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More labour market flexibility for more innovation? Evidence from employer–employee linked micro data

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ABSTRACT

This paper examines labour market flexibility in various definitions and its impact on innovation. The results demonstrate that the relationship strongly depends on the type of innovation as well as the predominant innovation regime in which a company operates. Thereby, labour market flexibility does not influence innovation in an entrepreneurial innovation regime characterised by high competition, low market entry barriers and generally available knowledge. That might explain why the Silicon Valley has been successful despite of having a labour market with a strong strong hire and fire mentality. In contrast, labour market flexibility significantly reduces the likelihood of innovation in a routinised innovation regime with leading innovators and high entry barriers similar to the US automobile industry and steel districts that did not succeed. These findings emphasise that the currently discussed structural labour market reforms might hamper innovation as technological change still requires a level of security and stability.

1. Introduction

Labour market flexibility continues to be a highly debated topic, be it in economics, politics, or in general society. Especially after the sharp rise in unemployment in Europe in the 1970s and 1980s many labour market economists call for increasing labour market flexibility in order to improve the adaptability and mobility of businesses and employees (Brodsky, 1994; OECD, 1994; Siebert, 1997). Accordingly, the potential impact of labour market flexibility on employment, growth, profits, or productivity has been discussed for a long time.[1]

At the same time, the need for more employment security, especially since the recent financial crisis, continues to grow. This trade-off between flexibility and security is reflected in the concept of "flexicurity" proposed by the Prime Minister Rasmussen of Denmark in the 1990s and further discussed by Wilthagen and Tros (2004) and Heyes (2013). This trade-off also significantly affects innovation projects. Following Acharya et al. (2010), labour security encourages employees to engage in more radical and risky innovations activities, in particular, cost intensive projects associated with high risks.

Thus, the relationship between labour market flexibility and innovation activities has gained more and more attention in recent years.[2] However, existing studies only focus on the impact of numerical and functional aspects of labour market flexibility such as part-time work or flexible working contracts. Wage flexibility, in contrast, has hardly been explored in previous studies, mainly due to the lack of data (Zhou et al., 2011, p. 3).[3] In addition, the majority of previous studies do not provide a sufficient analysis on company level (Freeman, 2005; Zhou et al., 2011).[4]

By joining three datasets from the Netherlands with information on employer as well as employee level, we obtain several measures of wage flexibility. Combined with data on external numerical

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[1] A review of labour market flexibility, its definitions, and implications can be found in e.g. Beatson (1995), Salvanes (1997), or Solow (1998). A survey of theoretical approaches is given in Towers (1992) or Solow (1998).

[2] A survey of previous studies can be found in Storey (2001).

[3] Previous studies only analyse the impacts of flexible work on wage levels. See Kleinknecht et al. (2006), McGinnity et al. (2004) or Sànchez and Toharia (2000).

[4] Studies with data on company level include Arvanitis (2005), Kleinknecht et al. (2006), Michie and Sheehan (2003), or Zhou et al. (2011).

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and functional flexibility, we are able to characterise labour market flexibility much more comprehensively.

The rest of the paper is structured as follows. At first, we give a definition of labour market flexibility followed by a theoretical discussion of possible effects on innovation including a short review of existing studies. A description of the available dataset as well as the empirical model used in the analysis can be found in Sections 4 and 5. The results are discussed in Section 6 and section 7 concludes.

2. Definition of labour market flexibility

Labour market flexibility represents the capacity of the labour market to adapt quickly to changes in the economy or society. The most commonly used definition is given by Atkinson (1984).[5] He defines labour market flexibility as a function of corporate strategy and divides it into three different dimensions: numerical, functional and financial or wage flexibility. Thereby, external and internal aspects of flexibility can be distinguished.

External numerical flexibility refers to the mobility of employees between different companies, illustrating the extent to which the number of employees can be quickly adapted to economic requirements. Examples of external numerical flexibility are flexible employment contracts such as temporary employment that facilitate a fast change of the number of employees. Internal numerical flexibility refers to the ability of a company to adjust the working hours of its employees and might affect daily, weekly or annual working time as well as seasonal arrangements or short-time work.

Functional flexibility describes how a company can use its employees for different tasks. External solutions are possible through outsourcing or temporary employment, while internal functional flexibility refers to continued training that allows multi-skilled employees to fulfil a variety of tasks.

Wage flexibility as the third dimension of labour market flexibility can be defined as the flexibility of wages. A high wage flexibility is associated with a decentralised wage-setting where the wage level represents the equilibrium of supply and demand on the labour market.

Flexible labour such as temporary employment contracts are often labelled as atypical work. In selected sectors and especially for certain groups of employees, for example low-skilled employees or women, atypical work is now common practice (De Grip et al., 1997; O'Reilly and Fagan, 2002). Thereby, the share of temporary employment increased significantly from 1994 to 2010 across all OECD countries (OECD, 2010). However, the results vary greatly depending on the considered country. In most countries, the share of temporary employment contracts is significantly higher, or even twice as high for women and especially for young people aged between 15 and 24 (OECD, 2010, p. 288). The same applies to part-time contracts. In most countries, more than 70 percent of all part-time positions are filled by women because they frequently use part-time contracts when re-entering the labour market after childbirth (OECD, 2010, p. 286) and because of a lack of affordable childcare (Ingold and Etherington, 2013).

3. Labour market flexibility and innovation

Below, we discuss the relationship between innovation and the different aspects of labour market flexibility, external numerical and functional as well as wage flexibility.

According to the resource-based view, a company creates a competitive advantage by utilising its own internal resources and capabilities. Thereby, a sustained competitive advantage can be achieved by having resources that cannot be easily imitated or substituted (Barney, 1991). Based on this theoretical approach, the relationship between external numerical and functional flexibility and innovation is not unambiguous. Researchers such as Grant (1991) argue that the capabilities of an organisation cannot be completely utilised using short-term, temporary or part-time employment contracts. This results in a negative relationship between flexible work and innovation as empirically shown by e.g. Michie and Sheehan (2003). In addition, the development of innovation is path dependent and therefore influenced by earlier investments as well as accumulated previous knowledge (Pavitt, 1991). Temporary employment contracts might therefore undermine training investments of a company resulting in a loss of competitive advantage (Zhou et al., 2011). Additionally, the likelihood of successful innovation depends on the commitment of a company's employees. As shown by Acharya et al. (2010), employees have an additional incentive to engage in risky innovation projects if their employment status provides them with security and stability. Following Lorenz (1999), employment contracts that provide high employment security will increase the incentive of the employees to share their knowledge about labour saving innovations with their company.

However, the relationship between external labour market flexibility and innovation is not necessarily negative.[6] Following Kodama (1995) or Matusik and Hill (1998), not only internal resources are used for innovation. Instead, innovation depends much more on the effective utilisation of technology and knowledge, even beyond internal capacities. According to Teece (1986, pp. 288–289), the use of external capacities can be seen as additional innovation input factors, especially in the case of open source projects. As Bassanini and Ernst (2002) or Scarpetta and Tressel (2004) emphasise, severe restrictions on terminations of labour contracts may limit the incentive to implement labour-saving process innovations. Following Adams and Brock (2004), flexible employment also allows a larger labour turnover which introduces new knowledge and fresh ideas into a company and additionally allows an easier replacement of inefficient workers (Zhou et al., 2011, p. 4). Finally, Ichniowski and Shaw (1995) think that permanent employees may be disinclined to change in the form of innovation due to habit or so called lock-in effects. In this respect, flexible working arrangements such as outsourcing, temporary, or fixed-term contracts can fit exactly right with the innovation process.

In the end, the question which effect predominates also depends on the sector and its innovation regime. The negative impact of external numerical and functional labour market flexibility particularly applies to sectors where companies depend on their historically accumulated knowledge. These sectors are dominated by a so-called routinised innovation regime characterised by leading innovators and high entry barriers (Kleinknecht et al., 2014). Sectors with a high competition, low market entry barriers and generally available knowledge, in contrast, tend to have an entrepreneurial innovation regime. Those sectors might much more benefit from flexible labour contracts.[7]

Hypothesis I. The impact of external numerical and functional flexibility on innovation depends on the innovation regime. It is negative in a routinised innovation regime, while for sectors that

[5] Further classifications of labour market flexibility can be found in Beatson (1995), Blyton (1992), or Klau and Mittelstädt (1986).

[6] A more detailed survey is given by Pieroni and Pompei (2008, pp. 326–329), Storey et al. (2002, pp. 3–4), or Zhou et al. (2011, pp. 3–6).

[7] These two innovation regimes are also referred to as Schumpeter mark I and Schumpeter mark II innovation models. More information describing the different innovation regimes based on Schumpeter can be found in Breschi et al. (2000), Kleinknecht et al. (2006) and Kleinknecht et al. (2014).

tend to have entrepreneurial innovation regime benefit from external numerical and functional labour market flexibility.

Compared to numerical and functional aspects of labour market flexibility, the potential impact of wage flexibility has been explored much more rarely. Wage flexibility refers to the costs of a company's resources and capabilities. Following Atkinson (1984), it is represented by wage levels that are not decided collectively. In this way, the costs of labour reflect the actual supply and demand on the labour market. Accordingly, wage flexibility includes two aspects.

The first aspect is the wage bargaining process describing the way wages are set as well as the institutions involved. While decentralised wage bargaining occurs between a company and its individual employees, more centralised negotiations involve potentially powerful labour unions resulting in less flexibility for the company. In general, the relationship between labour unions and innovation is assumed to be negative.[8] Based on the hold-up effect, as established by Grout (1984), a union acts like a tax on intangible capital returns in order to get a share of quasi-rents (Hirsch and Connolly, 1987). This means that a union will claim higher wages for innovative companies with higher profits. Therefore, innovation gains are reduced by higher wage demands. Following this so-called rent-seeking approach, the anticipation of the hold-up situation decreases the incentive to invest in innovations. However, the impact depends on the level at which the wage negotiation takes place. Following the model of Haucap and Wey (2004), the negative hold-up effect is highest when the negotiations take place at the company level where a union sets the wages according to the profit of the individual company allowing the union to capture any monopoly innovation gains. In that case the more centralised industry level bargaining is more beneficial for innovators. At the same time, unions might also be scared to increase their wage claims in a centralised wage-setting system at the sector level to avoid any decrease of employment in non-innovating companies. The impact of decentralised wage-setting might depend on the predominant innovation regime. Individual wage negotiation still bears the risk of individual rent-seeking depending on the power of the employees. This power is higher in routinised innovation regimes where companies depend much more on the knowledge of their insiders.

Hypothesis II. Wage flexibility represented by a less centralised wage-setting has a negative impact on innovation. This is particularly true for negotiations at the company level. The impact of individual wage bargaining depends on the innovation regime and will be higher in a routinised innovation regime.

The second aspect of wage flexibility on the labour market refers to the actual level of wages. With a decentralised wage-setting, the wage level reflects the demand and supply on the labour market allowing for potentially higher wages for individual employees. For several years, economists have often called to decrease wages in order to reduce unemployment (OECD, 1994). A similar argument can be found for innovation activities as lower wages allow a company to invest more wage resources into research and development (R&D) and also increase the benefits gained by successful innovations. However, the effect of wage levels does not seem to be unambiguous. Kleinknecht (1998) shows, that decreasing wages with an associated increase in labour demand and a decline in unemployment, might also be attributed to a low growth in labour productivity. From an innovation economic perspective, a company with low labour costs has only a limited incentive to replace old with new capital (Kleinknecht, 1998, pp. 389–391) and therefore a lower incentive to implement process innovations. In addition, a restriction of wage increases also leads to the prevention of creative destruction, the core of the Schumpeterian theory. Following Schumpeter (1976), only strong and innovative companies will survive. Due to the possibility of higher monopoly profits as a result of a successfully implemented innovation, the innovator has an advantage over non-innovators in higher wage demands and consequently a higher chance of survival. Based on the theory of efficiency wages, companies also offer higher wages to attract more productive workers and increase the motivation and loyalty of its employees (Zhou et al., 2011). Again, this impact might be even stronger in a routinised innovation regime where companies depend more on their internal employees (Kleinknecht et al., 2014, p. 1208). In contrast, a company in an entrepreneurial innovation regime might benefit more from outsiders.

In addition to the wage level itself, individually negotiated wages imply that the wage level of individual employees might be more diverse resulting in higher wage differentials within one company. Thereby, highly skilled employees are able to ask for higher wages resulting in better opportunities to innovate, especially for research and innovation projects that require highly educated workers. However, large wage differentials also increase internal competition and might therefore undermine team work which has been proven to have a significant impact on innovation (Hoegl and Gemuenden, 2001).

Therefore, the impact of the wage level is not unambiguous and also depends on the predominant innovation regime.

Hypothesis III. The relationship between innovation and wage flexibility measured by wage levels differs depends on the innovation regime. Companies operating in a routinised innovation regime might pay higher efficiency wages to increase their likelihood for innovation.

The data as well as the empirical model to test the three hypotheses are described in the following chapters.

4. Data

The dataset used for our analysis is a combination of three different datasets from the Netherlands. Thereby, we are able to avoid any common method bias as these datasets come from independent sources (Podsakoff et al., 2003).

First of all, we use two datasets from the Centraal Bureau voor de Statistiek (CBS), the Central Bureau of Statistics of the Netherlands in The Hague. The first one is the Community Innovation Survey (CIS) of the European Commission with a standardised questionnaire for all participating European countries. In this way, it offers harmonised information on research and innovation such as R&D expenditures, incentives, as well as barriers to innovation using the official definitions of the Oslo Manual provided by the OECD (2005). CIS surveys of innovation are often described as subject-oriented as they ask individual firms directly whether they were able to produce an innovation. The interpretability, reliability, and validity of the survey were established by extensive piloting and pre-testing. The survey as then implemented within different European countries and across firms from a variety of industrial sectors including services, construction and manufacturing for more than twenty years.

Second, we use data of the Dutch income tax office. This dataset on employee level contains extensive information about employment contracts including working hours and wage levels, in addition to employee information such as gender or age. An identification number allows the assignment of employees to a company. Entry and exit data indicate the duration of employment

[8] A theoretical and empirical survey of literature focusing on the relationship between labour unions and innovation activities can be found in Menezes-Filho and Van Reenen (2003).

of individual employees in a specific company within a respective year and illustrate employment changes within an organisation. Thereby, the entrance month is counted only if the employment has started not later than the 15th day of the month, while the leaving month is counted only if the employment has determined after the 15th day of the month. The variable Collective Labour Agreement (CAO), assigned by the negotiating union, shows for each employee whether its salary was negotiated collectively. The number identifies a specific collective agreement, if one has been completed. However, there is no information on whether this agreement was negotiated at company or industry level.

That is why we also use the Dutch Database of Collective Agreements (DUCADAM) of the Amsterdam Institute for Advanced Labour Studies (AIAS), a research institute of the University of Amsterdam. This data collection contains all collective labour agreements (CLAs) in the Netherlands, resulting from an extensive inquiry as well as a co-operation with the Federatie Nederlandse Vakbeweging (FNV), the Dutch Trade Union Confederation. The dataset contains the CAO number, used to match the DUCADAM data with the wage dataset from the CBS, as well as other relevant company and bargaining variables including the level of the bargaining process.[9] Aggregated on company level, we match this dataset with the CIS data using the company's identification number.

The whole dataset contains data from manufacturing as well as service sectors for every second year from 1998 until 2008. With approximately 9000 surveyed companies per year, the whole dataset covers about 50,000 observations

The CIS data contains two types of innovation that we use in our analysis, product and process innovations. Based on the Oslo Manual (OECD, 2005), a product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. The intention of the process innovation can either be the reduction of costs, the increase in quality, or the production of new or improved products. Thereby, both types include true innovations that are new to the entire market as well as imitations that are only new to an individual company.[10] The latter type of innovation is dominating the overall figures, whereas innovations new to the market are in general the exception.

Table 1 summarises some descriptive statistics of our dataset. More than 36 percent of all observed companies are innovators. Thereby, product innovations are more common than process innovations.

More than 50 percent of all companies belong to service sectors, while most of the innovators are manufacturing companies. The majority of all observations are small companies with less than 50 employees, whereas only ten percent have 200 or more employees. However, innovative companies are significantly larger. The share of companies that are doing research regularly is about thirteen percent for all observed and more than 35 percent for innovators.

More than 85 percent of the companies pay a collectively bargained wage mostly negotiated at industry level. Although the share of agreements at company level is much smaller, the percentage is higher for innovators compared to non-innovating companies.

Almost 25 percent bout 40 percent of the employees within a company have a temporary contract. Thereby, this share is lower for companies with successful innovation. The same can be said for flexible contractors who only work on demand. About 6 percent of the employees in all observed companies are working on demand. Once again this percentage decreases for innovative companies.

Table 1
Summary of descriptive statistics, percentage.

	All	Innovators	Process innovators	Product innovators
Innovation	36.59			
Process innovation	21.58			
Product innovation	27.79			
Sectors				
Agriculture	2.17	2.17	1.93	2.53
Nutrition	4.29	4.82	4.99	6.32
Consumer goods	1.40	1.30	1.90	2.39
Publishing industry	4.18	4.39	4.08	6.05
Producer goods	9.41	12.43	12.58	14.35
Machine construction	5.12	12.60	14.15	13.58
Investment goods	16.69	13.52	13.87	14.96
Wholesale	10.82	12.69	12.40	9.83
Retail	12.45	5.66	4.68	4.34
Transportation	7.83	5.70	4.76	5.52
Business services	4.68	6.55	7.59	5.17
Real estate	18.59	15.89	15.31	12.90
Other services	2.39	1.77	1.77	2.05
Total	100.00	100.00	100.00	100.00
Employment size				
Less than 50	50.75	39.61	38.86	36.54
50–199	39.07	44.06	44.28	44.22
200 and more	10.18	16.33	16.86	19.25
Total	100.00	100.00	100.00	100.00
Research				
Non-researching companies	87.63	68.70	64.88	62.12
Researching companies	12.37	31.30	35.12	37.88
Total	100.00	100.00	100.00	100.00
Collective bargaining				
Bargaining at industry level	86.11	82.71	81.78	81.91
Bargaining at company level	6.12	9.58	11.08	10.14
No collective bargaining	7.77	7.70	7.13	7.95
Total	100.00	100.00	100.00	100.00
Labour market flexibility				
Flexible contract	6.58	3.20	3.24	2.83
Temporary contract	24.45	21.04	20.60	20.75

Source: CBS, AIAS 1998–2008, own calculations.

5. Empirical model

As the dependent variable, we use the binary-coded variable *Innovation*, which identifies companies with a successful innovation. Due to the binary coding of the dependent variable, we use a Random Effects Panel Probit model. It can be written as follows

$$\text{Prob}(\textit{Innovation} = 1|X) = \Phi(X'\beta) + \varepsilon, \quad (1)$$

with X as a vector of independent variables and Φ as the Cumulative Distribution Function of the standard normal distribution. It can be interpreted as the probability of a company to be an innovator given the variables summarised in X. The vector X contains information on labour market flexibility as well as additional control variables. Wage flexibility is measured by variables describing the two aspects of wage flexibility on the labour market, the bargaining process as well as the wage level. The grouped variable *Bargainlev* specifies the level of wage bargaining. The higher the value of *Bargainlev*, the more likely the transaction takes place at a decentralised level. The lowest value is the inflexible wage-setting

[9] Further information about the DUCADAM dataset can be found in Hartog et al. (1999). Details about the variables and their encoding are given in Schreuder and Tijdens (2004).

[10] In this paper new products and processes are called innovations. These might be new to the entire market or only new to the company.

at industry level. In contrast, a fully flexible wage-setting includes no collective bargaining. *Bargaincov* indicates the percentage of employees in a company that are subject to the collectively agreed wages. Variables describing the second aspect of wage flexibility, the level of wages, are *Medwage* as the median wage level and *Dif fwage* as the wage differential within a company.

External numerical and functional flexibility are measured by three variables.[11] The company's labour turnover *Labturn* indicates changes in employment given by the share of employees that left the company within a year (Zhou et al., 2011, p. 8). *Employstat* indicates the share of on-demand workers with a flexible contractor status, while the share of workers with a temporary employment contract is represented by the variable *Tempemp*. In order to avoid any potential multicollinearity with *Labturn*, these two items are united into one *Factor* using a factor analysis.[12]

The control variables include the firm's size measured by the annual logs of a company's turnover. Thereby, the variable *Turn* refers to the turnover of the previous period which reduces potential endogeneity problems. The binary coded variable *Research* controls for existing research activities of a company. *Holland* identifies companies with headquarters in the Netherlands and is used to measure activities in foreign markets. The variable *Group* refers to companies that are part of a corporate group. The firm's *Age* is approximately given by the age of employees within a company.[13] In addition, the individual dummies *Sec* and *Year* for industries and years are included.

Given the described variables, the following equation (2) is obtained:

$$\begin{aligned}\text{Prob}(\textit{Innovation} = 1|X) = \Phi(&\beta_0 + \beta_1 \cdot \textit{Bargainlev} + \beta_2 \cdot \textit{Bargaincov} \\ &+ \beta_3 \cdot \textit{Medwage} + \beta_4 \cdot \textit{Diffwage} \\ &+ \beta_5 \cdot \textit{Factor} + \beta_6 \cdot \textit{Labturn} + \beta_7 \cdot \textit{Turn} \\ &+ \beta_8 \cdot \textit{Research} + \beta_9 \cdot \textit{Holland} + \beta_{10} \cdot \textit{Group} \\ &+ \beta_{11} \cdot \textit{Age} + \beta_{12} \cdot \textit{Sec} + \beta_{13} \cdot \textit{Year}) \end{aligned} \quad (2)$$

To test a potential non-linearity as stated in the model of Haucap and Wey (2004), we use individual wage-setting levels to measure the level of wage bargaining in the regression in a further step. Using the most centralised bargaining at industry level *Indlev* as reference category, *Nolev* identifies companies without collective bargaining agreements, whereas *Complev* indicates companies with a wage-setting at company level. Eq. (3) can be written as:

$$\begin{aligned}\textit{Prob}(\textit{Innovation} = 1|X) = \Phi(&\beta_0 + \beta_1 \cdot \textit{Nolev} + \beta_2 \cdot \textit{Complev} \\ &+ \beta_3 \cdot \textit{Bargaincov} + \beta_4 \cdot \textit{Medwage} \\ &+ \beta_5 \cdot \textit{Diffwage} + \beta_6 \cdot \textit{Factor} + \beta_7 \cdot \textit{Labturn} \\ &+ \beta_8 \cdot \textit{Turn} + \beta_9 \cdot \textit{Research} + \beta_{10} \cdot \textit{Holland} \\ &+ \beta_{11} \cdot \textit{Group} + \beta_{12} \cdot \textit{Age} + \beta_{13} \cdot \textit{Sec} + \beta_{14} \cdot \textit{Year}) \end{aligned} \quad (3)$$

In order to account for the potential impact of the different innovation regimes, both equations are estimated separately for two different models, the *Entrepreneurial model* and the *Routinised Model*. Similar to Kleinknecht et al. (2014, p. 1211), the grouping is based on the Herfindahl index measuring the concentration ratio of R&D budgets in each sector. Thereby, the higher the concentration ratio in a sector, the higher the likelihood it is dominated by a routinised innovation regime.[14]

In addition, Eqs. (2) and (3) are estimated for process and product innovations using the variables *Process* and *Product* as dependent variables. Table A4 in the appendix summarises the individual empirical regression equations and describes the variables used in each case.

6. Results

The results of the Panel Probit regression for equation (2) for both innovation regime models are presented in Table 2. The marginal effects are sorted by the different types of flexibility as well as the dependent variables *Innovation*, *Process* and *Product*.[15]

The impact of a flexible wage bargaining system on innovation differs depending on the innovation regime model. A flexible wage-setting has a significant positive impact on innovation in the *Routinised Model*, whereas the marginal effects of *Bargainlev* and *Bargaincov* are smaller and not significant for companies in the *Entrepreneurial model*. In addition, there are also significant differences between the two types of innovation *Process* and *Product*. A wage negotiated at a flexible level and a high share of employees within a company that are affected by these wage agreements significantly increase the probability of *Process*. The marginal effects for *Product*, in contrast, are not significant in both innovation regimes. That means that while process innovations always benefit from a flexible wage-setting system, it does not have a significant impact on the generation of product innovations.

Contrary to our third hypothesis, the results for the relationship between innovation and wage flexibility on the labour market measured by wage levels are the same for both innovation regime models. The median wage *Medwage* has a significant positive association with *Innovation*, while a high wage differential *Diffwage* significantly decreases the likelihood of an innovation. These results apply to *Process* as well as *Product* innovations. Even though the marginal effects are very small, the impact of *Medwage* seems to be slightly stronger for companies operating in the *Entrepreneurial Model*. In addition, the marginal effects for *Diff wage* for *Product* compared to *Process* innovations are slightly higher in the *Entrepreneurial Model*and slightly lower in the *Routinised Model*.

The results of Eq. (3), including the individual bargaining levels, can be found in Table 3. Again, the impact of the wage bargaining system depends on the innovation regime model as well as the type of innovation. Compared to centralised wage bargaining at industry level, *Nolev* and *Complev* are positively associated with all types of innovation in the *Routinised Model*. Thereby, the impact of individual wage negotiations *Nolev*, representing the most flexible level of wage bargaining, is almost twice as high compared to negotiations at the company level which confirms our second hypothesis. However, the marginal effects are again not significant for *Product* innovations.

In contrast, companies operating in the *Entrepreneurial Model*benefit from negotiations on the firm level *Complev* compared to wages set at the industry level *Indlev*. This applies to

[11] The dataset does not contain any internal indicators.

[12] The results of the factor analysis can be found in Table A5.

[13] Unfortunately, the dataset does not contain information about the age of a company. Following the results of Ouimet and Zarutskie (2011, p. 1), the employee's age can be used as a proxy as it is strongly positively associated with the age of the company.

[14] More details on the industries can be found in Kleinknecht et al. (2014)Kleinknecht et al. (2014, p. 1219).

[15] The difficulties in the estimation of the marginal effects are known, particularly when several binary coded explanatory variables are used. The resulting coefficients are listed in Tables A5 and A6 in the appendix.

Table 2
Marginal effects of the Panel Probit regression equation (2), estimated separately for the entrepreneurial and the routinised model.

	Entrepreneurial Model			Routinised Model		
	Innovation	Process	Product	Innovation	Process	Product
BargainLev	0.025	0.039**	0.026	0.079***	0.062***	0.028
BargainCov	0.008	0.068*	−0.033	0.157***	0.119***	0.047
MedWage	$5.06e^{-05}$***	$2.99e^{-05}$***	$2.75e^{-05}$***	$2.56e^{-05}$***	$1.31e^{-05}$***	$1.67e^{-05}$***
DiffWage	$-5.20e^{-04}$***	$-2.42e^{-04}$**	$-5.85e^{-04}$***	$-5.24e^{-04}$***	$-4.18e^{-04}$***	$-2.52e^{-04}$***
LabTurn	−0.092	−0.063*	−0.013	−0.150***	−0.087**	−0.076*
Factor	−0.015	0.008	0.011	−0.023***	−0.008	−0.024***
Turn	0.005	0.004	0.007	0.018***	0.015***	0.016***
Research	0.788***	0.417***	0.731***	0.659***	0.379***	0.665***
Group	0.071***	0.044***	0.043***	0.078***	0.047***	0.076***
Holland	−0.137***	−0.059**	−0.040	−0.024	0.015	0.015
Age	−0.259***	−0.170***	−0.167***	−0.233***	−0.145***	−0.129**
Sec	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	6540	6540	6540	9913	9913	9913
Wald-Chi^2	637.90***	621.17***	785.80***	1195.86***	972.06***	118.94***
Pseudo-R^2	.81071	.82359	.81801	.82142	.83573	.82902
Log-Likelihood	−2812.43	−2805.21	−2265.2798	−5042.95	−4939.36	−4419.22

Source: CBS, AIAS 1998–2008, own calculations.
Significance levels: ***/**/* 1%/5%/10%.

Table 3
Marginal effects of the Panel Probit regression equation (3), estimated separately for the entrepreneurial and the routinised model.

	Entrepreneurial Model			Routinised Model		
	Innovation	Process	Product	Innovation	Process	Product
NoLev	−0.055	−0.014	−0.004	0.146**	0.160***	0.046
ComLev	0.112**	0.115***	0.070**	0.089***	0.060***	0.035
IndLev	–	–	–	–	–	–
BargainCov	−0.088	−0.015	−0.083	0.141**	0.133***	0.034
MedWage	$4.82e^{-05}$***	$2.78e^{-05}$***	$2.63e^{-05}$***	$2.45e^{-05}$***	$1.30e^{-05}$***	$1.65e^{-05}$***
DiffWage	$-4.97e^{-04}$***	$-2.23e^{-04}$**	$-5.67e^{-04}$***	$-5.25e^{-04}$***	$-4.18e^{-04}$***	$-2.52e^{-04}$***
LabTurn	−0.090	−0.062*	−0.012	−0.149***	−0.087**	−0.076*
Factor	−0.015	0.008	0.011	−0.023***	−0.008	−0.024***
Turn	0.004	0.003	0.007	0.018***	0.015***	0.016***
Research	0.787***	0.413***	0.730***	0.659***	0.380***	0.665***
Group	0.068***	0.042***	0.042***	0.078***	0.048***	0.076***
Holland	−0.133**	−0.056*	−0.038	−0.023	0.015	0.015
Age	−0.275***	−0.184***	−0.176***	−0.234***	−0.144***	−0.130**
Sec	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	6540	6540	6540	9913	9913	9913
Wald-Chi^2	640.43***	624.05***	785.59***	1195.57***	972.38***	1184.56***
Pseudo-R^2	.81058	.82449	.81728	.82162	.83678	.82819
Log-Likelihood	−2809.17	−2799.74	−2263.66	−5042.87	−4939.27	−4419.17

Source: CBS, AIAS 1998–2008, own calculations.
Significance levels: ***/**/* 1%/5%/10%.

all different types of innovation *Innovation*, *Process* and *Product*, while the marginal effect is slightly lower for product innovations. Decentralised wage bargaining between a company and its individual employees *NoLev* is negatively associated with all types of innovation. However, the marginal effects are not significant. The positive impact of *ComLev* in both regimes can also be explained by the fact that mainly the largest companies have specific company-level wage agreements. With higher productivity gains and the opportunity to pay better wages they are also more likely to innovate. That is why *ComLev* can also be interpreted as a large firm effect.

The marginal effects and significance level of the other variables of wage flexibility change only slightly in Eq. (3). *BargainCov* still has a positive and significant relationship with *Innovation* and *Process* for companies operating in a routinised innovation regime. In contrast, the marginal effects are negative and not significant for all types of innovation in the *Entrepreneurial Model*.

Overall, a high wage flexibility on the labour market measured by a decentralised wage-setting system has a stronger association particularly with process innovation in the *Routinised Model* where companies much more depend on the cumulated knowledge of their employees. Measured by wage levels, wage flexibility has a significant relationship with all types of innovation regardless of the innovation regime. Thereby, a higher median wage slightly increases the likelihood of an innovation, while a high wage differential within a company has a slightly negative impact.

The results for the variables measuring external numerical and functional labour market flexibility as well as the control variables in Eqs. (2) and (3) remain relatively constant. Thereby, the results for *LabTurn* and *Factor* differ depending on the innovation regime, which confirms our first hypothesis. A company operating in the *Routinised Model* indeed depends on the knowledge of its employees, which is why both items have a negative impact on all types of innovation. Thereby, the association with *LabTurn* is slightly stronger for *Process* innovations, while a higher share of flexible working contracts including temporary and on-demand employees summarised in *Factor* only has a significant negative impact on *Product* innovations. That means that companies operating in a routinised innovation model need stability in order to implement innovations. In the *Entrepreneurial Model*, in contrast, external numerical and functional flexibility is not significantly associated with any type of innovation, apart from a slightly negative impact of *Labturn* on *Process*.

The control variable *Research* significantly increases the probability of successful innovations. Thereby, the development of product innovations seems to depend much more on research and investments, which is why the marginal effects are almost twice as high for *Product* compared to *Process*. In addition, the variable *Group* is positively correlated, while the *Age* is rather negatively associated with all types of innovation.

However, there are also some significant differences between the two innovation regimes. While the size of a company, measured by *Turn*, is positively associated with *Innovation*, *Process* and *Product* in the *Routinised Model*, it does not have a significant impact on the likelihood to innovate in the *Entrepreneurial Model*. In addition, *Holland* is negatively associated with innovation for companies operating in the *Entrepreneurial Model*. However, the marginal results are only significant for *Innovation* and *Process*.

Based on our findings, companies operating in a routinised innovation regime are likely to generate innovations, and especially process innovations, if they have a low external flexibility, but a high wage flexibility measured by decentralised wage-setting. Innovators in an entrepreneurial innovation regime, in contrast, prefer a slightly more flexible wage-setting, while external numerical and functional labour market flexibility does not have a significant impact. For both regimes, a high median wage and a low internal wage differential increases the likelihood to innovate.[16]

7. Conclusions

In this paper, we investigate the relationship between labour market flexibility in various definitions and innovation. Our results demonstrate that this relationship strongly depends on the type of innovation as well as the predominant innovation regime in which a company operates. Thereby, market flexibility labour market flexibility does not influence innovation in an entrepreneurial innovation regime characterised by high competition, low market entry barriers and generally available knowledge. That might explain why the Silicon Valley has been successful despite of having a labour market with a strong hire and fire mentality. In contrast, labour market flexibility significantly reduces the likelihood of innovation in a routinised innovation regime with leading innovators and high entry barriers similar to the US automobile industry and steel districts that did not succeed.

Novel to the literature, we distinguish between different aspects of labour market flexibility and also analyse the potential impact of indicators measuring wage flexibility – in addition to external numerical and functional flexibility. Our results show that wage flexibility as a part of labour market flexibility indeed is correlated with the probability to innovate. However, the relationship depends on the specific measurement of wage flexibility, the type of innovation as well as the predominant innovation regime.

A high wage flexibility measured by a decentralised wage bargaining system is positively associated with innovations. However, this positive impact only applies to process innovations and is much stronger for companies operating in a routinised innovation regime, in which companies rely much more on their historically accumulated knowledge. Product innovations, in contrast, are not significantly correlated with flexibility indicators of the wage bargaining system. The results for wage flexibility measured by wage level indicators instead are the same for both types of innovation, regardless of whether the company is operating in an entrepreneurial or a routinised innovation regime. Thereby, a higher median wage and a lower wage differential always increase the likelihood to innovate, which is contradicting the logic of the neoclassical homo economicus, but in line with studies that emphasise commitment and teamwork such as Tidd et al. (1997).

Thus, process innovation is more likely in a flexible wage bargaining system, while both innovation types always benefit from higher wages and less wage flexibility measured by wage levels.

The findings for external numerical and functional labour market flexibility also depend on the innovation regime. While our results are not significant for companies operating in the entrepreneurial innovation regime, a high level of flexibility decreases the likelihood of innovation in the routinised innovation regime, especially for product innovations.

Overall, high labour market flexibility is obviously not positive for product innovation, whereas process innovations are fostered by wage flexibility, i.e. their cost decreasing impact can be pushed by strong financial incentives.

The Dutch findings are highly indicative for European labour market policy, which is currently promoting an increased labour market flexibility.[17] However, our results in this paper show that this call for structural labour market reforms might be in conflict with the intention to encourage innovation activities in European companies. Our analysis illustrates that the relationship between labour market flexibility and innovation activities strongly depends on the type of innovation as well as the predominant innovation regime a company is operating in.

Finally, despite the discussed differences for the different types of innovation as well as the two innovation regimes, our findings do not support that increasing numerical or functional labour market flexibility is beneficial for the development of innovation. Therefore, even if some aspects of labour market flexibility might support one type of innovation, technological change always still requires a level of security and stability.

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[16] The analysis induces potential problems with endogeneity as the wage-setting or the wage levels as well as the number of flexible employment contracts may also be influenced by the generation of innovations, as shown by Storey et al. (2002). Their results demonstrate that flexible working contracts are often a consequence of innovation (Storey et al., 2002, p. 1). Michie and Sheehan (1999, pp. 221–222) also refer to a possible reverse causality. In addition, they also point to a simultaneous incidence of technological changes and changes in the organisational structure of work which is particularly related to the variables of numerical and functional labour market flexibility. Due to the lack of suitable instrumental variables for all individual aspects of labour market flexibility, we tested the results using lagged values of the variables without finding significant differences. However, it is important to note that the resulting correlations do not necessarily reflect a one-way causality.

[17] See also Schils and Houwing (2010).

Appendix A.

Table A4
Description of included variables and regression models.

Variables	Description	Code	(2)	(3)
Dependent variables				
INNOVATION	Innovator	Binary	x	x
PROCESS	Process innovator	Binary	x	x
PRODUCT	Product innovator	Binary	x	x
Wage flexibility				
BARGAINLEV	Wage bargaining level	Grouped 1–3	x	x
BARGAINCOV	Share of employees with collective wages	Percentage	x	x
NOLEV	No collective bargaining	Binary		x
COMPLEV	Collective bargaining at company level	Binary		x
INDLEV	Collective bargaining at industry level	Binary		
MEDWAGE	Median monthly wage per employee	Continuous	x	x
DIFFWAGE	Wage differential within a company	Continuous	x	x
External numerical and functional flexibility				
LABTURN	Share of employees who left within a year	Percentage	x	x
FACTOR	Summarising:	Continuous	x	x
	EMPLOYSTAT	Share of on-demand employees		
	TEMPEMP	Share of temporary employees		
Control variables				
SIZE	Logarithm of the number of employees	Continuous	x	x
TURN	Logarithm of the previous annual turnover	Continuous	x	x
RESEARCH	Company is doing research	Binary	x	x
HOLLAND	Headquarter is in the Netherlands	Binary	x	x
GROUP	Company is part of a group of companies	Binary	x	x
AGE	Age of the employees within a company	Continuous	x	x
SEC	Sectors dummies	Binary	x	x
YEAR	Year dummies	Binary	x	x
Technological regimes				
ENTREPRENEURIAL MODEL	Schumpeter mark I model, 'entrepreneurial' innovation regime	Binary	x	x
ROUTINISED MODEL	Schumpeter mark II model, 'routinised' innovation regime	Binary	x	x

Table A5
Results of the factor analysis.

Variable	Factor 1	Uniqueness
Employstat	0.806	0.3504
Tempemp	0.806	0.3504

Source: CBS, AIAS 1998–2008, own calculations.

Table A6
Coefficients of the Panel Probit regression equation (2), estimated separately for the entrepreneurial and the routinised model.

	Entrepreneurial model			*Routinised Model*		
	Innovation	*Process*	*Product*	*Innovation*	*Process*	*Product*
Bargainlev	0.069	0.172**	0.111	0.207***	0.216***	0.098
Bargaincov	0.023	0.301*	−0.144	0.410***	0.411***	0.161
Medwage	1.43^{-04}***	1.32e^{-04}***	1.19e^{-04}***	6.68e^{-05}***	4.53e^{-05}***	5.74e^{-05}***
Diffwage	−1.46e^{-03}***	−1.07e^{-03}**	−2.54e^{-03}***	−1.37e^{-03}***	−1.44e^{-03}***	−8.65e^{-04}***
Labturn	−0.258	−0.279*	−0.054	−0.390***	−0.300**	−0.261*
Factor	−0.042	0.036	0.048	−0.059***	−0.028	−0.083***
Turn	0.015	0.018	0.032	0.047***	0.053***	0.056***
Research	2.879***	1.302***	2.270***	2.052***	1.092***	1.952***
Group	0.202***	0.198***	0.193***	0.206***	0.166***	0.267***
Holland	−0.363***	−0.232**	−0.160	−0.061	0.052	0.052
Age	−0.728***	−0.750***	−0.726***	−0.607***	−0.503***	−0.444**
Sec	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	6540	6540	6540	9913	9913	9913
Wald-Chi^2	637.90***	621.17***	785.80***	1195.86***	972.06***	118.94***
Pseudo-R^2	.81071	.82359	.81801	.82142	.83573	.82902
Log-Likelihood	−2812.43	−2805.21	−2265.2798	−5042.95	−4939.36	−4419.22

Source: CBS, AIAS 1998–2008, own calculations.
Significance levels: ***/**/* 1%/5%/10%.

Table A7
Coefficients of the Panel Probit regression, Eq. (3).

	Entrepreneurial Model			Routinised Model		
	Innovation	Process	Product	Innovation	Process	Product
Nolev	−0.160	−0.065	−0.016	0.370**	0.482***	0.151
Complev	0.299**	0.423***	0.271**	0.227***	0.196***	0.115
Indlev	–	–	–	–	–	–
Bargaincov	−0.247	−0.065	−0.362	0.367**	0.460***	0.118
Medwage	$1.36e^{-04}$***	$1.22e^{-04}$***	$1.14e^{-04}$***	$6.61e^{-05}$***	$4.61e^{-05}$***	$5.67e^{-05}$***
Diffwage	$-1.40e^{-03}$***	$-9.79e^{-04}$**	$-2.46e^{-03}$***	$-1.37e^{-03}$***	$-1.45e^{-03}$***	$-8.66e^{-04}$***
Labturn	−0.253	−0.273*	−0.052	−0.390***	−0.301**	−0.260*
Factor	−0.043	0.036	0.048	−0.059***	−0.028	−0.083***
Turn	0.012	0.014	0.030	0.047***	0.053***	0.056***
Research	2.867***	1.291***	2.264***	2.051***	1.093***	1.951***
Group	0.194***	0.190***	0.188***	0.205***	0.167***	0.266***
Holland	−0.353**	−0.223*	−0.153	−0.061	0.052	0.052
Age	−0.772***	−0.810***	−0.765***	−0.610***	−0.498***	−0.447**
Sec	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
N	6540	6540	6540	9913	9913	9913
Wald-Chi^2	640.43***	624.05***	785.59***	1195.57***	972.38***	1184.56***
Pseudo-R^2	.81058	.82449	.81728	.82162	.83678	.82819
Log-Likelihood	−2809.17	−2799.74	−2263.66	−5042.87	−4939.27	−4419.17

Source: CBS, AIAS 1998–2008, own calculations.
Significance levels: ***/**/* 1%/5%/10%.

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