firms initiate layoffs, whereas highly educated workers might know their rights better and/or be more inclined to exercise them (see, e.g., Meager et al., 2002, for such evidence with additional references in Denvir et al., 2013). Thus, under a negative shock, higher amounts of high-skilled labour hoarding emerge, leading to lower labour productivity growth in sectors with a large share of skilled workers. This is consistent with evidence presented in Egert and Gal (2016) that stricter EPL might even encourage *hiring* of high-skilled workers while impeding their *firing*. In principle, this problem could be mitigated by unionization. However, OECD data on unionization suggests that, in the analysed countries in 2019, the employee participation rate in trade unions exceeded 50% only in Scandinavian countries.[50]

From the firms' perspective, EPL may potentially imply higher costs associated with redundancy in higher-skilled sectors compared to lower-skill sectors. Once the financial crisis shock materialized, those firms employing a more skilled workforce likely found it more costly to dismiss their higher-skilled workers than firms with a relatively lower-skilled workforce,[51] especially, in sectors relying more on human capital-based technology. This in turn might owe also to the fact that these workers are usually

[49] Notice that the short-term and long-term changes in EPL, captured by $\Delta_3 EPL_{2007}$ and $\Delta_7 EPL_{2007}$, retain the same signs as in the basic specifications in Table 1, and they are significant in all cases but Column (4), which is likely caused by the previously discussed multicollinearity of many controls.

[50] In other countries this percentage is much lower; while Denmark (67.0%), Sweden (65.2%), and Finland (58.8%) have much higher unionization rates than Germany (16.3%), Spain (12.5%), and France (10.8%).

[51] This is consistent with the patterns observed during business cycle downturns (see, e.g., Klein, 2015, Pollmann-Schult, 2005).

paid higher wages and thus tend to accumulate more rights in case of redundancies and/or be better organised (Heywood et al., 2018). This might lead to inefficiently high levels of labour hoarding of more skilled labour and, therefore, lower labour productivity growth. Stronger EPL amplifies all these effects, partly explaining why we find that EPL is more binding in industries with a higher skill composition of the workforce.

So far, we have discussed only the conditional marginal effects. We have shown that the total impact of EPL on aggregate labour productivity in a given sector hinges on the particular labour skill distribution of that sector. In extreme cases where the number of workers with no secondary education is prevailing, our results suggest that an increase in EPL can lead to a higher aggregate productivity growth in the whole sector. However, the number of country-sector pairs with a predominant share of workers who have lower than secondary education is very small.[52] Therefore, at the sector level, we can expect the negative EPL impact to prevail.[53]

Crisis vs recovery

In previous sections, we focused on average labour productivity growth over the whole period under investigation (2008-2017). However, the impact of EPL policies on labour productivity might differ substantially during the crisis and recovery periods. A negative shock that reduces demand creates an immediate pressure on firms to act on the extensive margin by shrinking labour as the main variable of adjustment in the short term. Therefore, during the crisis period a stricter EPL might hurt labour productivity growth to a greater extent, due to *forced* labour hoarding, whereas it might induce an even more intensive labour-replacing process after the crisis than the one initiated already before the crisis. Both factors might thus give rise to higher productivity growth in the recovery period, once demand resumes, on the back of readily available labour and greater production capacity due to heightened capital investment

Consequently, next we investigate if our relationship of interest differs between the crisis and recovery periods. In Table 3, we split the whole sample into two parts: i) the period of the crisis (2008-2012), in Columns (1)-(3), and ii) the recovery period (2013-2017), in Columns (4)-(6). The triplet of columns in each case again corresponds to the equation specifications with secondary and tertiary education levels together, with only tertiary education, and with unrestricted secondary and tertiary education levels, respectively.

Table 3: Dependent variable: Labour productivity growth. Crisis and post-crisis periods.

	Economic crisis: 2008-2012			Recovery period: 2013-2017		
	(1)	(2)	(3)	(4)	(5)	(6)
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.1462*** (0.0313)**	**-0.1460*** (0.0326)**	**-0.1426*** (0.0321)**	**-0.0518** (0.0232)**	**-0.0504** (0.0253)**	**-0.0524** (0.0248)**
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0102** (0.0043)**	**0.0059 (0.0041)**	**0.0083* (0.0048)**	**0.0075** (0.0035)**	**0.0056 (0.0037)**	**0.0067* (0.0038)**
Level: $EPL_{c,2007}$	**0.0310*** (0.0099)**	**0.0147*** (0.0047)**	**0.0294*** (0.0112)**	**0.0092 (0.0067)**	**0.0031 (0.0033)**	**0.0078 (0.0070)**
Interaction with joint second. and tertiary education (regular	**-0.0395*** (0.0131)**			**-0.0144* (0.0086)**		

[52] For instance, there are only two country-sector pairs in which the percentage of workers with at least secondary education is below 10% (sectors A and B in Portugal).

[53] See Section 6 for a broader discussion.

contr.): $EPL_{c,2007}$ x ($S2_{s,c,2007}$ + $S3_{s,c,2007}$)						
Interaction with tertiary education: $EPL_{c,2007}$ x $S3_{s,c,2007}$		**-0.0402*** (0.0096)**	**-0.0434*** (0.0121)**		**-0.0148* (0.0083)**	**-0.0176* (0.0099)**
Interaction with secondary education: $EPL_{c,2007}$ x $S2_{s,c,2007}$			**-0.0325 (0.0210)**			**-0.0086 (0.0121)**
Secondary and tertiary educ. jointly: ($S2_{s,c,2007}$ + $S3_{s,c,2007}$)	0.1917** (0.0891)			0.0793 (0.0545)		
Tertiary educ.: $S3_{s,c,2007}$		0.1889*** (0.0515)	0.2277*** (0.0829)		0.0733 (0.0463)	0.0963 (0.0625)
Secondary educ.: $S2_{s,c,2007}$			0.1503 (0.1226)			0.0511 (0.0662)
Eastern Europe dummy	0.0525** (0.0217)	0.0528*** (0.0167)	0.0599** (0.0235)	0.0240 (0.0160)	0.0295** (0.0135)	0.0261 (0.0165)
First principal component of macro/institutional controls	-0.0108*** (0.0038)	-0.0092*** (0.0035)	-0.0113*** (0.0038)	-0.0039 (0.0029)	-0.0038 (0.0026)	-0.0039 (0.0028)
Second principal component of macro/institute. controls	-0.0330*** (0.0088)	-0.0221*** (0.0078)	-0.0320*** (0.0103)	-0.0086 (0.0062)	-0.0051 (0.0061)	-0.0072 (0.0065)
Sector-specific FE	+	+	+	+	+	+
R^2	0.2693	0.2529	0.2764	0.2641	0.2634	0.2666
R^2-adjusted	0.1985	0.1804	0.1980	0.1928	0.1920	0.1872
Degrees of Freedom	196	196	194	196	196	194

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

Two important differences emerge from inspection of Table 3 when comparing the estimates obtained for the crisis and recovery periods. First, the size and significance of the short-term change of EPL ($\Delta_3 EPL$) is much larger during the crisis episode than in the recovery period. This is consistent with our interpretation linking the short-term change in EPL to labour hoarding: upon a negative shock, stricter EPL policies imply falling labour productivity due to *forced* labour hoarding, whereas this channel becomes less relevant during the recovery period. On the contrary, the long-term change in EPL ($\Delta_7 EPL$), which we link to regulation-induced labour-saving investments, remains of a very similar magnitude.

Second, the impact of the level of EPL is only significant during the crisis, and its interactions with education levels are much larger in absolute terms during the crisis. During the recovery period, all EPL-linked coefficients become less significant and are accompanied by a substantial reduction in their absolute size. This is again consistent with the labour hoarding argument in the presence of a negative shock to output under stricter EPL: in the recovery period, the need for layoffs disappears and therefore EPL ceases to be binding, irrespective of the skill distribution of industries.

Regular vs temporary contracts

So far, we have explored the significance of an aggregate EPL indicator, obtained as the sum of the respective components for regular and temporary contracts. In this subsection, we examine the differences in results when these are used separately.

Table 4 presents the results when distinguishing between the EPL strictness indicators for regular and temporary contracts, again differentiating them according to the triplet specifications, namely with

secondary and tertiary education levels together, only tertiary education, and secondary and tertiary education levels separately (Columns (1)-(3)).[54]

Table 4: Dependent variable: average labour productivity growth, 2008-2017. Regular and temporary contracts.

		(1)	(2)	(3)
Regular contracts	**Short-term change: $\Delta_3 EPL_{c,2007}$**	**-0.1429** (0.0550)**	**-0.1078** (0.0514)**	**-0.1538** (0.0635)**
	Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0157 (0.0130)**	**-0.0055 (0.0135)**	**0.0084 (0.0141)**
	Level: $EPL_{c,2007}$	**0.0282*** (0.0088)**	**0.0080* (0.0046)**	**0.0318*** (0.0090)**
	Interaction with joint secondary and tertiary education: $EPL_{c,2007} \times (S2_{s,c,2007} + S3_{s,c,2007})$	**-0.0410*** (0.0113)**		
	Interaction with tertiary education: $EPL_{c,2007} \times S3_{s,c,2007}$		**-0.0223* (0.0131)**	**-0.0295** (0.0134)**
	Interaction with secondary education: $EPL_{c,2007} \times S2_{s,c,2007}$			**-0.0535*** (0.0174)**
Temporary contracts	**Short-term change: $\Delta_3 EPL_{c,2007}$**	**-0.1096*** (0.0233)**	**-0.1024*** (0.0219)**	**-0.1149*** (0.0247)**
	Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0041 (0.0036)**	**0.0067** (0.0033)**	**0.0018 (0.0038)**
	Level: $EPL_{c,2007}$	**0.0122 (0.0117)**	**0.0088* (0.0045)**	**0.0090 (0.0127)**
	Interaction with joint secondary and tertiary education: $EPL_{c,2007} \times (S2_{s,c,2007} + S3_{s,c,2007})$	**-0.0122 (0.0157)**		
	Interaction with tertiary education: $EPL_{c,2007} \times S3_{s,c,2007}$		**-0.0294** (0.0118)**	**-0.0243 (0.0160)**
	Interaction with secondary education: $EPL_{c,2007} \times S2_{s,c,2007}$			**0.0050 (0.0199)**
Secondary and tertiary educ. jointly: $(S2_{s,c,2007} + S3_{s,c,2007})$		0.1413** (0.0512)		
Tertiary educ.: $S3_{s,c,2007}$			0.1239*** (0.0418)	0.1514** (0.0539)
Secondary educ.: $S2_{s,c,2007}$				0.1405* (0.0723)
Eastern Europe dummy		0.0556*** (0.0186)	0.0400*** (0.0127)	0.0695*** (0.0178)
First principal component of macro/institutional controls		-0.0096*** (0.0031)	-0.0055** (0.0023)	-0.0112*** (0.0030)
Second principal component of macro/institutional controls		-0.0209*** (0.0010)	-0.0119** (0.0059)	-0.0237*** (0.0078)
Sector-specific FE		+	+	+
R^2		0.3956	0.3777	0.4152
R^2-adjusted		0.3232	0.3032	0.3347
Degrees of Freedom		192	192	189

[54] It is important to stress that some previous studies considered only models using an EPL indicator of either regular or temporary contracts. Such omission when explaining the labour productivity effects of both types of contracts may result in omitted variable bias. Hence, in our estimations, we include EPL indicators for both types of contract lengths.

p-value of H_0: all EPL-linked parameters of regular and temporary contracts are the same	0.2833	0.8094	0.1706

Note: * 10% significance level, ** 5% significance level, *** 1% significance level

The comparison of results for regular and temporary contracts reveals the following. First, the significance of the short-term change in EPL, $\Delta_3 EPL_{c,2007}$, is stronger for temporary contracts, although its size is about the same in both cases. Also, its effect of seems to be somewhat more muted for temporary contracts. Second, there is a qualitative difference in terms of the conditional impact of the interaction terms. For temporary contracts, the coefficient attached to the interaction term is significant only for tertiary education (Column (2)),[55] whereas for regular contracts, the interaction of EPL with tertiary and secondary education together is strongly significant.[56,57] Thus, we conclude that regulatory provisions for temporary contracts only exert a negative effect on productivity growth in sectors relying more on the highest-skilled workers, while regulations referring to permanent contracts are binding also at lower skill levels. It is possible that EPL is more binding in high-skilled sectors because they require higher flexibilityIn Table 4, we also provide a statistical test to justify the use of the sum of EPL indicators for regular and temporary contracts. For that purpose, we test the hypothesis that the parameters corresponding to the EPL for regular and temporary contracts[58] are equal. We employ a standard Wald chi-square test and find that the hypothesis cannot be rejected at the usual significance levels (see p-values in the last row of Table 4). This provides evidence in favour of the suitability to use the sum of EPL indicators for temporary and regular contracts throughout our analyses.

Potential nonlinear impact of EPL

The squared EPL term was insignificant in the baseline specifications considered in Table 1 and Table 2, leading us to reject the presence of the quadratic nonlinearity there. In this subsection we show that there are some significant subtler nonlinearities whenever certain thresholds and interactions are taken into account. *Table 5* summarizes the results in the cross-section framework defined by eq. (1), whereas further evidence on non-linear impact of EPL within the panel framework will be explored in the next subsection.

[55] This is consistent with findings in Lisi and Malo (2017).

[56] This is in line with the work of Bassanini et al. (2009), who found a stronger negative relation between productivity growth and EPL for regular contracts.

[57] We should note that, given the doubling in the number of parameters in these specifications relative to the previous ones, the precision of the estimates is likely to be lower, especially because of larger collinearity (the generalized Variance Inflation Factor almost doubles)

[58] That is, the parameters of EPL in levels and its cross-terms.

Table 5: Some nonlinear effects. Dependent variable: average labour productivity growth in 2008-2017.

	(1)	(2)	(3)	(4)	(5)	(6)
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.0855*** (0.0196)**	**-0.1000*** (0.0199)**	**-0.0960*** (0.0198)**	**0.2566** (0.1268)**	**-0.1093*** (0.02002)**	
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0076*** (0.0029)**	**0.0089*** (0.0031)**	**0.0090*** (0.0031)**	**0.0051 (0.0032)**	**-0.0003 (0.0040)**	
Level: $EPL_{c,2007}$	**0.0071** (0.0028)**	**0.0230*** (0.0068)**	**0.0179*** (0.0068)**	**0.0176*** (0.0065)**	**0.0221*** (0.0066)**	**0.0220*** (0.0069)**
Interaction with tertiary education: $EPL_{c,2007}$ x $S3_{s,c,2007}$		**-0.0283*** (0.0085)**	**-0.0216** (0.0092)**	**-0.0268*** (0.0084)**	**-0.0290*** (0.0083)**	**-0.0222** (0.0089)**
Interaction with secondary education: $EPL_{c,2007}$ x $S2_{s,c,2007}$		**-0.0196* (0.0115)**	**-0.0132 (0.0121)**	**-0.0214* (0.0112)**	**-0.0258** (0.0115)**	**-0.0200 (0.0124)**
Tertiary educ.: $S3_{s,c,2007}$	0.0070 (0.0243)	0.1439** (0.0562)	0.1272** (0.0580)	0.1494*** (0.0541)	0.1526*** (0.0540)	0.1315** (0.0563)
Secondary educ.: $S2_{s,c,2007}$	-0.0376* (0.0200)	0.0803 (0.0696)	0.0637 (0.0707)	0.0939 (0.0664)	0.1121* (0.0670)	0.0827 (0.0701)
Eastern Europe dummy	0.0537*** (0.0134)	0.0527*** (0.0137)	0.0522*** (0.0136)	0.0585*** (0.0143)	0.0551*** (0.0134)	0.0636*** (0.0131)
First principal component of macro/institutional controls	-0.0080*** (0.0022)	-0.0091*** (0.0022)	-0.0091*** (0.0022)	-0.0097*** (0.0023)	-0.0123*** (0.0028)	-0.0139*** (0.0026)
Second principal component of macro/institutional controls	-0.0219*** (0.0061)	-0.0266*** (0.0066)	-0.0264*** (0.0067)	-0.0243*** (0.0065)	-0.0238*** (0.0065)	-0.0294*** (0.0070)
$ShPerm_{c,2007}$				-0.0667** (0.0311)		
$EPL_{c,2007}$ with values above the median: $EPL_{c,2007}$ x 1{$EPL_{c,2007} > 4$}	**-0.0037*** (0.0013)**	**-0.0032** (0.0013)**				
Interaction when $EPL_{c,2007}$ > median: $EPL_{c,2007}$ x ($S2_{s,c,2007}$ + $S3_{s,c,2007}$) x 1{$EPL_{c,2007} > 4$}			**-0.0040** (0.0016)**			**-0.0029* (0.0015)**
$\Delta_3 EPL_{c,2007}$ interaction with the share of permanent workers: $\Delta_3 EPL_{c,2007}$ x $ShPerm_{c,2007}$				**-0.4069*** (0.1520)**		**-0.1267*** (0.0238)**
$\Delta_7 EPL_{c,2007}$ whenever it is positive: $\Delta_7 EPL_{c,2007}$ x 1{$\Delta_7 EPL_{c,2007} > 0$}					**0.0334** (0.0133)**	**0.0331*** (0.0100)**
Sector-specific FE	+	+	+	+	+	+
R^2	0.3472	0.4067	0.4078	0.4131	0.4076	0.4208
R^2-adjusted	0.2803	0.3391	0.3403	0.3428	0.3400	0.3548
Degrees of Freedom	195	193	193	192	193	193

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

Although the quadratic term was previously found to be insignificant in Table 1 and Table 2, in column (1) we find the evidence that there is a significant kink in the effect of the EPL; its effect reduces whenever the EPL level is above the cross-country median level (~4).[59] The result holds both whenever interactions with education levels are absent (as in column (1)) or present (see column (2)). This effect

[59] This simple cross-country median approach is very close to (and insignificantly different from) the estimated structural break point at the EPL value of 3.9 using the Muggeo (2003) approach.

seems to be driven more strongly by the share of more educated labour (see column (3)), as its interaction leads to a higher model precision.

Next, column (4) reveals that the productivity adjustment to the short-term EPL change ($\Delta_3 EPL_{c,2007}$) depends crucially on the share of permanent workers in an economy. Larger share of permanent contracts could generate larger amounts of labour hoarding thus reducing the adjustment size and consequently leading to a lower productivity growth. The significance of the interaction with the share of permanent contracts in column (4) suggests that such processes are important.

In column (5) we also find a significant nonlinearity connected with the long-term EPL change ($\Delta_7 EPL_{c,2007}$). Namely, its positive values ($\Delta_7 EPL_{c,2007} \times 1\{\Delta_7 EPL_{c,2007}>0\}$) have a significant positive impact on productivity growth leaving the unconditional linear term ($\Delta_7 EPL_{c,2007}$) insignificant. This asymmetric influence of the EPL changes indicate that, during the crisis, the substitution of labour with capital takes place more whenever the EPL is increasing, whereas there is little influence whenever EPL becomes softer.

Column (6) reconfirms the significance of these nonlinearities when considering them jointly and dropping the connected (highly) insignificant linear terms to reduce the collinearity.

Going beyond the crisis period

Up until now we limited our analysis to the consideration of the crisis-linked implications by exploiting mostly the cross-sectional variation in the country-sector dimension. Although this allowed us to condition the impact on the pre-crisis state in 2007 avoiding many issues appearing when mixing various periods, the mechanisms during the financial crisis might be specific and the obtained results might be also particular to the financial crisis influence. For instance, the established 'labour cleansing' effect, connected mostly with the short-term EPL change, might be much higher during and immediately after the crisis in comparison with more usual times.

In order to investigate if and how much of the results hold more generally, we turn in this section to the (dynamic) panel framework reconsidering the importance of the previously established processes without limiting ourselves only to the crisis episode. Namely, by keeping the same country-sector cross-sectional dimension (with the respective fixed effects included), we look hereafter at the panel with the yearly data ranging from 2005 to 2017, which leads to the respective 'averaged over time' perspective in terms of the relevance of the investigated variables. The endogeneity issue here becomes of the utmost importance and, the usual properly lagged series[60] are employed applying the generalized method of moments (GMM) estimation using the respective adequacy testing framework. Hence, besides the number of instruments, we report the typical testing results for the adequacy of instruments in terms of the over-identification restriction and the absence of higher-order serial correlations. The results provided in *Table 6* rely on the two-steps 'system-GMM' estimator which is preferred on efficiency grounds.

[60] A lag of explanatory variables is used to avoid the simultaneity-induced bias a priori, whereas lags 2 and 3 are used for instrumenting.

Table 6: (Dynamic) panel framework. Dependent variable: labour productivity growth (yearly data in 2006-2017).

	(1)	(2)	(3)	(4)	(5)	(6)
Lagged labour productivity	**0.0015**	**0.0022**	**0.0008**	**0.0012**	**0.0016**	**-0.0198**
	(0.0344)	**(0.0344)**	**(0.0347)**	**(0.0345)**	**(0.0346)**	**(0.0353)**
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.0085*****	**-0.0088****	**-0.0077***	**-0.0087****	**-0.0088****	**-0.0231**
	(0.0042)	**(0.0041)**	**(0.0042)**	**(0.0042)**	**(0.0042)**	**(0.0480)**
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0088*****	**0.0082*****	**0.0091*****	**0.0073*****	**0.0075*****	**0.0089*****
	(0.0027)	**(0.0027)**	**(0.0026)**	**(0.0027)**	**(0.0027)**	**(0.0034)**
Level: $EPL_{c,2007}$	**0.0026*****	**0.0057*****	**0.0042*****	**0.0021***	**0.0022****	**0.0016**
	(0.0004)	**(0.0015)**	**(0.0005)**	**(0.0011)**	**(0.0011)**	**(0.0013)**
Level squared: $(EPL_{c,2007})^2$		**-0.0007****				
		(0.0003)				
Interaction when $EPL_{c,2007}$ > median: $EPL_{c,2007} \times (S2_{s,c,2007} + S3_{s,c,2007}) \times 1\{EPL_{c,2007} > 4\}$			**-0.0033*****		**-0.0026****	**-0.0030****
			(0.0009)		**(0.0013)**	**(0.0014)**
Interaction with tertiary education: $EPL_{c,2007} \times S3_{s,c,2007}$				**-0.0158*****	**-0.0131****	**-0.0145****
				(0.0052)	**(0.0055)**	**(0.0067)**
Interaction with secondary education: $EPL_{c,2007} \times S2_{s,c,2007}$				**0.0002**	**-0.0061**	**0.0072**
				(0.0049)	**(0.0056)**	**(0.0068)**
Tertiary educ.: $S3_{s,c,2007}$				0.0690***	0.0640***	0.0741**
				(0.0233)	(0.0240)	(0.0289)
Secondary educ.: $S2_{s,c,2007}$				0.0027	-0.0162	-0.0239
				(0.0182)	(0.0208)	(0.0246)
$\Delta_3 EPL_{c,2007}$ interaction with the share of permanent workers: $\Delta_3 EPL_{c,2007} * ShPerm_{c,2007}$						0.0126
						(0.0558)
$\Delta_7 EPL_{c,2007}$ whenever it is positive: $\Delta_7 EPL_{c,2007} \times 1\{\Delta_7 EPL_{c,2007}>0\}$						0.0073
						(0.0080)
Point of inflection		4.33				
p-val(Sargan test)	0.6014	0.1788	0.6766	0.6940	0.7820	0.1119
Degrees of freedom (Sargan test)	5	6	6	9	10	12
p-val(1st order serial correlation)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
p-val(2nd order serial correlation)	0.2903	0.2966	0.2792	0.2920	0.2879	0.1313
Number of cross-sections	276	276	276	276	276	276

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

Column (1) in *Table 6* presents the baseline specification analogous to that in column (3) of Table 1, just augmented with the lagged dependent series.[61] The lag of EPL is quite insignificant thus pointing also to the possibility of estimating the respective static models.

[61] Note that country-level variables used previously become redundant due to the presence of country-sector fixed effects and will not be used in the specifications that follow.

Other than in the previous analysis, the EPL level is positive in *Table 6* and significant already in the baseline column (1). Furthermore, even the simple squared term becomes significant in column (2) pointing to the potential presence of an inverted-U shape in the relationship between productivity and the EPL level. The estimated inflection point is very close to the previously used cross-country median EPL value (compare 4.33 and 4). This might indicate that, during more normal (non-crisis) periods, an increase in the strictness of EPL might even facilitate the productivity growth up to some point. Consistent with our previous findings, the kink-like nonlinearity not only is significant, as presented in column (3), but also is more significant than the quadratic term in column (2), i.e., significant at the 1% significance level as compared with the significance at the 5% level. As the quadratic term becomes insignificant when considering together, we use only the kink-like nonlinearity in the specifications that follow.

Next, columns (4) and (5) reveal that the previously established skill-dependent impact of EPL is retained when the whole period is under consideration. However, an important difference is that only the tertiary education remains significant (both unconditionally and interacted), whereas during the crisis also the secondary education appeared as a significant determinant. Hence, industries relying more on workers with tertiary education seem to experience more negative influence because of the EPL increase.

Although the nonlinear impact of EPL remains significant similar to one observed in Table 5, the other two nonlinearities established there – connected with the importance of permanent contracts for the short-term change impact and positivity of the long-term change impact – vanish using the whole period (see column (6)).

Along all the considered specifications, the signs of the short- and long-term EPL changes remain consistent not only mutually but also with our previous findings. However, the absolute size of the short-term change ($\Delta_3 EPL_{c,2007}$) is much smaller as derived from reactions during this whole period and not only the crisis period. Hence, the 'labour cleansing' effect is indeed much smaller on average relative to the one that takes place during the crises.

6. Detailed analysis of impact across countries and sectors

Next, we provide a simple back-of-the-envelope calculation of the potential impact of EPL changes on average labour productivity growth during 2008-2017 in the EU countries for which we have data. We rely on the estimates reported in Column (6) of Table 2 and use the education level of employees as a proxy for their skill level in each sector of each country to derive the impact of a change in the EPL indicator (namely, the sum of regular and temporary EPL indicators). In the simulations, we assume that the EPL reduction is equal to the average *absolute* yearly change in EPL, which amounts to around 0.5.

Table 4 and Figure 5 report the calculated total change in labour productivity growth due to a unit reduction of the EPL indicator. A relatively small impact is observed in Figure 4 for Greece (EL), Spain (ES), Italy (IT), and Portugal (PT). The pattern in terms of the size of effects across different industries is also very similar in these countries. The impact in Luxembourg (LU) and Denmark (DK) is outstanding in

a few sectors. Concerning the impacts at the sectoral level, these are strongest for E, and J through MN, whereas a typically lower impact is seen for A, B, and F trough I activities (see Figure 5).

Figure 4: Impact on labour productivity growth due to a 0.5-unit reduction in the EPL indicator across different countries (in p.p.).

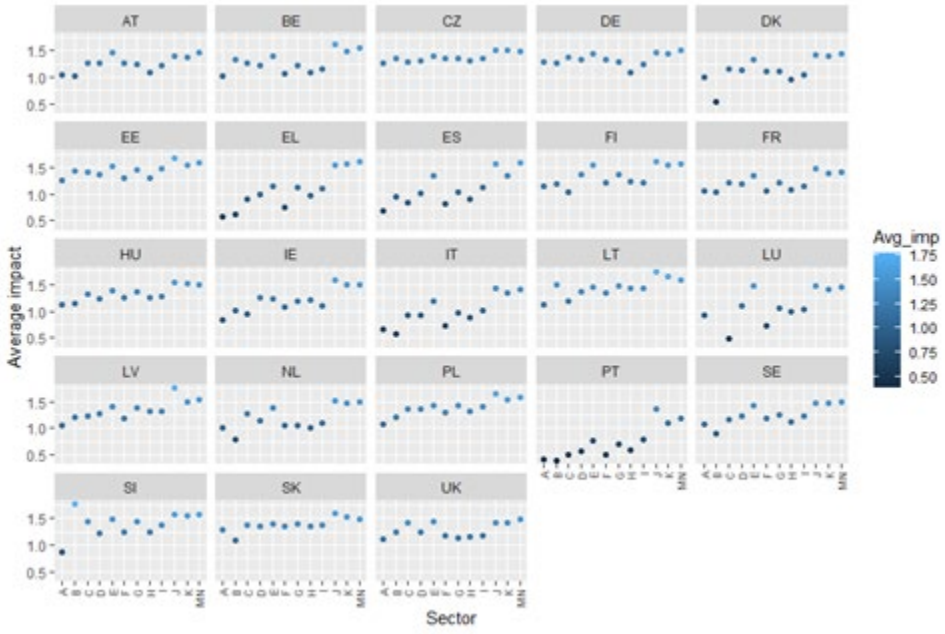
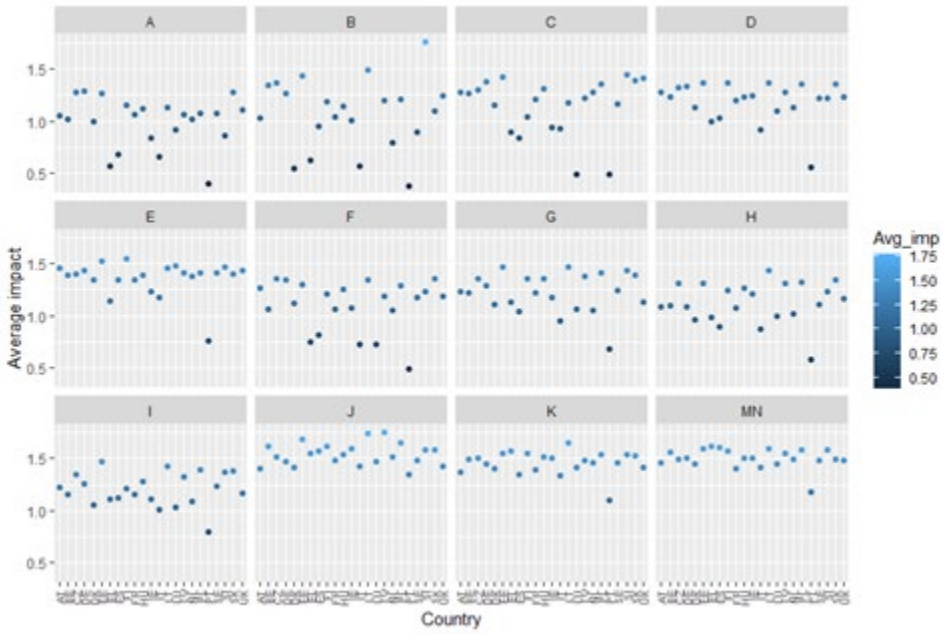


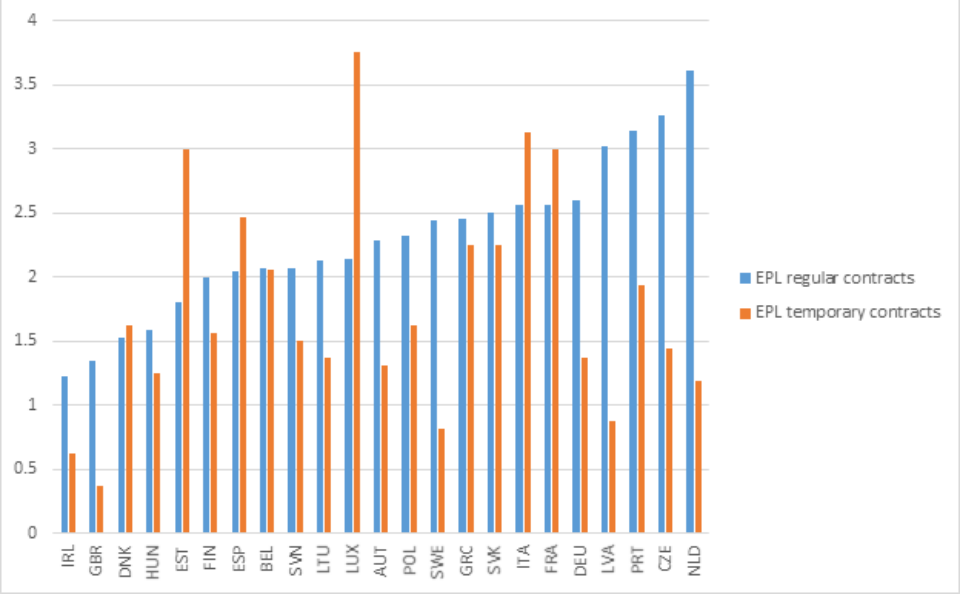
Figure 5: Impact on labour productivity growth due to a 0.5 unit reduction in the EPL indicator across different sectors (in p.p.).



The calculated impact is sizeable, and, at the country level, it could have typically led to a slightly more than one percentage point higher growth in labour productivity. Nevertheless, one needs to keep in mind a few caveats related to the fact that a large part of this impact is determined by temporary changes in EPL. First, we recall that the short-term change ($\Delta_3 EPL$) is specific to the three countries driving its value in 2007 (see the discussion in the previous section on robustness) and thus might be insufficiently precise. The use of the ridge regression-based results, which reduces the variance of coefficients, would yield, in an analogous simulation, about a tenfold smaller average impact without a noticeable change in other observed patterns, i.e., the impact remains positive and the variation across countries and sectors is remarkably similar. Second, the consideration of only the permanent part of the impact connected with the EPL level and its interactions with the education levels leads to a much more different picture in terms of the size of the impact (see Figure 8).Apart from that, different models result in slightly different results. For example, model 4 (Table 4), which captures nonlinearities in EPL, estimates average effects on productivity by 0.3-0.5 p.p. greater than in the case of a linear model (Figure 9). At the same time, its permanent effects are lower (Figure 10).

Turning to the degree of manoeuvre for policy intervention, Figure 6 presents EPL by country in 2019. It indicates that the countries with the most stringent regular-contract employment protection legislation were the Netherlands, Czech Republic, Portugal, Germany, France and Italy. The highest values of EPL for temporary contracts are in Luxembourg, Italy, France, Estonia and Spain. It thus is in all these countries where the scope is most ample for labour market reforms conducive to stimulating labour productivity growth.

Figure 6: EPL by country (2019)



7. Further robustness and impact analysis

In this section, we provide twelve (augmented) variations of previous specifications to assess the robustness of our earlier findings and to obtain further insights. We cover several different definitions of the dependent variable (namely, TFP, quality-adjusted labour productivity, as well as different types of averages), one alternative skill indicator, and several additional control variables not covered previously (namely, post-crisis EPL policy, lagged productivity variable, unionization level, GDP growth rate, periphery indicator, etc.). Furthermore, we also carry out two additional estimations including country and sector random effects and using the RIDGE regression. Due to extensive robustness coverage, we look hereafter only at a single specification, corresponding to Column (5) in Table 2, corresponding to separate tertiary and secondary education variables, a dummy variable for Central and Eastern European (CEE) countries, and the two principal component controls. The findings with other specifications are very similar to the ones in Table 2.[62]

First, we re-estimate the same specification of Column (5) in Table 2, using total factor productivity (TFP) as the dependent variable in Column (1) of Table 9. The impact of EPL conditional on education remains highly significant. However, all the other controls as well as the changes of EPL over time become statistically insignificant. This might partially be because the number of observations and degrees of freedom is smaller when using TFP compared with labour productivity. [63]

Second, in Column (2) we provide evidence indicating that the use of the geometric average, which is more robust to outliers, instead of the arithmetic average of labour productivity, would only increase the significance of our earlier findings.[64] We retain the use the arithmetic average in our main estimations as it is more generally applied in the related literature.

Third, in Column (3) we augment the previous specification with an additional metric for workers' skills. Specifically, we use the share of white-collar employees in each sector of each country, next to the education levels, as a proxy for the distribution of skills across industries. The coefficients associated with changes in EPL over time as well as EPL interactions with education retain the same signs as earlier and become even more significant. Although the unconditional white-collar variable is marginally significant, its interaction with EPL is not significant. This further substantiates our choice of education as the relevant proxy for skills in previous sections.

Fourth, the EPL policy might be responsive to the crisis event and, if modified as a consequence, it could influence labour productivity differently. To capture such a possibility, we introduce in Column (4) the change of EPL during the post-Great Recession 2008-2017 period and its interaction with the 2007 level of EPL.[65] We carry out this exercise for a simple robustness illustration since, as opposed to variables fixed at the pre-crisis level, this additional post-crisis EPL change might be endogenous. Nevertheless,

[62] In particular, we find that the results are stronger with i) only tertiary education, ii) merged tertiary and secondary education levels, and iii) the additional controls considered in Table 2.

[63] The precision of the estimations is also lower, as measured by both R^2 indicators, which reinforces our choice of labour productivity for the main analysis; EPL policies directly affect labour hiring/firing conditions while they affect TFP only indirectly. In addition, the drivers of TFP are manifold.

[64] The geometric average of the whole post-crisis period is defined here by $\bar{y}_{s,c,p} = [\prod_{t=2008}^{2017}(1 + y_{s,c,t})]^{1/10} - 1$, where $y_{s,c,t}$ denotes the labour productivity growth rate in a particular period t.

[65] Also, the variation in the post-crisis period by using later starting years to account for a potential lag in the decision making process while introducing the EPL changes did not produce significant results.

neither post-crisis changes in EPL nor its interaction with pre-crisis EPL level are significant in Column (4), indicating that the relationship between labour productivity growth and EPL was not significantly altered after the crisis.[66]

Fifth, as different degrees of trade unionization in countries might lead to varying responses to EPL policies, in Column (5) we check the robustness of our results to the inclusion of the unionization level and its interaction with the EPL indicator. Both coefficients are not significant, while as in Column (4), the impact of EPL conditional on tertiary education is more stable compared with the secondary education indicator.

Sixth, in order to account for the dynamics of productivity (e.g., the capital accumulation process might be highly persistent), we include the average growth rate of productivity during the ten-year period prior to the crisis (1998-2007), as well as its interaction with the EPL level. Both variables appeared to be insignificant. Nevertheless, the other explanatory variables remain significant, except the secondary education and its interaction with EPL.[67]

Seventh, in addition to accounting for the specificity of the CEE region, we check in Column (7) the significance of a dummy variable for 'Southern periphery' that takes value one for Greece, Italy, Spain, and Portugal, and zero otherwise. We do not detect any significant effect of belonging to any of these countries in conditioning the impact of EPL on productivity growth.

Eighth, in Columns (8) and (9), we explore the relevance of the share of temporary workers in two different ways. First, we include directly the share of temporary workers and its interaction with the EPL indicator in Column (8). This renders all the previously established results stronger in terms of statistical significance. Furthermore, a negative coefficient of the EPL interaction with the share of temporary workers indicates that a stricter EPL has a stronger negative impact in country-sector pairs with a larger share of temporary contracts[68]. Second, instead of using the sum of the EPL indicators for regular and temporary contracts, in Column (9) we employ a weighted EPL measure where the shares of regular and temporary workers are used to weigh the respective EPL indicators. All the main results are robust to this alternative way of defining the EPL indicator. Furthermore, we find a larger and more significant negative effect of secondary education in its interaction with the weighted EPL indicator.

Ninth, in Column (10) we perform an additional verification of the skill dependence of the impact of EPL on productivity established in previous sections. For this purpose, we calculate sector-specific productivity growth rates based on the Quality Adjusted Labour Input (QALI) skills indicator, instead of quality-unadjusted hours.[69] This aims at factoring out the influence of employees' differences in qualification levels on labour productivity. With this metric, the previously established significance of the effect of EPL conditional on educational levels on labour productivity is expected not to be detected, since in principle it already controls for differences in skills. The results in Column (10) concord well with these expectations. Therefore, we conclude that qualification levels are indeed closely linked to the conditional impacts we found before. Nevertheless, the coefficient of the short-term change in EPL remains negative and highly significant, showing that this effect is robust to removing the heterogeneity stemming from differences in the skills of workers.

[66] The interaction term between EPL and the share of workers with secondary education becomes insignificant, however. The conditional impact of EPL in connection with tertiary education remains highly significant.
[67] Analogous results hold for the (pre-crisis) GDP and GDP per capita growth rates and thus they are not reported here.
[68] This is consistent with the findings described in the literature review.
[69] The data can be found in: https://ec.europa.eu/eurostat/web/experimental-statistics/qali

In Column (11) we report the estimation results obtained after controlling for sector specificity using random effects at both the sector and country levels. At the cost of potential bias due to existing covariance between the errors and the explanatory variables, this aims at checking whether the previously used combination of sector fixed effects with a set of country-specific variables is sufficient for explaining the underlying heterogeneity. Negative and highly significant coefficients attached to the short-term changes in EPL and the interaction term of EPL with tertiary education are found again, further reinforcing the robustness of our initial analyses.

Finally, in Column (12), the RIDGE regression estimation results are presented with the estimated coefficients of all education shares.[70] Despite the reduction in the value of the estimated parameters imposed by this approach, the results remain very similar in qualitative terms both for EPL changes over time and for the interactions of EPL with secondary and tertiary education shares. All coefficients related with the share of primary education are insignificant.

Despite these alterations and the limitations due to a sizeable variation in degrees of freedom, due to missing data for some additional variables, Table 9 reveals that the finding that EPL exerts a negative impact on labour productivity growth, and that the long-run effect is larger in industries with more qualified workers, still holds.[71]

To finalize this section, we would like to underline that, out of all the effects, the short-term EPL change term (Δ_3EPL) exhibits the largest variation in terms of its estimated coefficient across the different models considered. In this sense, it is the least robust component in our estimations. This is directly connected with the fact that, in 2007, there were only three countries (Czech Republic, Ireland, and Spain) where Δ_3EPL changed. To evaluate how influential they are individually, we perform an additional robustness check by dropping/keeping various combinations of these countries in the estimations (see Table 12 in the Appendix). Despite these variations, the short-term change remains significant, indicating that the considered change is informative and important even if derived from a handful of countries.

[70] The RIDGE regression penalization parameter is chosen according to the method proposed by Cule and Iorio (2013).

[71] It is also worth noting that our findings are also robust to the use of various approaches to provide heteroscedasticity-r estimation of standard errors. Table 9 in Appendix B reports the estimation results without any correction and using the following methods: HC0 (White ,1980), HC1 (MacKinnon and White, 1985), HC3 (Davidson and MacKinnon, 1993), with clustering by countries, with clustering by sectors. In additional robustness checks that are available upon request, we further show in the additional robustness checks (see Table 10) that our main results are retained when further controlling for financial deepening (in terms of private credit to GDP), foreign trade openness, government expenditure to GDP, investment (capital formation) to GDP, population, inflation, and several interactions of the share of permanent workers with education levels S2 and S3, aiming to evaluate robustness to the potential presence of links between education level and permanency of contracts.

8. Final remarks

Our findings are in line with previous studies establishing that stricter EPL hurts productivity growth, especially during the period of crisis, whereas less binding EPL is associated with greater labour productivity growth, at least up to some point. Indeed, our results confirm that there exists some room for improving productivity growth by adopting a less stringent EPL framework, especially in countries with very strict EPL regulations. However, we also find that the predominant part of such positive effect is retained only for about three years, whereas the long-term impact of EPL is conditional on the specific skill/education distribution of workers across sectors, with higher education associated with a stronger positive effect under decreasing EPL.

Our results point to several policy-relevant message insights. First, our results show that EPL should take into account not only its level, but also sectoral specificities, especially in terms of the varying distribution of skills across industries. In particular, overly stringent EPL is especially harmful for productivity growth in sectors employing a relatively more skilled workforce. Thus, the sectoral dimension is an important element to consider in the design of employment protection policy as regards its potential impact on labour productivity growth at the sectoral level. Second, the simultaneous reduction of EPL together with the promotion of education and skills is important to foster labour productivity growth in high-skilled sectors, especially in countries where EPL is very binding. Third, moderate levels of EPL might not be productivity-harming in the long run, since it stimulates the substitution of labour for capital. This effect needs to be balanced against the negative shorter-term effects.

At the same time, the established dependence of the impact of EPL on productivity growth on the education levels of the workforce and the share of permanent contracts might also hint that the less educated workforce is more easily dismissed, especially during the crisis period, as they also tend to work more based on temporary contracts. This might indicate either insufficient legislative regulation for less educated workers or their inability to properly understand and exploit their rights.[72]

In sum, in light of our analysis, it follows that a policy mix that bundles laxer EPL with increased education of the labour force is best suited for raising labour productivity growth in the short and in the long run.

In terms of the lessons that can be extracted from this analysis for the COVID-19 crisis, it is worth noting the markedly different features between both crises. The most recent crisis was characterized by the preservation of jobs in all industries, irrespective of their skill and/or EPL levels (Arpaia et al. 2021). This effectively meant that the work support schemes put in place by the majority of EU countries were especially important to safeguard labour relationships in contact-intensive industries, since the latter were hit harder by the containment measures implemented by most governments. On one hand, these policies might have helped preserve efficient labour matches, thereby rendering labour productivity more resilient to the crisis. On the other hand, if these work support schemes assisted relatively low-productivity workers in maintaining their jobs when they would have otherwise been dismissed and/or if they led to *artificially* long spells from the workforce, then it is likely they might have hampered labour productivity and prevented the so-called *cleansing* effect. To the extent that the job protection measures adopted correlate highly and positively with EPL, then it is likely that the latter has helped to amplify both the negative and positive effects on labour productivity just discussed. Confirming this hypothesis and deepening the analysis of the effects of the job support measures widely implemented throughout

[72] See, e.g., Meager et al., 2002, Denvir et al., 2013, and OECD, 2019.

the crisis — including the role played by the skill level of the workforce as we do in this paper —is a fruitful avenue for future research.

It is also important to note that our conclusions are subject to the limitations of the performed analysis and the underlying empirical approach assumptions. One important caveat is that EPL data from the OECD database are country-specific and do not capture the specificities of sectors, whereas formal employment protection and informal rules of conduct can vary between the sectors. Apart from that we focused on aggregate economic sectors using country-level data. An analysis at a more granular disaggregation of both sectors and regions is left for future research. Furthermore, the aggregate EPL indicator masks the detailed regulatory policies within it, which might also exert a particular influence. A deeper understanding of these more fine-grained regulatory aspects and additional sources of heterogeneity in responses, including EPL-induced changes in the skill composition of the labour force across sectors, would require further analysis, potentially using different datasets and econometric models.

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Appendix A

Table 7: Sector codes

Sector code	Sector name
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Total manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage; waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
M_N	Professional, scientific, technical, administrative and support service activities

Table 8: Descriptive Statistics

	mean	sd	min	max	N
Productivity growth 2008-2017	0.0029	0.0299	-0.1998	0.0768	299
Productivity growth 2008-2012	-0.0026	0.0452	-0.3574	0.1337	299
Productivity growth 2012-2017	0.0088	0.0310	-0.1062	0.1235	299
Δ $EPL_{2005-2007}$	-0.0008	0.0376	-0.0833	0.1237	234
Δ $EPL_{2001-2007}$	-0.0326	0.0983	-0.2857	0.1429	234
EPL_{2007}	4.0842	1.3209	1.728	6.978	234
Tertiary education (25+ year old)	0.2613	0.1804	0	0.7889	298
Secondary educ. (15+ year old)	0.5156	0.1894	0	0.9405	298
Eastern Europe dummy	0.3478	0.4771	0	1	299
Principal component (1)	0	2.0731	-2.9094	3.3000	299
Principal component (2)	0	0.3480	-1.9120	0.7021	299
Log(GDP/cap), 2007	10.6026	0.3660	9.9779	11.6563	299
Shadow economy, % of GDP, 2007	14.7261	5.2776	6.4	23.8	299
Control of corruption, 2007	1.2213	0.7676	0.13	2.45	299
Δlog(k), 2008-2017	-0.0284	0.0765	0.5057	0.1669	284

Appendix B

Figure 7: EPL dynamics by country

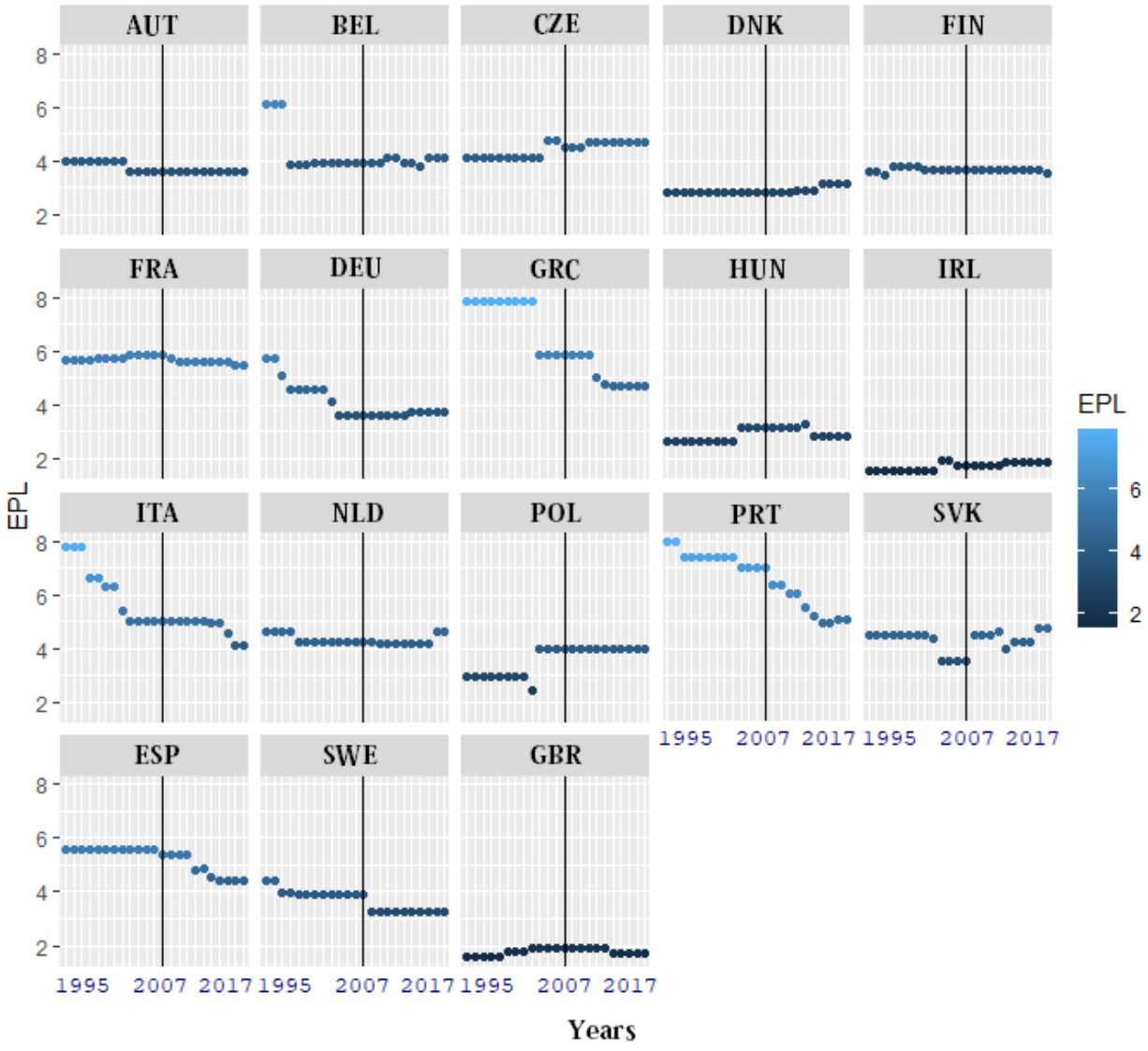

Figure 8: Permanent impact on labour productivity growth due to a 0.5-unit reduction in the EPL indicator across different countries (in p.p.).

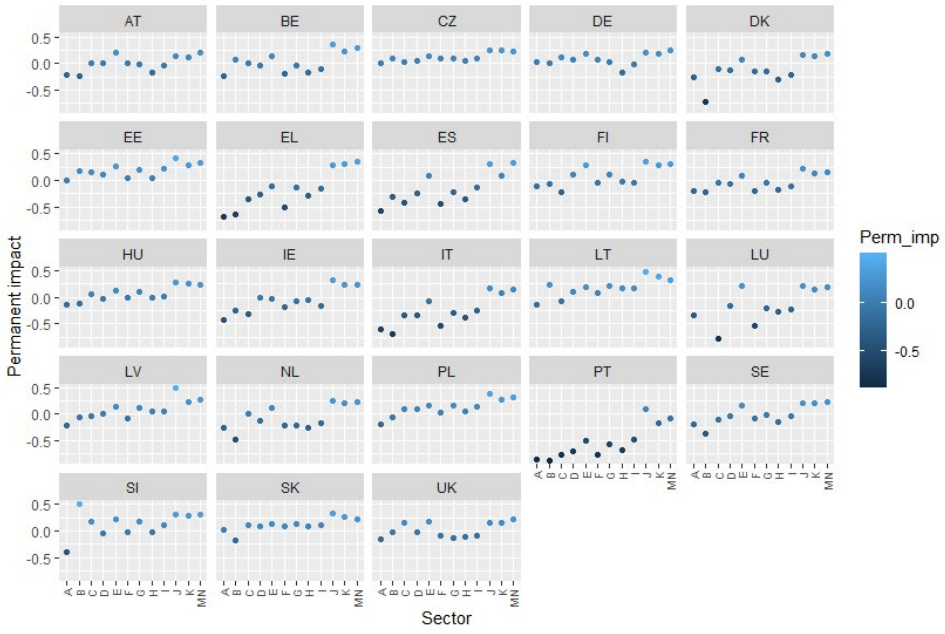

Figure 9: Average impact on labour productivity growth due to a 0.5-unit reduction in the EPL indicator across different countries, nonlinear model (in p.p.).

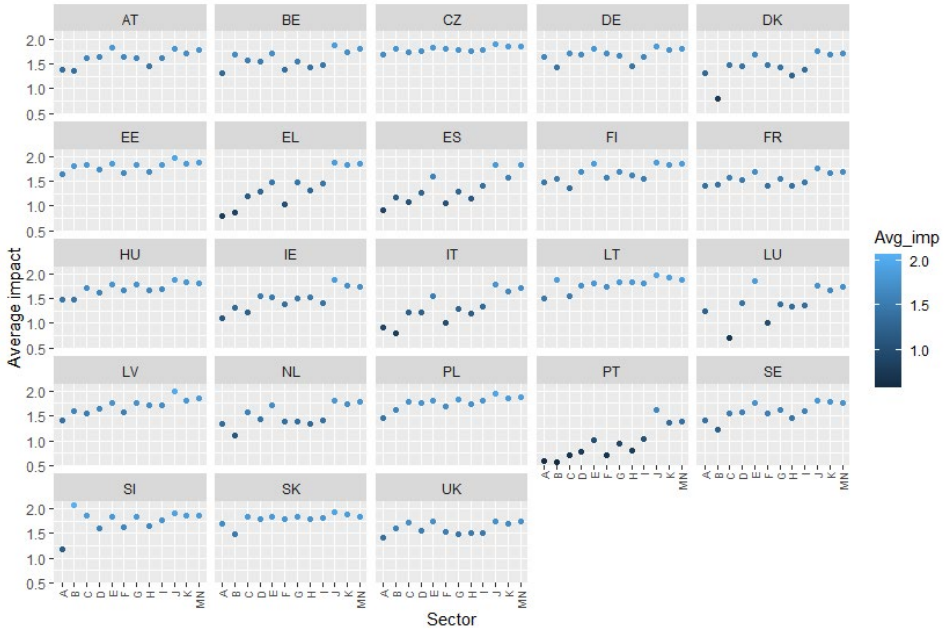

Figure 10. Permanent impact on labour productivity growth due to a 0.5- unit reduction in the EPL indicator across different countries, nonlinear model (in p.p.).

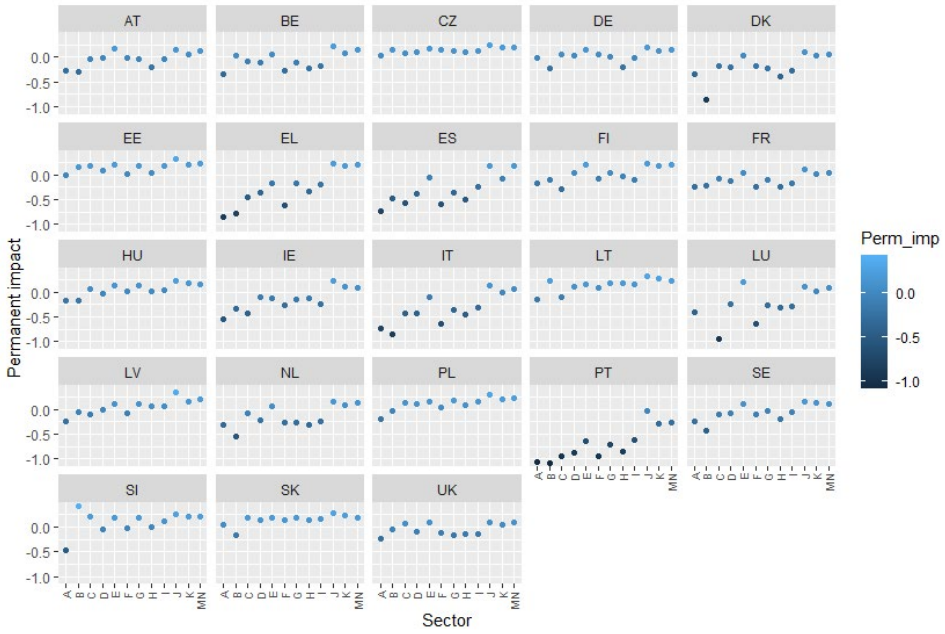

Table 9: Robustness checks. Dependent variable: average productivity growth in 2008-2017 (TFP in Column (1), geometric average of labour productivity in Column (2), labour productivity adjusted for quality of labour in Column (10), and arithmetic average of labour productivity in the remaining columns).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Short-term change: $\Delta_3 EPL_{c,2007}$	0.00260 (0.0410)	-0.0992*** (0.0204)	-0.0968*** (0.0202)	-0.1000*** (0.0209)	-0.1169*** (0.0236)	-0.1034*** (0.0210)	-0.1046*** (0.0209)	-0.1090*** (0.0244)	-0.0953*** (0.0211)	-0.0919** (0.0352)	-0.0786*** (0.0247)	-0.013*** (0.0045)
Long-term change: $\Delta_7 EPL_{c,2007}$	-0.0072 (0.0055)	0.0087*** (0.0032)	0.0081** (0.0031)	0.0082** (0.0033)	0.0065* (0.0039)	0.0071** (0.0032)	0.0062* (0.0034)	0.0088*** (0.0034)	0.0053* (0.0029)	-0.0058 (0.0067)	0.0049 (0.0037)	0.0018*** (0.0046)
Level: $EPL_{c,2007}$	0.0362** (0.0159)	0.0210*** (0.0060)	0.0183*** (0.0064)	0.0172* (0.0078)	0.0196 (0.0146)	0.0188*** (0.0065)	0.0196*** (0.0067)	0.0300*** (0.0084)	0.0362*** (0.0102)	0.0145 (0.0112)	0.0116 (0.0075)	-0.0129*** (0.0042)
Interaction with tertiary education: $EPL_{c,2007} \times S3_{s,c,2007}$	-0.0368** (0.0161)	-0.0310*** (0.0078)	-0.0376*** (0.0104)	-0.0290*** (0.0086)	-0.0353*** (0.0120)	-0.0319*** (0.0085)	-0.0284*** (0.0084)	-0.0307** * (0.0085)	-0.0482*** (0.0145)	-0.0191 (0.0135)	-0.0151** (0.0064)	-0.0078** (0.0039)
Interaction with second. education: $EPL_{c,2007} \times S2_{s,c,2007}$	-0.0499* (0.0264)	-0.0239** (0.0109)	-0.0233** (0.0115)	-0.0187 (0.0128)	-0.0171 (0.0216)	-0.0185 (0.0114)	-0.0224* (0.0115)	-0.0309*** (0.0119)	-0.0527*** (0.0186)	-0.0197 (0.0216)	0.0048 (0.0058)	-0.0097** (0.0039)
Interaction with primary education: $EPL_{c,2007} \times S1_{s,c,2007}$												-0.0017 (0.0035)
White-collar share: $WC_{s,c,2007}$			-0.0601* (0.0329)									
Interaction with white-collar share: $EPL_{2007} \times WC_{s,c,2007}$			0.0058 (0.0052)									
Post-crisis EPL change: $\Delta_{10} EPL_{c,2017}$				0.0070 (0.0126)								
Interaction with post-crisis EPL change: $EPL_{c,2007} \times \Delta_{10} EPL_{c,2017}$				-0.0012 (0.0027)								
Unionization: $UNZ_{c,2017}$					0.0003 (0.0007)							
Interaction with unionization: $EPL_{c,2007} \times UNZ_{c,2017}$					-0.0005 (0.0018)							

Pre-crisis productivity growth: $\Delta_{10}\bar{y}_{s,c,2007}$						0.1794 (0.2314)						
Interaction with pre-crisis productivity growth: ***EPL*$_{2007}$ x** $\Delta_{10}\bar{y}_{s,c,2007}$						-0.0480 (0.0469)						
Southern periphery dummy							-0.0129 (0.0087)					
Interaction with share of temporary workers: ***EPL*$_{c,2007\ x}$ *SHTMP*$_{c,2017}$**								-0.0592** (0.0241)				
Share of temporary workers: ***SHTMP*$_{c,2017}$**								0.2630*** (0.0986)				
Tertiary educ.: *S3*$_{s,c,2007}$	0.2064** (0.0846)	0.1650*** (0.0512)	0.2060*** (0.0618)	0.1539*** (0.0558)	0.1812*** (0.0687)	0.1575*** (0.0571)	0.1447** (0.0562)	0.1552*** (0.0550)	0.1456*** (0.0483)	0.1664** (0.0764)	0.0569* (0.0287)	0.0029 (0.0036)
Secondary educ.: *S2*$_{s,c,2007}$	0.2261* (0.1165)	0.1159* (0.0638)	0.1172* (0.0685)	0.0918 (0.0707)	0.0870 (0.1028)	0.0855 (0.0683)	0.0970 (0.0676)	0.1297* (0.0672)	0.1344** (0.0580)	0.0842 (0.1149)	-0.0434 (0.0275)	-0.0067 (0.0034)
Primary educ.: *S1*$_{s,c,2007}$												-0.0019 (0.0034)
Eastern Europe dummy	0.0170 (0.0185)	0.0456*** (0.0060)	0.0451** (0.0134)	0.0436*** (0.0156)	0.0549*** (0.0159)	0.0487*** (0.0138)	0.0423*** (0.0130)	0.0491*** (0.0131)	0.0553*** (0.0122)	0.0498** (0.0207)	0.0379** (0.0143)	0.0123*** (0.0040)
First principal component of macro/institutional controls	-0.0062 (0.0037)	-0.0083*** (0.0021)	-0.0080*** (0.0021)	-0.0073*** (0.0024)	-0.0081*** (0.0023)	-0.0078*** (0.0021)	-0.0063*** (0.0021)	-0.0083*** (0.0021)	-0.0089*** (0.0020)	-0.0082* (0.0042)	-0.0042 (0.0026)	0.0024 (0.0046)
Second principal component of macro/institut. controls	-0.0085 (0.0110)	-0.0204*** (0.0057)	-0.0213*** (0.0060)	-0.0193*** (0.0061)	-0.0224** (0.0069)	-0.0184*** (0.0059)	-0.0208*** (0.0062)	-0.0215*** (0.0060)	-0.0229*** (0.0064)	-0.0242* (0.0130)	-0.0089 (0.0059)	0.0043 (0.0043)
Sector-specific FE	+	+	+	+	+	+	+	+	+	+	-	+
Sector and country RE	-	-	-	-	-	-	-	-	-	-	+	-
R^2	0.3049	0.4088	0.4032	0.3926	0.4306	0.4357	0.3962	0.4093	0.4002	0.2846	0.2011	0.1674
R^2-adjusted	0.2035	0.3448	0.3317	0.3198	0.3466	0.3635	0.3274	0.3385	0.3352	0.1911		0.0676
Degrees of Freedom	144	194	192	192	156	180	193	194	194	153	192	191

Notes: * 10% significance level, ** 5%significance level, *** 1% significance level. In Column (9), the weighted EPL is used with the shares of temporary and regular workers as weights. The conditional R^2 is reported in Column (11).

Table 10: Further robustness checks. Dependent variable: average productivity growth in 2008-2017.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Short-term change: $\Delta_3 EPL_{c,2007}$	-0.1011*** (0.0203)	-0.1011*** (0.0195)	-0.1066*** (0.0212)	-0.1006*** (0.0222)	-0.0728*** (0.0219)	-0.1052*** (0.0211)	-0.0994*** (0.0250)	-0.1166*** (0.0250)
Long-term change: $\Delta_7 EPL_{c,2007}$	-0.0078** (0.0033)	-0.0075** (0.0031)	-0.0072** (0.0032)	-0.0075** (0.0032)	-0.0103** (0.0032)	-0.0071** (0.0032)	0.0055* (0.0031)	0.0067* (0.0037)
Level: $EPL_{c,2007}$	0.0181*** (0.0067)	0.0181*** (0.0068)	0.0190*** (0.0067)	0.0181*** (0.0067)	0.0179*** (0.0066)	0.0184*** (0.0068)	0.0104** (0.0045)	0.0308** (0.0086)
Interaction with tertiary education: $EPL_{c,2007} \times S3_{s,c,2007}$	-0.0296*** (0.0083)	-0.0295*** (0.0084)	-0.0302*** (0.0086)	-0.0296*** (0.0083)	-0.0314*** (0.0089)	-0.0295*** (0.0085)	-0.0293*** (0.0076)	-0.0346*** (0.0090)
Interaction with second. education: $EPL_{c,2007} \times S2_{s,c,2007}$	-0.0199* (0.0115)	-0.0199* (0.0117)	-0.0221* (0.0115)	-0.0202* (0.0118)	-0.0294*** (0.0112)	-0.0213* (0.0119)		-0.0357*** (0.0123)
Population size: $Pop_{c,2007}$	-0.0007 (0.0018)							
Trade openness: $Open_{c,2007}$		0.0001 (0.0001)						
Government expenditure to GDP: $GvExp_{c,2007}$			0.0004 (0.0005)					
Capital formation to GDP: $Cap_{c,2007}$				0.0001 (0.0007)				
Private credit to GDP: $Cred_{c,2007}$					-0.0001 (0.0001)			
Inflation: $Inf_{c,2007}$						-0.0009 (0.0013)		
Interaction: Share of temporary workers with S3							0.0523 (0.1135)	0.1906 (0.1335)
Interaction: Share of temporary workers with S2								0.2761* (0.1525)
Interaction: Share of temporary workers with EPL level							-0.0140 (0.0198	-0.0251 (0.0296
Share of temporary workers: $SHTMP_{c,2017}$							0.0664 (0.0853	-0.0657 (0.1985
Tertiary educ.: $S3_{s,c,2007}$	0.1562*** (0.0550)	0.1545*** (0.0555)	0.1604*** (0.0566)	0.1549*** (0.0553)	0.1729*** (0.0575)	0.1544*** (0.0562)	0.1260*** (0.0407)	0.1498*** (0.0559)
Secondary educ.: $S2_{s,c,2007}$	0.0966 (0.0681)	0.0949 (0.0685)	0.1017 (0.0675)	0.0964 (0.0712)	0.1382** (0.0712)	0.0973 (0.0692)		0.1125 (0.0708)
Primary educ.: $S1_{s,c,2007}$								
Eastern Europe dummy	0.0447*** (0.0145)	0.0460*** (0.0138	0.0516*** (0.0154)	0.0456** (0.0187)	0.0212 (0.0140)	0.0507*** (0.0146)	0.0433*** (0.0113)	0.0622*** (0.0168)
First principal component of macro/institutional controls	-0.0074*** (0.0023)	-0.0077*** (0.0022)	-0.0084*** (0.0022)	-0.0076*** (0.0026)	-0.0044* (0.0025)	-0.0082*** (0.0023)	-0.0063*** (0.0020)	-0.0109*** (0.0027)

Second principal component of macro/institut. controls	-0.0193*** (0.0059)	-0.0192*** (0.0063)	-0.0217*** (0.0061)	-0.0191*** (0.0062)	-0.0156** (0.0063)	-0.0204*** (0.0062)	-0.0128** (0.0051)	-0.0253*** (0.0067)
Sector-specific FE	+	+	+	+	+	+	+	+
Sector and country RE	-	-	-	-	-	-	-	-
R^2	0.3917	0.3912	0.3938	0.3912	0.4277	0.3935	0.3782	0.4180
R^2-adjusted	0.3224	0.3218	0.3247	0.3218	0.3581	0.3244	0.3073	0.3415
Degrees of Freedom	193	193	193	193	181	193	193	190

Notes: * 10% significance level, ** 5%significance level, *** 1% significance level. In Column (9), the weighted EPL is used with the shares of temporary and regular workers as weights. The conditional R^2 is reported in Column (11).

Table 11: Robustness to different estimators of heteroscedasticity-consistent (HC) standard errors.

	No HC correct.	HC0	HC1	HC3	Clustered by country	Clustered by sector
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.1015*** (0.0193)**	**-0.1015*** (0.0194)**	**-0.1015*** (0.0205)**	**-0.1015*** (0.0224)**	**-0.1015*** (0.0237)**	**-0.1015*** (0.0208)**
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0074** (0.0029)**	**0.0074** (0.0030)**	**0.0074** (0.0031)**	**0.0074** (0.0035)**	**0.0074** (0.0030)**	**0.0074** (0.0030)**
Level: $EPL_{c,2007}$	**0.0181*** (0.0049)**	**0.0181*** (0.0063)**	**0.0181*** (0.0067)**	**0.0181** (0.0083)**	**0.0181*** (0.0054)**	**0.0181*** (0.0060)**
Interaction with tertiary education: $EPL_{c,2007}$ x $S3_{s,c,2007}$	**-0.0295*** (0.0069)**	**-0.0295*** (0.0079)**	**-0.0295*** (0.0083)**	**-0.0295*** (0.0100)**	**-0.0295*** (0.0058)**	**-0.0295*** (0.0088)**
Interaction with second. education: $EPL_{c,2007}$ x $S2_{s,c,2007}$	**-0.0200** (0.0087)**	**-0.0200* (0.0115)**	**-0.0200* (0.0115)**	**-0.0200 (0.0139)**	**-0.0200 (0.0122)**	**-0.0200*** (0.0067)**
Tertiary educ.: $S3_{s,c,2007}$	0.1546*** (0.0391)	0.1546*** (0.0524)	0.1546*** (0.0553)	0.1546** (0.0678)	0.1546*** (0.0375)	0.1546** (0.0680)
Secondary educ.: $S2_{s,c,2007}$	0.0951** (0.0453)	0.0951 (0.0645)	0.0951 (0.0681)	0.0951 (0.0833)	0.0951 (0.0706)	0.0951** (0.0381)
Eastern Europe dummy	0.0467*** (0.0117)	0.0467*** (0.0129)	0.0467*** (0.0136)	0.0467*** (0.0148)	0.0467*** (0.0175)	0.0467*** (0.0124)
First principal component of macro/institutional controls	-0.0078*** (0.0022)	-0.0078*** (0.0020)	-0.0078*** (0.0022)	-0.0078*** (0.0023)	-0.0078** (0.0030)	-0.0078*** (0.0018)
Second principal component of macro/institut. controls	-0.0194*** (0.0053)	-0.0194*** (0.0056)	-0.0194*** (0.0059)	-0.0194*** (0.0067)	-0.0194*** (0.0044)	-0.0194*** (0.0050)
Sector-specific FE	+					
R^2	0.3912					
R^2-adjusted	0.3253					
Degrees of Freedom	194					

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

Table 12*: Robustness to dropping various combinations of potentially influential countries: CZ (Czech Republic), ES (Spain), IE (Ireland)*

	Without CZ	Without ES	Without IE	Without CZ and ES	Without CZ and IE	Without ES and IE
Short-term change: $\Delta_3 EPL_{c,2007}$	**-0.0849*** (0.0252)**	**-0.1253*** (0.0257)**	**-0.0855*** (0.0222)**	**-0.1657** (0.0659)**	**-0.0593** (0.0256)**	**-0.1088*** (0.0312)**
Long-term change: $\Delta_7 EPL_{c,2007}$	**0.0082*** (0.0030)**	**0.0083*** (0.0031)**	**0.0071** (0.0032)**	**0.0074** (0.0031)**	**0.0081** (0.0031)**	**0.0083*** (0.0032)**
Level: $EPL_{c,2007}$	**0.0199*** (0.0067)**	**0.0190*** (0.0065)**	**0.0215*** (0.0068)**	**0.0199*** (0.0065)**	**0.0239*** (0.0067)**	**0.0219*** (0.0067)**
Interaction with tertiary education: $EPL_{c,2007}$ x $S3_{s,c,2007}$	**-0.0307*** (0.0068)**	**-0.0260*** (0.0083)**	**-0.0267*** (0.0094)**	**-0.0273*** (0.0085)**	**-0.0278*** (0.0093)**	**-0.0234** (0.0096)**
Interaction with second. education: $EPL_{c,2007}$ x $S2_{s,c,2007}$	**-0.0213* (0.0114)**	**-0.0206* (0.0114)**	**-0.0276** (0.0115)**	**-0.0212* (0.0114)**	**-0.0295** (0.0114)**	**-0.0285** (0.0116)**
Tertiary educ.: $S3_{s,c,2007}$	0.1655*** (0.0569)	0.1474*** (0.0539)	0.1553*** (0.0589)	0.1555*** (0.0546)	0.1699*** (0.0581)	0.1471** (0.0587)
Secondary educ.: $S2_{s,c,2007}$	0.1022 (0.0689)	0.0941 (0.0677)	0.1417** (0.0685)	0.1062 (0.0685)	0.0295** (0.0114)	0.1411** (0.0698)
Eastern Europe dummy	0.0549*** (0.0165)	0.0526*** (0.0146)	0.0382*** (0.0144)	0.0484*** (0.0169)	0.0477*** (0.0171)	0.0444*** (0.0168)

First principal component of macro/institutional controls	-0.0095*** (0.0026)	-0.0088*** (0.0023)	-0.0065*** (0.0023)	-0.0083*** (0.0027)	-0.0085*** (0.0027)	-0.0077*** (0.0026)
Second principal component of macro/institut. controls	-0.0247*** (0.0069)	-0.0221*** (0.0063)	-0.0161** (0.0065)	-0.0198** (0.0078)	-0.0221*** (0.0075)	-0.0201*** (0.0073)
Sector-specific FE	+					
R^2	0.3945	0.4078	0.3575	0.4103	0.3660	0.3695
R^2-adjusted	0.3247	0.3395	0.2833	0.3374	0.2877	0.2916
Degrees of Freedom	182	182	182	170	170	170

Note: * 10% significance level, ** 5%significance level, *** 1% significance level.

Appendix C

Let us consider a generic underlying regression equation with the three interactions present while omitting unaffected terms and indexes:

$$y = \lambda_0 EPL + \lambda_1 EPL \times S1 + \lambda_2 EPL \times S2 + \lambda_3 EPL \times S3 + \varepsilon.$$

Since the shares satisfy $S1 = 1 - (S2+S3)$, it holds

$$y = \lambda_0 EPL + \lambda_1 EPL \times [1 - (S2+S3)] + \lambda_2 EPL \times S2 + \lambda_3 EPL \times S3 + \varepsilon$$

$$= (\lambda_0 + \lambda_1) EPL + (\lambda_2 - \lambda_1) EPL \times S2 + (\lambda_3 - \lambda_1) EPL \times S3 + \varepsilon$$

Hence, the conditional expectation

$$E(y \mid EPL,S2,S3) = \beta_0 EPL + \beta_1 EPL \times S2 + \beta_2 EPL \times S3,$$

where the link between the observed parameters β_0, β_1, and β_3 and the underlying ones is given by

$$\beta_0 = \lambda_0 + \lambda_1,\ \beta_1 = \lambda_2 - \lambda_1, \text{ and } \beta_2 = \lambda_3 - \lambda_1.$$

Hence, when the reduced form is under estimation, one cannot prescribe the change in variable to only the impact of a particular share. However, the conditional impact can be properly predicted from the reduced-form equation.

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