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When labour market rigidities are useful for innovation. Evidence from German IAB firm-level data☆

Sergei Hoxha[a,b], Alfred Kleinknecht[c,*]

[a] Hans-Böckler-Foundation, Düsseldorf, Germany
[b] Erasmus University College, Rotterdam, Netherlands
[c] Professor of Economics (Emeritus) of TU Delft and Visiting Professor at Kwansei Gakuin University, Japan

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ABSTRACT

Supply-side economists made numerous pleas for removing labour market rigidities through 'structural reforms'. From a Schumpeterian viewpoint, however, one can argue that labour market rigidities create useful incentives for innovation. Our estimates on German panel data (2007–2015) support the Schumpeterian view. Using the taxonomy of industries by Peneder (2010) we find that evidence of the Schumpeterian view is particularly strong in R&D intensive manufacturing industries, as well as in service industries with high degrees of cumulativeness of knowledge. Evidence of the Schumpeterian view is weaker in low-technology industries and in start-ups when firms rely more on generally available knowledge rather than on firm-specific and tacit knowledge accumulated in the past.

1. Introduction

Since the 1990s, the availability of firm-level data on innovation, mainly through the European *Community Innovation Survey* (*CIS*), enabled the growth of a substantial literature on determinants of innovation. Research has addressed the impact on innovation of a variety of factors such as firm size and market structure, technological spill overs, R&D collaboration, demand growth, regional innovation clusters or the impact of R&D on innovative output and on *Total Factor Productivity* (TFP). This paper addresses a different issue: What is the impact of labour relations on innovation?

In addressing this issue, we start from the *Varieties-of-Capitalism* literature. This literature suggests that distinct differences in innovative behaviour exist between Anglo-Saxon *Liberal Market Economies* (*LME*) versus *Coordinated Market Economies* (*CME*) of the 'Rhineland' type (Albert 1992; Hall and Soskice, 2001). It has often been argued that *LME* are better in disruptive ('creative destruction') innovations by garage business entrepreneurs as described by the early Schumpeter (1912). *CME*-countries do a better job in what is often referred to as the 'routine model' of innovation (or, in synonyms: the 'creative accumulation', or the 'Schumpeter II' innovation model) as described by the late Schumpeter (1943).

Although the latter idea received critical scrutiny (e.g. Akkermans et al., 2009), it seems to receive support by the contrast between the success of IT industries in regions like Silicon Valley, and, on the other hand, the strong competitive position of typical *CME* countries like Germany or Japan in a broad range of mature industries that have been extremely successful exporters to the US market (sometimes being accused of having contributed to the emergence of a US Rust Belt).

While some advocates of structural reforms of labour markets have suggested that more flexibility in labour markets might *enhance* innovation (e.g. Bassanini et al., 2009; Scarpetta and Tressel, 2004; Bartelsman et al., 2016), there is a literature that argues to the opposite.[1] Section 2 of this paper discusses theoretical arguments pro and con the hypothesis that achieving more flexibility in labour markets through regulatory reforms would positively or negatively impact on innovation. Section 3 discusses our firm-level data and provides some

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* Corresponding author.
E-mail address: alfred.kleinknecht@gmail.com (A. Kleinknecht).

[1] Among the studies that find a negative relationship between more flexible labour relations and productivity and/or innovation are: Acharya et al. 2010; Appelbaum et al., 2000; Auer et al., 2005; Buchele and Christiansen, 1999; Cappellari et al., 2012; Damiani et al., 2016; Franceschi and Mariani, 2015; Hartcourt and Wood, 2007; Hirsch and Mueller, 2012; Huselid, 1995; Lisi and Malo, 2017; Lucidi & Kleinknecht, 2010; Michie and Sheehan, 2001, 2003; Pieroni and Pompei, 2008; Storm and Naastepad, 2012; Rizov and Croucher, 2009; Serano and Altuzarra, 2010; Vergeer et al. 2015; Wachsen & Blind 2016; Zhou et al., 2011. But some studies arrive at insignificant solutions or find only minor effects, e.g. Arvanitis, 2005, or Berton et al. 2017.

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descriptive evidence, suggesting that technological laggards make more use of flexible labour. Section 4 summarizes our firm-level estimates from German IAB data over the period 2007–2015. We find that firing flexibility in German firms is negatively related to the probability that a firm would perform R&D and/or introduce an innovation. Section 5 covers our discussion and conclusions.

A novelty of our paper is the argument that previous empirical evidence was somehow ambiguous as the estimates did not control for the dominant innovation model in an industry. In a broad range of classical industries, a firm's innovative competencies depend not only on its present R&D but also on knowledge accumulated in the past, part of that knowledge being firm-specific and 'tacit' (Polanyi 1966); in other words, it tends to be 'embodied' in people. A high personnel turnover can then be a disadvantage for knowledge management. But in industries that rely strongly on generally available knowledge, labour turnover does not need to be a problem.

Recent studies that control for an industry's dominant innovation model report indeed a *negative* impact of more flexible personnel policies on innovation (Kleinknecht et al., 2014; Wachsen and Blind, 2016) and on labour productivity growth (Vergeer et al., 2015) in industries that rely on accumulation of knowledge. But they find little or no impact of flexible labour in low-technology and in garage business industries where general and generally available knowledge is dominant. A problem in the latter studies is that the division between the two types of innovation model was based on a crude measure: The concentration of R&D budgets in an industry, assuming that a low concentration of R&D was typical for low-technology industries and for garage businesses, while a high concentration of R&D would indicate a 'cumulative' innovation regime (see for details: Kleinknecht et al., 2014).

In this paper, we use for the first time a new indicator of 'cumulativeness of knowledge', making use of pioneering work by Peneder (2010). The latter used several vintages of the EU-wide *Community Innovation Survey (CIS)*. Our estimates show that, in industries in which cumulativeness is 'medium' or 'high', a higher firing flexibility is related to significantly *lower* probabilities that a firm would innovate. In industries with a low degree of 'cumulativeness' according to Peneder (2010), firms rely more on general knowledge. In such industries, flexibility of personnel tends to have an insignificant impact on innovation.

2. Why should labour market deregulation influence innovation?

Advocates of labour market deregulation gave several arguments of why more flexible personnel may favour innovation:

- Firms will more easily engage in risky new ventures if they can easily shed their personnel in the case of failure (Bartelsman et al., 2016). This argument implies that structural change, shifting employees from old and declining to newly emerging industries can happen more quickly if firing is easier.
- Higher labour turnover enhances the inflow of 'fresh blood': people with new ideas and new networks may foster innovation. This means that there is less chance that employees will be entrenched in safe jobs, gradually losing their creativity.
- The (latent) threat of easy firing may lead to greater effort. For example, Ichino and Riphahn (2005) observe that temporary workers have higher probabilities of working unpaid hours and report more seldom sick, which they interpret as proof that tenured workers are more likely to 'shirk'.

There are reasons for doubt about these arguments.

The argument by Bartelsman et al. (2016) can be relevant, as it allows the shifting of part of the entrepreneurial risks to employees. This could encourage garage business innovation by young and fragile firms. A counter-argument could be that, in an entrepreneurial high-risk-high-return environment, firing protection can hardly be an obstacle as employees tend to have short tenures and have anyway little to claim in young firms that go bankrupt. As to the easier shifting of personnel from declining into newly emerging sectors, one should note that newly emerging and innovative industries tend to pay better wages and offer better career opportunities than old and declining industries. Why should we not trust that workers follow such incentives? Is it indeed strong firing protection in coals mines that prevents miners moving to Silicon Valley?

On the other hand, the argument that the inflow of 'fresh blood' favours innovation, may indeed be relevant if (entrepreneurial) firms rely on readily available general knowledge in a garage business model (e.g. Breschi et al., 2000). It may, however, be counterproductive in an innovation model that relies upon continuous accumulation of firm-specific and tacit knowledge, since much of that knowledge is 'embodied' in people.

Advocates of deregulation also use arguments derived from job search theory (Pissarides 2000; Mortensen and Pissarides, 1994): High firing costs can prevent firms from terminating inefficient job matches. If deregulation allowed for a higher labour turnover, the higher number of job matches would increase the chance that employees end up in those jobs in which they are most productive (e.g. Bierhanzl 2005; Berton et al., 2017).

Against this upside of a higher job turnover, however, there are several downsides:

First, if firing is difficult, firms have incentives to invest in functional flexibility by means of training, which will allow the shifting of labour from old to new activities in internal labour markets (Agell, 1999). In other words, lack of numerical (or firing) flexibility will enhance functional flexibility. Note that Acemoglou and Pischke (1999) argue that wage compression (a labour market rigidity!) in German labour markets enhances training for highly educated *and* for low-educated workers, while in the liberalized US system, it is mainly highly educated workers who receive training. Moreover, with a higher labour turnover, payback periods for firm-financed training will become shorter.

Second, easy firing and short job tenures reduce loyalty, trust and commitment (e.g. Svensson, 2011). This can mean that a firm's trade secrets and technological knowledge could more easily be leaked to competitors, implying that Pigouvian externalities will become stronger. Moreover, lack of loyalty and trust forces firms to invest more into monitoring and control. Building on earlier work by Gordon (1994), Naastepad and Storm (2006) show that firms in flexible Anglo-Saxon labour markets have substantially thicker management bureaucracies. Kleinknecht et al. (2016) show that firms in the Netherlands that employ high shares of flexible personnel (i.e. people on temporary contracts, free lancers, or man power agency workers) also employ significantly higher percentages of managers. Needless to add that high shares of managers not only push up overhead costs; they also make decision-making more cumbersome which can be frustrating for creative intrapreneurs.

Third, with a higher labour turnover, a firm will also benefit less from learning-by-doing and its historical memory may become weaker, which can turn a firm into an un-learning organization. Note that, in a 'learning organization', it is not the organization but the people who learn.

Forth, easier firing changes power relations between management and the shop floor. This means that (top) managers receive less critical feedback from the shop floor as people do not dare anymore contradicting them. This is at odds with the emphasis in the innovation management literature that, for successful innovation, you need to mobilize knowledge from all corners of the organization (Tidd et al., 2018). Moreover, autocratic management practices create a culture of fear. Acharya et al. (2010) argue (and show empirically) that, under easier firing, employees tend not to engage in risky (but potentially highly rewarding) innovation projects, as they fear firing in the case of

failure.

Fifth, for the implementation of automation projects, engineers often need the tacit knowledge from experience by the people who still do the work. If these people have no safe insider position in an internal labour market (a labour market rigidity!), they will refuse collaborating (Lorenz, 1999). More generally, people that are easy to fire have motives hiding their knowledge about inefficient work practices, as greater efficiency may make them redundant.

Sixth, as indicated above, the impact of a larger labour turnover might differ, according to the dominant innovation model in a sector. In industries that are dependant on accumulated knowledge from the past, flexibility of personnel is negatively related to innovation (Kleinknecht et al., 2014; Wachsen and Blind, 2016) and to labour productivity growth (Vergeer et al., 2015); but in industries that rely more on general and generally available knowledge, flexible labour has less impact. In the literature, the two types of industries are often labelled as Schumpeter I versus Schumpeter II industries (e.g. Breschi et al., 2000).[2]

Finally, owing to Adam Smith's famous pin factory parable, economists generally recognize the favourable productivity effects of a deeper division of labour and specialization amongst workers (e.g. Corsi, 1991). The problem is that people who specialize in narrow knowledge niches will have very limited choices amongst alternative jobs (at a comparable productivity and pay-level) if they are fired. This can imply that people may be reluctant engaging in narrow specialization if they have no safe insider position, and this may hinder the working of the routine innovation model.

Such arguments illustrate that structural reforms of labour markets are not just labour market reforms. They are likely to have an impact on innovation and productivity in industries that rely on continuous learning and historically accumulated knowledge.

Some of the above arguments come close to efficiency wage theory (Shapiro and Stiglitz, 1984). For instance, Rebitzer (1995) found a relationship between higher wages and lower supervision costs. This implies that shirking is less likely as workers who earn wages above the market-clearing level have more to lose if shirking is discovered. While these arguments focus narrowly on wages and on the disciplinary effects of easy firing, the idea of an implicit contract ('gift exchange') between employer and employees (Akerlof 1982; Akerlof and Yellen, 1990) comes closer to our argument.

Other than the key arguments around efficiency wages, however, the main thrust of our above arguments relates to labour market rigidities such as firing protection, (implicit) job guarantees for insiders, or centralized bargaining. Such labour market rigidities increase mutual trust, commitment and loyalty, which, in turn, makes the management of innovation, mobilization of (tacit) knowledge from the shop floor and knowledge accumulation easier. More trust and loyalty also reduce costs of supervision and reduce externalities as committed employees will not so easily leak knowledge to competitors. All this contributes to a better working of the 'routinized' Schumpeter II innovation model (Schumpeter, 1943; for an update see Breschi et al., 2000) and can result, in the end, in higher innovation rates and higher productivity.

3. Concepts, data and descriptive evidence

The latter point raises the question of how to identify industries in which accumulation of knowledge from the past is more or less important. We use here a new measure developed by Peneder (2010). Analysing innovation data from several countries and several vintages of the European *Community Innovation Survey (CIS)*, Peneder (2010) arrived at a taxonomy of industries according to 'cumulativeness of knowledge'. His distinction of industries by degree of 'cumulativeness of knowledge' is based on the number of sources of information that a firm consulted and reported in the CIS survey as being important to their innovative projects. According to Peneder, market leading firms are supposed to show a high cumulativeness of knowledge if they rely on numerous *internal* sources of knowledge. Laggard firms are assumed to be highly cumulative if they rely on many *external* sources of knowledge. Table 3.1. covers a list of sectors according to degree of cumulativeness.

A closer look at Peneder's (2010) classification shows that, in manufacturing industries, his indicator of 'cumulativeness of knowledge' (see column *CuType* in his Table 5, p. 231) correlates closely with his indicator of innovativeness (see column *InnoType*, same table). This holds, however, less so in services. In service industries, innovative efforts are much less based on activities that nicely fit into the official definition of R&D, according to the OECD's *Frascati-Manual*, the latter being a somehow manufacturing-centred definition (Kleinknecht et al., 2002).

We have therefore decided using Peneder's (2010) *Cu-Type* classification (instead of his *InnoType*), but one should be aware that, in manufacturing, a high score on *Cu-Type* is almost identical to high R&D-intensities. The latter also come close to what the OECD defined as medium-high and high tech industries (see http://www.oecd.org/sti/ind/48350231.pdf). It is in any case interesting to note that R&D intensive manufacturing industries also show a high dependence on historically accumulated knowledge. Since the latter tends to be 'embodied' in people (being often poorly documented and ill-codified), the innovative capacities of these industries can be negatively affected by an increase in labour turnover through labour market reforms.

We use data from the German IAB Establishment Panel which is an annual survey of >16.000 establishments in Germany (of which 6.000 in East Germany) that employ at least one worker who pays social security taxes. The survey, which is commissioned by the Institute for Employment Research (IAB), was launched in Western Germany in 1993 and extended to Eastern Germany in 1996. Although the IAB panel is first of all a fairly detailed labour market survey, data on R&D and new product or service introductions were included from 2007 onwards, the latter being measured every second year. The survey is addressed to a firm's top management, but given the strong emphasis on labour market issues, it is likely that substantial parts of the survey have been filled in by senior personnel officers.

Data are made available to researchers via remote access or on-site at the Federal Employment Agency's Research Data Centre at IAB. As we are interested in innovation, we confine our analysis to manufacturing and commercial services firms, leaving out non-commercial (or not-for-profit) and governmental institutions. As the firms are interviewed through visits by trained interviewers, data quality is high, compared to postal or telephone interviews.

One should note that our observation period is after the so-called Hartz-reforms of the German labour market. The latter reforms made it easier for German firms hiring various types of flexible workers (e.g. manpower agency workers, part-timers or free-lance people). But some firms make more use of those flexible options than others. We assume that firing under adverse circumstances will be easier for those firms that hire more people on flexible contracts. We therefore use the percentage of people who left a firm during the first half of the business year as an indicator of a firm's firing flexibility. While this indicator does not directly measure contractual flexibility, it does so indirectly by giving an indication of a firm's flexibility for quitting people. The latter is higher if more people are on flexible contracts.

The adherents of structural reforms of labour markets would expect our indicator of firing flexibility to have a *positive* impact on innovation,

[2] Interpreting a low cumulativeness of knowledge as a Schumpeter-I model and a high cumulativeness as a Schumpeter-II model might be confusing as readers will identify a Schumpeter-I model with startups and new entrants and a Schumpeter-II model with incumbent firms. Indeed, the parallel between low cumulativeness and startups and between high cumulativeness and incumbent firms can hardly be found in Schumpeter's work. It has been worked out mainly by post-Schumpeterians (e.g. Breschi et al. 2000).

Table 3.1
Overview of sectors with high, medium or low cumulativeness of knowledge according to Peneder (2010: 331, see column *Cu-Type* in his Table 5).

Industries with *high* cumulativeness:
Chemicals; basic metals; machinery, nec.; electrical equipment, nec.; communication technology; precision instruments; motor vehicles, -parts; financial intermediation; insurance, pension funding; computer services; research and development; other business services.
Industries with *medium* cumulativeness:
Mining: petroleum, gas; textiles; Pulp/paper, -products; ref. petroleum, nuclear fuel; rubber and plastics; mineral products; computers, office machinery; other transport equipment; manufacturing nec.; post, telecommunications.
Industries with *low* cumulativeness:
Mining: coal, peat; mining: other; food products, beverages; tobacco products; wearing apparel, fur; leather, -products, footwear; wood, -products, cork; publishing, reproduction; fabricated metal products; recycling; electricity and gas; water supply; wholesale trade; land transport, pipelines; water transport; air transport; auxiliary transport services; auxiliary financial services.

Table 3.2
Technological laggards and the use of flexible labour.

State of technical equipment:	Indicators of innovation: Share of innovators*	Indicators of innovation: Share of firms that have R&D activities	Indicator of firing flexibility: % that left the firm in first half year
Outdated	3.6%	6.1%	14.6%
Rather old	5.7%	10.0%	8.7%
In between	6.4%	11.6%	6.4%
Rather new	8.9%	14.8%	5.0%
State of the art	12.9%	18.0%	5.4%

Source: IAB enterprise panel, averages over 2007–2015.
* Percentages of firms that realized a new product or service that created a new market.

while, from a Schumpeterian viewpoint, one would expect the opposite (see Section 2 above). A first indication that the effect of more flexible labour might be negative for innovation is given in Table 3.2. The table relates to the question in the IAB survey about the degree by which firms have modernized their equipment. The relevant question is worded as follows:

How do you assess the overall technical state of the plant and machinery, furniture and office equipment of this establishment compared to other establishments in the same industry? Please give your assessment using the scale below.

Firms can answer on a 5-point Likert scale, reaching from 'state of the art' down to 'outdated'. In Table 3.2 we compare the state of modernization of equipment with some variables that are relevant for our analysis. It is not surprising that a more advanced state of a firm's technical equipment correlates positively with the two innovation indicators: percentages of firms that introduced a new product or have some R&D activities. But it is interesting to see that there is a *negative* relationship between the state of technical equipment, new product introductions and R&D, on the one hand, and, on the other hand, our indicator of firing flexibility: percentages of people who left the firm during the first half year. Flexibility appears to be higher amongst technological laggards.

4. Regression analyses

In Table 4.1 we estimate Panel Probit Models, as our dependant variables are zero/one variables; i.e. we explain what factors influence the probability that a firm would tick 'yes' as an answer to two questions: (1) Do you have R&D activities (*R&D*)? And, (2) did you have R&D activities *and* did you introduce a new product or service that created a new market (*R&Dinnov*)?[3] We control for firm size and firm age. We also include a control for the presence of a works council which can capture elements of a cooperative 'Rineland' management style. We also control for sales growth in a firm's sector of principal activity which controls for 'demand-pull' effects. Besides a control variable for independent firms we include a constant term. Our variable of interest is of course the percentage of personnel that left the firm in the first half of the business year. Summarizing, our two models can be written as:

$$P(R\&Dinnov_{i,t}=1|Flex_{i,t}, \eta_i) = \Phi(Flex'_{i,t}\beta_1 + X'_{i,t}\alpha + \eta_t + \varepsilon_{i,t})$$

$$P(R\&D_{i,t}=1|Flex_{i,t}, X_{i,t}, \eta_i) = \Phi(Flex'_{i,t}\beta_1 + X'_{i,t}\alpha + \eta_t + \varepsilon_{i,t})$$

$$Flex'_{i,t} \in \{Percentage\ of\ terminated\ contracts_{i,t}\}$$

$$X'i,\ t \in \begin{cases} ln\ firm\ size_{i,t} \\ Average\ Industry\ Sales_{i,t} \\ works\ council_{i,t} \\ independent\ firm_{i,t} \\ firm\ age_{i,t} \\ firm\ age^2_{i,t} \\ state\ of\ technical\ eq_{i,t} \\ year\ dummies \end{cases}$$

We use the traditional random effect probit model and then the pooled probit model and we cluster standard errors around every firm in each year. Xt probit fits random-effects and population-averaged probit models. Unconditional fixed-effects probit models may be fit with the probit command with indicator variables for the panels. However, unconditional fixed-effects estimates are biased (Neuhaus, 1992). As the proportion of the total variance contributed by the panel-level variance component is quite high, the random effect dynamic probit model is preferred to the pooled OLS-estimator. The latter is documented in the Appendix and shows outcomes that would allow drawing the same conclusions. Specifying vce(robust) or vce (cluster clustvar) causes the Huber/White/Sandwich VCE estimator to be calculated for the coefficients estimated in this regression (Wooldridge, 1992).

In both models, we find mixed results for firm age and for the presence of a works council. The presence of works councils can indicate an orientation of management towards a 'Rhineland' style of labour relations. Some effects of this variable may, however, be picked up by the flexibility variable that seems to be stronger. In all estimates, firm size is highly significant, which is not surprising, given that we explain a zero/one variable. It neither comes as a surprise that a more modern state of a firm's equipment is positively related to a firm's innovativeness. Coefficients for independent firms (as compared to plants that are part of a conglomerate) tend to show negative but insignificant signs. We neither find evidence in favour of 'demand-pull' effects.

Our year dummies try to capture time variant effects such as the impact of the Great Recession (2008–10) after the Lehman Crash. The negative coefficients of the year dummy indicate that, over our observation period (2007–2015), a firm's probability of performing R&D is declining. This is consistent with evidence from published statistics that overall investment is lower after the Lehman Crash. But the decline of R&D during the period 2007–15 may also reflect negative effects on innovation of the Hartz-reforms of the German labour market.

Our main variable of interest on firing flexibility behaves as expected: Whatever version we choose (see also the Pooled Probit regressions in

[3] The wording in the questionnaire is as follows: "Have you started to offer a completely new product or service in the last business year … for which a new market had to be created?"

Table 4.1
Marginal effects after random effects panel probit model: Factors that influence the probability of a firm having some R&D (Model 1) and that a firm will have some R&D and realize a product or service innovation that created a new market (Model 2).

	Model 1: Probability that firm has some R&D			*Model 2: Probability that firm has some R&D and introduced a new product or service*		
	Total sample Coefficients:	High-cum[@] Coefficients:	Low-Cum[@] Coefficients:	Total sample Coefficients:	High-cum[@] Coefficients:	Low-cum[@] Coefficients:
Variable of interest:						
% terminated contracts[#]	−0.1068***	−0.2028***	−0.0232	−0.0655***	−0.1501***	−0.0074
	(−3.25)	(−3.10)	(−0.75)	(−2.66)	(−2.66)	(−0.43)
Controls:						
Industry-average	−0.0007*	−0.0002	−0.0008**	−0.0002*	0.0001	−0.0002**
sales growth	(−1.88)	(−0.49)	(−2.51)	(−1.93)	(0.63)	(−2.40)
Firm size	0.0551***	0.0668***	0.0365***	0.0178***	0.0242***	0.0107***
	(21.38)	(13.62)	(12.23)	(11.25)	(8.82)	(6.14)
Works council (yes/no	0.0545***	0.0847***	0.0295***	−0.0020	0.0002	−0.0052
	(5.88)	(4.93)	(2.90)	(−0.37)	(0.03)	(−0.89)
Independent firm (yes/no)	−0.0006	−0.0033	−0.0094	−0.0008	0.0015	−0.0056
	(−0.08)	(−0.26)	(−1.20)	(−0.18)	(0.19)	(−1.37)
Firm age	0.0049*	0.0050	0.0027	0.0027**	0.0042*	0.0011
	(2.36)	(1.50)	(1.13)	(2.05)	(1.75)	(0.80)
Firm age squared	−0.0001	−0.0001	−0.0001	−0.0001	−0.0001	−0.0000
	(−1.19)	(−0.67)	(−0.66)	(−1.63)	(−1.55)	(−0.51)
State of technical equipment	0.0073**	−0.0014	0.0136***	0.0094***	0.0106**	0.0082***
	(2.09)	(−0.27)	(3.17)	(3.97)	(2.53)	(3.17)
Year	−0.046***	−0.0056***	−0.0040***	−0.0008	−0.0017	0.0001
	(−3.34)	(−2.63)	(−2.39)	(−0.95)	(−1.11)	(−0.15)
Number of obs.	14 550	6 660	7 890	14 555	6 660	7 890

Z-statistics in brackets.
*** = $p < 0.01$;.
** = $p < 0.05$;.
* = $p < 0.10$.
[#] Percentage of total personnel that left the firm during the first half year.
[@] = Industries that have a high & medium vs. low degree of 'cumulativeness of knowledge' according to Peneder (2010; see Table 3.1 above).

Appendix II), all coefficients of our flexibility variable are significantly *negative* in the industries that are classified by Peneder (2010) as medium and highly cumulative.[4] As expected, in industries with a low cumulativeness of knowledge, coefficients are lower and mostly insignificant. If we ignore the distinction by cumulativeness, i.e. if we estimate our model for the total sample, coefficients are, as expected, lower than in the medium and highly cumulative industries, but they tend to remain significant, in spite of an omitted variable bias.

Summing up, the negative relationship between labour market flexibility and innovation is highest in sectors with a medium and high cumulativeness of knowledge and insignificant in the low cumulative sectors. Other than supply-side economists might have intuitively expected, we find *no* positive coefficients whatsoever.

5. Discussion and conclusions

Adherents of structural reforms of labour markets argued that more flexible labour relations might be favourable to innovation. But there are counter-arguments and our estimates suggest that these have more weight. In none of our Probit estimates we find a *positive* relationship between firing flexibility and the probability that a firm will innovate. We find a significantly *negative* relationship between firing flexibility and our innovation indicators in those industries that are classified by Peneder (2010) as medium or highly cumulative, i.e. in the highly innovative segments of manufacturing and services. In industries with low cumulativeness of knowledge (i.e. in traditional industries and services) we find, as expected, much weaker support for the hypothesis that labour relations matter for innovation.

It is suggestive that, in our descriptive data, we see that technological laggards make more use of flexible arrangements. Of course, working with outdated machinery and equipment, and having no R&D or new product introductions, is a competitive disadvantage for laggard firms. It looks as if easier firing through flexible contracts functions as a survival kit for backward firms, which hinders the Schumpeterian process of creative destruction and thus increases the chance of survival for technological laggards. It is tempting to conclude that this may contribute to explaining the empirical observation of a growing productivity gap between 'superstars' and 'laggard firms' (Andrews et al., 2015; OECD, 2015).

From Walrasian general equilibrium thinking, one can of course make powerful pleas for making labour markets more flexible by removing rigidities through structural reforms. In neoclassical theory, perfectly competitive markets are the best of all Worlds, allowing for a welfare-maximizing allocation of scarce resources. Why should this not hold for labour markets and with respect to innovation? Seemingly, it does not. In fact, our findings support a point made by Joseph A. Schumpeter as early as 1943, when he wrote:

'Perfect competition … is a condition for optimal allocation of resources … But … introduction of new methods of production and new commodities is hardly conceivable with perfect … competition … And this means that the bulk of … economic progress is incompatible with it. As a matter of fact, perfect competition is and always has been temporarily suspended whenever anything new is being introduced …' (Schumpeter, 1943: 104–5).

Implicitly, Schumpeter argues that innovation needs *im*perfect markets with high entry barriers. This hints to a trade-off between static Walrasian efficiency ('how to allocate scarce resource efficiently?') and dynamic Schumpeterian efficiency ('how to make resources less scarce through innovation?').[5] While monopoly power is valued negatively in

[4] Separate estimates for sectors with medium and high cumulativeness (not documented) show almost identical results.

[5] Recently, similar arguments emerge from agent-based models: negative hysteresis effects of recessions are not due to rigid industrial relations. In the contrary, the latter may actually dampen hysteric dynamics thus making the economy more resilient (Dosi et al., 2018).

neoclassical theory (leading to welfare losses), from a Schumpeterian view, monopoly power is 'good': firms that reap monopoly rents from innovation can more easily maintain the funding of large, long-run and risky innovation projects that often involve high sunk costs that are irreversible if the project fails.

Moreover, larger monopolists typically have a whole portfolio of innovation projects running in parallel, thus reducing innovation risks through diversification. Moreover, we could even define innovation itself as a deliberate attempt at creating an *im*perfect market: An innovator invests in unique new knowledge and the better this knowledge can be protected against imitators, the higher are the entry barriers to the new product's market and the higher are the monopoly rents from the innovation – and hence the incentive for accepting high risks and uncertainties of innovation. In neoclassical theory, monopoly power leads to welfare losses; in a Schumpeterian innovation perspective, (expectation of) substantial monopoly profits is an essential incentive for innovation.

Key problems around innovation are high risks and uncertainties, as well as the public goods character of technological knowledge which creates strong externalities. Under perfect competition, monopoly profits for innovators will be quickly eroded by new entry and hence the incentive for accepting the high risks and uncertainties of innovative investments is weak. In order to somehow cure the externality problem, we have patents, trademarks or copyrights which can help but are far from perfect. In fact, we try curing one market imperfection (externalities) by introducing another one: systems that artificially create a degree of monopoly power.

Another case in point is the labour market rigidity of centralized wage bargaining, notably if government imposes the results of the bargain on everyone in the industry. From a Schumpeterian perspective, wage increases under centralized bargaining force technological laggards either to modernize their equipment and/or their product offerings, or exit business. Centralized bargaining is thus an excellent mechanism for enhancing the diffusion of advanced process and product technologies amongst laggards. In neoclassical theory, however, it is dismissed as a labour market rigidity that prevents an efficient allocation of scarce resources. Under decentralized bargaining, trade unions could demand lower wages in laggard firms in order to rescue jobs, while asking more in innovative firms that enjoy monopoly rents from innovation. This is comparable to government imposing a tax on innovation, using the tax revenues for subsidizing laggards for the sake of jobs.

While job matching theory emphasizes advantages of a larger labour turnover through easy hiring and firing, we have argued above that, from an innovation perspective, easy firing will destroy trust, loyalty and commitment of workers which results in thicker management bureaucracies for monitoring and control, as well as in easier leaking of a firm's technological knowledge to competitors, thus producing higher Pigouvian externalities. Moreover, easy firing will change power relations in favour of (top) management, thus creating a culture of fear and favouring autocratic management practices. The latter makes it more difficult for management mobilizing (tacit) knowledge from the shop floor, while innovation management textbooks emphasize that mobilization of knowledge from *all* corners of the organization is essential for successful innovation (e.g. Tidd & Bessant 2009).

Given the importance of innovation for long-run economic growth, our above results suggest that supply-side labour market reforms, as far as they took place, have contributed to a lower speed of innovation in mature firms and may hence have contributed to the productivity crisis in advanced OECD countries after 2005 (Kleinknecht 2020). But our results also suggest that highly flexible labour markets do not need to be an obstacle to garage businesses that use general knowledge rather than historically accumulated knowledge. This can explain why the US have been successful in the pioneering phase of IT, in spite of a flexible labour market and decentralized bargaining. It might also explain, however, why suppliers in the US lost the battle in the old economy from German and Japanese suppliers that benefited from rigid labour markets; the latter allowing for easier knowledge management, especially if knowledge tends to be 'tacit' (i.e. embodied in people).

In this context, we need to be aware that Albert's (1992) and Hall and Soskice's (2001) distinction between *Liberal* Market Economies (USA, UK, Canada, New Zealand and Australia) and *Coordinated* Market Economies (Old Europe and Japan) is today no more as sharp as it used to be in the 1990s. Some European countries have meanwhile undertaken labour market reforms. For example, after a series of labour market reforms in Italy in the 1990s, Italian labour productivity growth is almost zero since the turn of the century, and it has been shown that those firms that made most use of the new flexible options showed the lowest labour productivity growth (Lucidi & Kleinknecht, 2010). German labour market reforms (the so-called Hartz programmes) have not gone as far as the reforms in Italy, but our observation that German firms' probability of investing in R&D is declining since 2007 fits to the interpretation that labour market deregulation can harm innovation.

Such examples should be a warning to other would-be labour market deregulators such as France's president Macron: What you most likely get from deregulation of labour markets is a decline of (incremental) innovation in mature industries, and correspondingly, a lower productivity growth. The latter means that National Income that can each year be (extra) distributed between labour, capital and the government is growing more slowly, and this can aggravate distributional conflicts. The other side of the medal is of course that, at a given rate of GDP growth, a slower growth of labour productivity (i.e. GDP per working hour) means more employment. In the long run, this leads to tighter labour markets that increase the negotiating power of labour – while there is little to be distributed (see Kleinknecht 2020 for a more detailed discussion).

We conclude that the US Rust Belt (or the decline of British industry after Thatcher's reforms) must have something to do with a weakness in mastering knowledge accumulation processes under a Schumpeter II innovation regime. It should also be noted that many of the giants from Silicon Valley have meanwhile turned into mature firms for which properties of the Schumpeter II innovation model are increasingly relevant: continuous path-dependant learning, accumulation of knowledge that is 'embodied' by labour market insiders, etc. Hence the highly flexible US labour market is no longer a favourable place for them. The rigid German labour market, preferably before the Hartz-reforms, would have been a better place.

CRediT authorship contribution statement

Sergei Hoxha: Formal analysis, Investigation, Methodology, Software, Writing - review & editing. **Alfred Kleinknecht:** Funding acquisition, Methodology, Supervision, Writing - original draft, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix I. (a). Descriptive statistics for *full* sample

Variables:	*Observations:*	*Means:*	*SD:*	*Min*	*Max*
Ln firm size	98,337	2.93	1.79	0	10.994
Has R&D + innovation (dummy)	43,720	0.052	0.223	0	1
Has R&D (dummy)	43,270	0.177	0.382	0	1
% terminated contracts in first half year	98,337	0.051	0.12	0	1
Industry-average sales growth	69,981	0.06	7.07	−87.57	975.88
Work Council yes (dummy)	98,148	0.24	0.427	0	1
Independent firm (dummy)	98,337	0.751	0.431	0	1
Firm age	56,813	11.667	6.69	0	25
State of technical equipment	97,950	3.78	0.785	1	5
Year dummies	98,337	2010	2.61	2007	2015

Appendix I. (b). Descriptive statistics for firms with a *medium plus high* cumulativeness according to Peneder (2010)

Variables:	*Observations:*	*Means:*	*SD:*	*Min*	*Max*
Ln firm size	46,197	3.17	1.88	0	10.739
Has R&D + innovation (dummy)	20,618	0.079	0.27	0	1
Has R&D (dummy)	20,618	0.261	0.439	0	1
% terminated contracts in first half year	45,950	0.050	0.131	0	1
Industry-average sales growth	46,102	0.285	0.451	0	1
Work Council yes (dummy)	46,197	0.739	0.439	0	1
Independent firm (dummy)	27,190	12,17	6.603	0	25
Firm age	46,006	2010	2.64	1	5
State of technical equipment	46,197	2010	2.61	2007	2015

Appendix I. (c). Descriptive statistics for firms with a *low* cumulativeness according to Peneder (2010)

Variable	Observations	Mean	Std. Dev	Min	Max
Ln firm size	52,140	2.72	1.67	0	10.994
Has R&D + innovation (dummy)	23,102	0.028	0.16	0	1
Has R&D (dummy)	23,102	0.102	0.303	0	1
% terminated contracts in first half year	51,831	0.0424	0115	0	1
Industry-average sales growth	52,046	0.200	0.400	0	1
Work Council yes (dummy)	52,140	0.762	0.425	0	1
Independent firm (dummy)	29,623	11.202	6.751	0	25
Firm age	51,944	3.735	0.796	1	5
State of technical equipment	52,140	2010	2.64	2007	2015

Appendix II. Probit regressions (Pooled OLS)

Marginal effect after Probit models on a firm having some R&D (Model 1) and that a firm will have some R&D and realize a product or service innovation that created a new market (Model 2); Z-statistics in brackets

	Model 1: Probability that firm has some R&D			*Model 2: Probability that firm has some R&D and introduced a new product or service that created a new market*		
	Total sample Coeff.:	High-cum[@] Coeff.:	Low-Cum[@] Coeff.:	Total sample Coeff.:	High-cum[@] Coeff.:	Low-cum[@] Coeff.:
Variable of interest:						
% terminated contracts[#]	−0.2235***	−0.4526***	−0.0447	−0.0935***	−0.1968***	−0.0169
	(−5.07)	(−5.16)	(−1.27)	(−3.26)	(−3.01)	(−0.92)
Controls:						
Industry-average sales growth	−0.0006*	−0.0002	−0.0008***	−0.0002	−0.0001	−0.0002**
	(−1.65)	(−0.35)	(−2.58)	(−1.59)	(−0.38)	(−2.41)
Firm size	0.0596***	0.0756***	0.0376***	0.0184***	0.0249***	0.0108***
	(20.64)	(16.13)	(11.61)	(10.75)	(8.31)	(6.19)
Works council (yes/no	0.0449***	0.0719***	0.0202*	−0.0042	−0.0003	−0.0087
	(4.24)	(3.96)	(1.80)	(−0.73)	(−0.03)	(−1.46)
Independent firm (yes/no)	0.0024	−0.0044	−0.0151*	−0.0001	0.0030	−0.0063
	(0.27)	(0.28)	(−1.69)	(0.02)	(0.34)	(−1.53)
Firm age	0.0081***	0.0107**	0.0044*	0.0031**	0.0048*	0.0013
	(3.25)	(2.42)	(1.65)	(2.24)	(1.87)	(0.90)
Firm age squared	−0.0002**	−0.0003*	−0.0001	−0.0001*	−0.0002*	−0.0000
	(−2.29)	(−1.78)	(−1.24)	(−1.90)	(−1.71)	(−0.72)
State of technical equipment	0.0191***	0.0153**	0.0206***	0.0119***	0.0155***	0.0086***
	(4.28)	(1.99)	(4.20)	(4.58)	(3.34)	(3.18)

Year dummies	−0.0026*	−0.0023	−0.0033*	0.0007	−0.0011	−0.0005
	(−1.71)	(−0.89)	(−1.90)	(−0.74)	(−0.70)	-(0.48)
# observations	14 550	6 660	7 890	14 550	6 660	7 890

*** = $p < 0.01$; ** = $p < 0.05$; * = $p < 0.10$

[#] Percentage of total personnel that left the firm during the first half year

[@] = Industries that have a high/low degree of 'cumulativeness of knowledge' according to Peneder (2010; see Table 3.1 above).

Appendix III. Correlation amongst variables

	Firing flexibility	Industry-average sales growth	Firm size	Firm has a works council	Independent firm	Firm age	State of technical equipment	Year dummies
Firing flexibility	1							
Industry-average sales growth	−0.002	1						
Firm size	−0.0123	0.0010	1					
Firm has a works council	−0.054	0.0038	0.5744	1				
Independent firm	−0.0196	0.0056	−0.3343	−0.3686	1			
Firm age	−0.076	−0.007	0.1363	0.0912	−0.0189	1		
State of technical equipment	−0.0236	0.00060	0.0959	0.0255	−0.0493	−0.042	1	
Year dummies	0.0009	−0.0105	−0.0399	−0.0288	0.0075	0.1613	−0.0240	1

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