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## Summary of PhD Thesis

**Title:**

„Organisation of labour and technological change”

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The aim of the submitted doctoral thesis is to examine the impact of technology on the organization of labour. The thesis consists of two parts that focus on the impact of technological change on two areas of labour organization: (1) unionisation and (2) the use of teamwork in companies. The first part presents a mechanism of the impact of technology on decisions of employees and companies regarding trade unions' formation and membership. A theoretical model was constructed, combining decreasing trade union membership with an increase in productivity of unobservable effort and the related rise of performance-based remuneration. The theoretical discussion starts with a basic model that assumes a representative worker and firm. Then, an extended version is introduced, that takes into account differences in productivity of workers and firms. Finally, a testable prediction of the model, that there is a negative correlation between the level of unionisation and a variance of wages in the unionised sector, is empirically confirmed. The second part of the thesis presents the theory of the impact of technology on the size of teams, based on a model of searching for the best idea. The proposed theory was used to show the impact of a change in the distribution of ideas on team size. In particular, greater variability of ideas caused by technological progress leads to larger teams. In addition, it was shown through numerical simulations that with technological advancement, the share of employees with a relatively large variance of ideas in teams goes up.

## **Associated literature**

Last decades were marked by a substantial change on the labour market caused by the introduction of new technologies that enabled automation, improved communication, and the creation of a wide range of new services and goods. The most visible impact of technological progress on the labour market is when new products and services require new skills and knowledge to produce them. This contributes to the creation of new types of jobs and even entirely new industries. However, technological change is not restricted only to new emerging industries. Labour organization, the distribution of wages, skills and employment composition changes also within traditional industries. It can be said that in the last decades technological changes, including widespread adoption of ICT, affected directly or indirectly virtually all workers and firms.

The literature discussing the impact of technological change on labour can be divided into two strands: (1) the research on the impact of technological change on the distribution of wages and occupational structure and (2) studies on the impact of technology on labour organisation and institutions. The first strand of literature tries to answer

two main questions: (1) how technology affects the distribution of wages and (2) how technology affects the employment composition by skill and qualifications. It is worth emphasising that as indicated by Goldin (1994) at the beginning of the 20th century the majority of workers in the US could be classified as manual workers employed in industry or farming. However, in the last few decades the number of jobs that require higher qualifications and skills has grown and the importance of manual work has declined. Katz and Murphy (1992) and Berman et al. (1998) showed that since the 1960s the demand for high skilled workers has been increasing faster than the supply. The gap between demand and supply led to an increase in the returns to education in the US and Europe. The studies by Autor et al. (2003), Autor et al. (2006), Goos and Manning (2007), Goos et al. (2009), Acemoglu and Autor (2011), Goos et al. (2014) and de la Rica and Gortazar (2016) showed that in last decades developed economies are witnessing a process of gradual job polarization: the importance of jobs with low skill and high skill requirements increases at the expense of the middle skilled jobs. The reason behind this is that the middle jobs are mostly routine and thus relatively the easiest to automate. As a result income inequality increases and the occupational composition becomes dominated by simple and highly specialised jobs.

The second strand of literature focuses on the impact of technology on labour organization and labour market institutions. This strand of literature studies research questions related to, e.g., the relation between technology and management style (see for example Milgrom and Roberts 1990, Bloom et al. 2012), the incidence of particular types of contracts (see for example Lemieux et al. 2009, Katz and Krueger 2016), or specialization within teams (Dessein and Santos 2006, Garicano and Rossi-Hansberg 2006).

The presented thesis is placed within the latter strand of literature and deals with two particular issues: (1) the decline in labour union membership, (2) the increase in popularity and the scope of team work. The decline in unionisation can be explained by (1) changes in institutions, (2) international trade and (3) technology. The institutional hypothesis assumes that there exists an institutional factor, that increasingly prevents or restricts the possibility to become a member of a union. However, as shown by Farber (2005) it is not the supply of unionised jobs that declined, but the demand for unionisation from workers. A second hypothesis is that a negative impact on unionisation could be assigned to trade liberalization and increased international competition. However, as argued by Baldwin (2003), trade liberalization had minimal effects on unionisation.

The alternative for changes in institutions and international trade as main factors behind deunionisation is technological change. Technological progress may have reduced labour union participation through a number of channels. First, technological change



affects industrial composition. The share of manufacturing industries declines and the share of services, that traditionally have lower unionisation rates, increases. However, the decline in unionisation takes place also within industries. The structural change alone does not explain the overall change in unionisation; an approach is required that does allow technology to have an impact within sectors. In this regard Acemoglu et al. (2001) propose a theoretical model based on the assumption of two sectors. The first sector is highly productive and employs only high skilled workers and pays high wages according to their high productivity. The second sector is less productive and hires high and low skilled workers. In the model proposed by Acemoglu et al. (2001) the second sector is unionised and a single wage is negotiated for all workers. It leads to redistribution of income from high skilled workers to the low skilled and the high skilled workers in the second sector earn below their productivity. Technological change, however, increases the productivity gap between both sectors. This results in an increase in the flow of high skilled workers from the second to the first sector. The consequence is that the benefits from being a member of a union in the second sector diminish. The process leads to erosion of unions in the second sector. Moreover, Acemoglu et al. (2001) shows how technological change through deunionisation can lower the propensity to invest in the training of workers.

A different theory has been formulated by Dinlersoz and Greenwood (2016) who argue that low skilled jobs are more homogeneous and, as a result, easier to unionise. The opposite can be said of jobs that require high qualifications, because in this category tasks even within the same occupation might differ substantially. Starting with this assumption and the observation that the income gap between high skilled and low skilled workers increases, Dinlersoz and Greenwood (2016) propose a model that is able to reproduce the evolution of unionisation and wage inequality in the twentieth century in the US. Açıkgöz and Kaymak (2014) propose a similar model of deunionisation, based on increasing wage inequality. Açıkgöz and Kaymak (2014) show that unionised jobs tend to be in the middle of the skill distribution. In their model technological change increases wage inequality: wages of high skilled workers increase and the productivity of low skilled workers declines. As a result, benefits of union membership decline and the propensity to unionise is lower.

In the first part of the current thesis a new mechanism is presented that links technological progress with unionisation. The basis of the proposed mechanism is the assumption that technological change increases the productivity of jobs in which workers' effort is unobservable. In this situation employers offer contracts that link wages to individual output (a canonical result in contract theory, see for example Grossman and Hart, 1983).

With observable effort, in turn, workers can be paid either a fixed wage negotiated by a union or a variable wage based on individual performance. Trade unions negotiate a flat wage that is set through collective bargaining. However, the fixed wage does not provide incentives to exert unobservable effort. When the productivity of effort is low, trade unions work as a mechanism of redistribution of income from the firm to workers. With technological change, however, the productivity of unobservable effort grows and the benefits of larger output may eventually outweigh the benefit of larger output share for workers. Technological change makes the option with performance pay increasingly beneficial for both workers and firms.

The second part of the thesis studies the relation between technological change and the rising popularity of teamwork. As shown by Mohrman et al. (1995), Lawler et al. (2001) and Bryson and Wood (2008) the number of firms in the US and Great Britain organising workers in teams substantially increased between 1980 and 2000. This trend is present also in the broader group of advanced economies and continues in the 21st century.

The starting point of all research on teamwork is specialization. Already Adam Smith noticed that specialization is one of the crucial drivers of economic growth. Technological progress increases the number of jobs that people can specialize in, as new knowledge and skills are required to perform new jobs. The acquisition of even newer skills requires more and more time and resources, so specialization increases further. If we assume that the main objective of teamwork is cooperation of workers with complementary skills and knowledge to achieve synergy, then technological change naturally promotes teamwork. However, the decision to form a team does not need to rely solely on specialization: another important factor is coordination costs. Arguably, recent technological developments related to ICT are systematically bringing these costs down. The issues of specialization and coordination costs are mutually intertwined, since as shown by Becker and Murphy (1992) the decline in coordination costs leads to deeper specialization and increase the number of people who cooperate with each other. However, Dessein and Santos (2006) argue that it is not always the case that technological change increases specialization. It may contribute to relaxation of the strict division of work and make it more flexible.

The modelling approach taken in this thesis derives from the approaches to teamwork based on specialization and coordination costs. Teamwork is modelled here through the means of a search model for ideas. Lazear (1999) argues that one of the reasons for which innovative firms may want to hire more *ex ante* identical workers is to increase their chance of finding the best idea. By emphasising this perspective, the current model tries to describe innovative industries and R&D organisations. In this approach, each worker



is hired because he/she can produce an idea. However, the output is determined only by the best idea. The current thesis develops this approach further with the emphasis on the shape of the distribution of ideas, which is expected to change with technological progress.<sup>1</sup> If technological change increases the expected value and dispersion of the distribution of ideas, then the size of teams should grow.

## Research objectives and hypotheses

The fundamental goal of the thesis is to identify the key mechanisms of impact of technological change on trade unions and the incidence of teamwork. This goal is further decomposed into two main objectives of the thesis: (1) the construction of a novel theoretical model that describes the mechanism of the impact of the technology on unionisation and (2) the construction of a model that links the increase in teamwork with technological change. In case of the first object the theoretical analysis was supported by empirical investigation. Empirical verification of the second model is left for further research.

The first objective was achieved in the following steps: (1) presentation of a model of a representative worker and firm, (2) presentation of a model that incorporates heterogeneous firms and workers, (3) empirical verification of the key properties of the model. The aim of the basic model with a representative worker and firm was to outline the relation between the level of available technology and the willingness to adopt a performance pay contract. In the model two types of employment contracts were considered: individual performance pay and collective agreement with a fixed wage for all workers. In the next step the model was expanded to include heterogeneous firms and workers. Additionally, a mechanism assigning the workers to firms was introduced. The constructed model was used to characterize unionisation at the industry and economy-wide level. The extended model was a starting point for the empirical analysis: it was used to map the crucial relations between variables.

The second main objective of the thesis associates the increasing scope of teamwork with technological change. We proposed a model based on the concept of searching for the best idea. Search models for the best idea were developed among others by Lazear (1999), Jones (2005) and Growiec (2013). Each worker presents his/her idea, but only the best, most profitable one is chosen. Analogously to the first objective, at the

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<sup>1</sup>The distribution of ideas is directly unobservable. However, if one believes that the distribution of ideas is correlated with firm productivity, then the dispersion of ideas should be on the rise, just as productivity differences between firms increased markedly between 1998-2013, see Andrews et al. (2016).

beginning a basic, static model is developed to highlight the core mechanism. Next, the time dimension is introduced to the model and sequential search is allowed. Moreover, the optimal composition of a team was studied in an environment of heterogeneous workers.

Two main hypotheses of the thesis are:

1. Technological change has the potential to cause a secular reduction in trade union membership:
  - a. If technological change increases productivity of the effort that is not directly observable, it makes it profitable for firms and workers to move away from collective bargaining and implement individual performance pay instead. This, in effect, reduces workers' propensity to join trade unions.
2. Technological change has the potential to cause a secular increase in the popularity of teamwork:
  - a. If technological change increases the mean and variance of ideas, innovative firms will gradually increase the number of workers in teams;
  - b. With worker heterogeneity technological change affects team composition: teams get larger and hire more workers with a higher dispersion of ideas.

Furthermore, the theoretical Hypothesis 1 implies three empirically testable relations verified in this thesis:

- 1a. The variance of wages of non-unionised workers in an industry is negatively correlated with the level of unionisation in the industry.
- 1b. The variance of bonuses of non-unionised workers in an industry is negatively correlated with the level of unionisation in the industry.
- 1c. The variance of wages of non-unionised workers is negatively correlated in time with unionisation.

Hypothesis 2 is not empirically tested in this thesis. However, numerical simulations were conducted in some cases to obtain better insight into the formalized mechanism.

## Results and contributions

In the current thesis the above research hypotheses have been confirmed. The main contributions of this thesis to the economic literature on technological change and the organisation of labour are as follows.

Firstly, it was shown that technology can affect unionisation through a change of productivity of unobservable effort. In the proposed model technological change leads to a rise in the productivity of unobservable effort and as a result it increases benefits from a transition from a collective agreement to individual performance pay. In the situation of the higher productivity of unobservable effort firms can achieve higher profits and afford to offer wages linked to performance that are higher than those negotiated collectively. The reason behind this result is that workers under collective agreement with a fixed wage have no financial incentives to exert effort. However, additional effort increases total production, which allows firms to share the profit in a way that both sides benefit from the higher output. It is a novel channel of the impact of technological change on labour union density. The extended model that takes into account heterogeneity of firms and workers in terms of productivity is used to examine the mechanism at the level of industries and the entire economy.

The proposed model of the impact of technological change on the level of unionization has been subjected to two preliminary empirical tests. In the first test, it was shown that in line with the model's predictions, in European countries the level of unionization in a sector is negatively correlated with the variance of wages in this sector. The second empirical test confirmed the hypothesis that trade union density in the US was negatively correlated over time with the variance of wages. This empirical analysis sheds new light on the relationship between unionisation, reliance on performance pay and the distribution of wages.

Secondly, based on a model of search for the best ideas, the thesis has demonstrated how technological change can positively affect the incidence of team work in firms. The proposed model complements the standard approach to the issue, based on the growth of specialization and reduction of communication costs (see Becker and Murphy 1992). In the model the following candidate factors increasing the size of the team were considered: (1) increase in synergy between employees, (2) decrease in communication costs, and (3) change in the idea distribution. The key emphasis was on changes the distribution of ideas, in particular the increase in the dispersion of ideas. It has been shown that the increase in the dispersion of ideas, caused by technological progress, leads to an increase in the number of people working in teams. This is a proposal of a new channel of impact



of technology on teamwork.

Finally, as part of the analyses of the search model, numerical simulations were carried out showing that technological progress also influences the composition of the teams. Due to the positive impact of technological change on team size companies, having a choice of generally highly productive employees with a low variance of ideas and employees with generally low productivity but with a high variance of ideas and hence somewhat greater chance to produce an exceptional idea, increase the percentage of employees with the greater variance of ideas. Conducted simulations of team composition add a new dimension to the analysis of the relationship between technology and group work.

## Concluding remarks

The submitted doctoral dissertation has successfully verified the proposed hypotheses. At the same time, however, it leaves the possibility of many further developments. First of all, in contrast to the model of unionisation, no empirical test was carried out for the teamwork model. This is mainly due to the lack of appropriate data. However, even if individual data containing information about the teams would be available, the problem of observability and quantification of ideas remains to be solved. This would probably require devising an unconventional empirical strategy.

Secondly, the relationship between technology, labour organization and income inequality is not the central point of the thesis. Focusing more on the labour income share and income inequality could provide new conclusions. It could provide a new perspective on the issues discussed in the thesis and it could directly refer to the research literature on the impact of technology on the distribution of wages and income.

Thirdly, the thesis was focused on two selected aspects of the relationship between technological change and labour organization. This provides the possibility of expanding the scope of research to new areas. Examples of such areas are: technological determinants of management styles, technology and contract types, choice of working time, etc. Given that the modern technology is increasingly used in the workplace, the number of issues related to technology and labour will probably be only growing with time.

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## *Appendix*      Research and Academic Activity

### ***Education:***

1. **M.A. in Economics**  
Warsaw School of Economics 2010-2012  
Major: *Economics*  
Thesis: *Democratization - an economic approach*  
Advisor: dr hab. Maciej K. Dudek
2. **B.A. in Economics,**  
Warsaw School of Economics 2006-2010  
Major: *Economics*  
Thesis: *The impact of institutions on economic growth*  
Advisor: dr Maciej Bukowski

### ***Publications:***

1. Chrostek P., 2016, *An empirical investigation into the determinants and persistence of happiness and life evaluation*, **Journal of Happiness Studies**, 17, issue 1, p. 413-430. [JCR 5-Year Impact Factor: 2,863, Liczba pkt MNiSW: 40]

### ***Other works:***

1. 11/2014 Chrostek P., Baran J., Lewandowski P., *Labour demand and the challenges of restructuring*, [in:] „**Employment in Poland 2013**”, ed. Piotr Lewandowski and Iga Magda, CRZL 214.
2. 05/2013 Chrostek P., Kamińska A., Lewandowski P., *The excluded – socio-economic dimensions of poverty in Poland*, [in:] „**Employment in Poland 2011**”, ed. Maciej Bukowski, CRZL 2013.

***Conferences and workshops:***

1. **The structure and effectiveness of the Polish tax system**, Warsaw, 03/2019.  
Presentation: *The selected aspects of the Polish tax and social security systems, based on the joint tax and social security data 2016.*
2. **Warsaw International Economics Meeting**, Warsaw, 07/2014.  
Presentation: *The evolution of job tasks in Poland.*
3. **Workshop - National Commission for Strategy and Prognosis**, Bucharest, 01/2013.  
Two-week workshop: *The EU-fund impact assesment with the HEROM model.*

***Teaching:***

1. **Econometrics 2013 - 2018**  
Introductory econometrics training session.
2. **Microeconomics I 2014 - 2016**  
Introductory microeconomics training session.
3. **Microeconomics II 2014-2016**  
Intermediate microeconomics training session.

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