

Cords, Dario; Prettnner, Klaus

Working Paper

Technological unemployment revisited: Automation in a search and matching framework

Hohenheim Discussion Papers in Business, Economics and Social Sciences, No. 19-2018

Provided in Cooperation with:

Faculty of Business, Economics and Social Sciences, University of Hohenheim

Suggested Citation: Cords, Dario; Prettnner, Klaus (2018) : Technological unemployment revisited: Automation in a search and matching framework, Hohenheim Discussion Papers in Business, Economics and Social Sciences, No. 19-2018, Universität Hohenheim, Fakultät Wirtschafts- und Sozialwissenschaften, Stuttgart,
<https://nbn-resolving.de/urn:nbn:de:bsz:100-opus-15305>

This Version is available at:

<https://hdl.handle.net/10419/183112>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



UNIVERSITY OF
HOHENHEIM

200
1818 2018
YEARS

Hohenheim Discussion Papers in Business, Economics and Social Sciences

TECHNOLOGICAL UNEMPLOYMENT REVISITED: AUTOMATION IN A SEARCH AND MATCHING FRAMEWORK

Dario Cords

University of Hohenheim

Klaus Prettner

University of Hohenheim

Research Area INEPA

19-2018

Discussion Paper 19-2018

Technological Unemployment Revisited: Automation in a Search and Matching Framework

Dario Cords, Klaus Prettnner

Research Area “INEPA – Inequality and Economic Policy Analysis”

Download this Discussion Paper from our homepage:

<https://wiso.uni-hohenheim.de/papers>

ISSN 2364-2084

Die Hohenheim Discussion Papers in Business, Economics and Social Sciences dienen der schnellen Verbreitung von Forschungsarbeiten der Fakultät Wirtschafts- und Sozialwissenschaften. Die Beiträge liegen in alleiniger Verantwortung der Autoren und stellen nicht notwendigerweise die Meinung der Fakultät Wirtschafts- und Sozialwissenschaften dar.

Hohenheim Discussion Papers in Business, Economics and Social Sciences are intended to make results of the Faculty of Business, Economics and Social Sciences research available to the public in order to encourage scientific discussion and suggestions for revisions. The authors are solely responsible for the contents which do not necessarily represent the opinion of the Faculty of Business, Economics and Social Sciences.

Technological Unemployment Revisited: Automation in a Search and Matching Framework

Dario Cords[†]

Klaus Prettner[‡]

University of Hohenheim, Germany

University of Hohenheim, Germany

August 10, 2018

Abstract

Will low-skilled workers be replaced by automation? To answer this question, we set up a search and matching model that features two skill types of workers and includes automation capital as an additional production factor. Automation capital is a perfect substitute for low-skilled workers and an imperfect substitute for high-skilled workers. Using this type of model, we show that the accumulation of automation capital decreases the labor market tightness in the low-skilled labor market and increases the labor market tightness in the high-skilled labor market. This leads to a rising unemployment rate of low-skilled workers and a falling unemployment rate of high-skilled workers. In addition, automation leads to falling wages of low-skilled workers and rising wages of high-skilled workers.

JEL Classification: C78, J63, J64, O33.

Keywords: Unemployment, automation, search and matching model, technological progress, inequality, skill premium.

[†]Corresponding Author. University of Hohenheim (520G), Schloss Hohenheim 1c, 70593 Stuttgart, Germany. Email: dario.cords@uni-hohenheim.de.

[‡]University of Hohenheim (520H), Schloss Hohenheim 1d, 70593 Stuttgart, Germany. Email: klaus.prettner@uni-hohenheim.de.

1 Introduction

Reports in the news show on a daily basis that robots are outcompeting humans on more and more tasks (see, for example, The Economist, 2014, 2017; Davison, 2017). This holds true even for tasks that were seen as unautomatable just a few years ago. While industrial robots are substituting for assembly line workers in the automotive industry since decades, recent years are characterized by advances in driverless cars and trucks, diagnosing diseases, producing customized parts and medical implants, writing novels, and even doing science (National Science Foundation, 2009; Schmidt and Lipson, 2009; Barrie, 2014; Abeliansky et al., 2015; Ford, 2015).

Ever since the publication of the working paper version of Frey and Osborne (2013, 2017), who claim that 47% of the jobs in the United States are highly susceptible to computerization over the coming two decades, policymakers, economists, and the general public have been concerned about mass unemployment in the age of automation. However, these high numbers are criticized for various reasons. For example, Arntz et al. (2016) argue that specific tasks get automated but not whole jobs. They incorporate this insight into the method used by Frey and Osborne (2013, 2017) and calculate that only 9% of all jobs in the United States can be automated in the near future when assuming such a task-based perspective. In addition, there are compensating mechanisms in actually existing economies such as i) decreasing prices of the goods that are produced in an automated manner such that spending on goods and services that are produced by humans might increase, or ii) an increase in the production of robots and 3D printers that might require additional human labor. On top of these arguments, Bloom et al. (2018) take into account that building robots is costly and takes time. Thus, not all jobs that could be substituted by robots from a technical perspective will indeed vanish soon. Instead, economic considerations need to be taken into account because often it will not pay off for firms to substitute cheap labor by expensive robots. Bloom et al. (2018) calculate that the predicted evolution of the stock of industrial robots according to the International Federation of Robotics (2017) together with the estimates of Acemoglu and Restrepo

(2017) that one industrial robot substitutes for around six workers, implies the loss of approximately 60 million jobs worldwide until 2030. While these numbers are nowhere near the 47% of all jobs mentioned by Frey and Osborne (2013, 2017), they are nevertheless large and give rise to some concern. Thus, it is important to analyze the pathways by which robots have the potential to lead to technological unemployment within the modern literature on the determinants of endogenous unemployment levels.

Most recently, Hémous and Olsen (2016) and Acemoglu and Restrepo (2016) pioneered the analysis of the effects of automation on economic growth and inequality within the R&D-based growth literature. In Hémous and Olsen (2016), final goods are produced using a variety of intermediate goods, while in Acemoglu and Restrepo (2016), final goods are produced using a variety of tasks. In both papers the intermediate varieties/tasks are either produced by labor or by labor-replacing machines. R&D-driven innovation leads to new varieties/tasks that always come into existence as un-automated and, thus, have to be produced by human labor. Firms then decide whether to make investments to automate the production of their intermediate variety/task. Along the balanced growth path, there is always a constant range of goods/tasks that are produced by low-skilled workers. As a consequence, technological unemployment is less of a concern in the long run. The wages of low-skilled workers rise due to innovation because a higher rate of creation of intermediate goods/tasks raises the range of these goods/tasks that are produced by low-skilled labor. Even more productive automation could lead to higher wages for low-skilled workers because it encourages more innovation. In both contributions, technological unemployment is not at the focus.

As far as the theoretical underpinnings of changing unemployment in the age of automation are concerned, Prettnner and Strulik (2017) explore some potential channels. They propose an R&D driven growth model in which new technologies are labor-replacing robots that substitute for low-skilled workers. High-skilled workers are either engineers in the final goods sector or scientists in the R&D sector. Low-skilled workers are employed at assembly lines in the final goods sector. As a consequence, the wages of low-skilled workers stagnate in the face of automation, whereas the wages of high-skilled workers

rise. In their model, equilibrium voluntary unemployment will result if there exists a social safety net that is financed out of a wage tax on low-skilled and high-skilled workers. The reason is that the outside option for low-skilled workers becomes more attractive over time because the wages of low-skilled workers stagnate, while the social security benefits rise due to the contributions of high-skilled workers.

In an extension of the model, Prettner and Strulik (2017) show that even involuntary equilibrium unemployment is possible in such a setting. The argument is rooted in the fair wage theory based on Akerlof and Jellen (1990): individuals compare their own wages with those of their peers and perceive their wage as unfair if it lies below a weighted average of their own market clearing wage and the wage of their reference group on the labor market. If workers perceive their wage as unfair, they do not entail full effort at work. The wages of high-skilled workers, which constitute the reference group for low-skilled workers, are higher than the wages of low-skilled workers. Thus, the wages of low-skilled workers that are perceived as fair have to be higher than their market clearing wages to induce full effort of low-skilled workers. At this wage rate, more low-skilled workers seek jobs than firms are willing to provide. Thus, there is involuntary unemployment of low-skilled workers in equilibrium.

The discussions so far show that equilibrium unemployment in the age of automation can take the form of voluntary unemployment and involuntary unemployment based on fair wage considerations. We aim at contributing to this debate by introducing automation into the modern search and matching theory of frictional unemployment based on Mortensen and Pissarides (1994) and Pissarides (2000). Assuming that low-skilled workers are easier to substitute than high-skilled workers, which is the empirically relevant case up to now, we show that automation leads to higher equilibrium wages of high-skilled workers and to a tighter high-skilled labor market. The reverse holds true for low-skilled workers. As a consequence, unemployment of low-skilled workers rises, while unemployment of high-skilled workers falls.

Our paper is organized as follows. In Section 2, we discuss the related literature on automation and search and matching models. Section 3 contains the description of the

model. In Section 4, we derive our analytical results, and in Section 5, we conclude, draw potential lessons for policy makers, and discuss promising future research avenues.

2 Related Literature

Our paper builds upon the literature on automation and the search and matching theory of the labor market. As far as automation is concerned, Steigum (2011) and Prettner (2018) augment the standard neoclassical growth models of Solow (1956), Cass (1965), and Koopmans (1965) by a production factor that is a perfect substitute for labor, while it is accumulated similar to physical capital. They show that this automation capital has the potential to lift an economy out of the traditional stagnation steady state even in the absence of technological progress. The reason is that automation capital makes the production factor labor accumulable such that the Cobb-Douglas production technology is transformed endogenously into an AK production technology. Thus, the possibility for long-run economic growth emerges in the neoclassical growth model, which has considerable consequences for welfare in the long run.

While the long-run implications of capital accumulation for economic growth are strikingly similar in the models of Solow (1956), Cass (1965), and Koopmans (1965) on the one hand, and in the overlapping generations model of Diamond (1965) on the other hand, their implications on the growth effects of automation are the opposite of each other. Sachs and Kotlikoff (2012), Benzell et al. (2015), and Sachs et al. (2015) show numerically that long-run stagnation emerges in an overlapping generations model with automation. Gasteiger and Prettner (2017) provide an analytical explanation for this finding. Since individuals save exclusively out of wage income in the overlapping generations model and automation reduces wages, there is a vicious circle that prevents the economy from taking off. In the standard neoclassical growth framework of Solow (1956), Cass (1965), and Koopmans (1965), by contrast, individuals save out of wage income *and* out of capital income. Thus, a similar vicious circle is not present in these types of models with automation such that long-run growth is feasible.

Irrespective of whether automation is analyzed in the neoclassical growth models of Solow (1956), Cass (1965), and Koopmans (1965) or in the overlapping generations model of Diamond (1965), the distributional effects of automation are similar. Since automation substitutes for workers but the income of robots flows to capital owners, the capital income share of the economy rises, which is consistent with the stylized facts over the last decades (Elsby et al., 2013; Karabarbounis and Neiman, 2014). The fact that wealth is more concentrated than income implies that the automation-induced rise in the capital income share contributes to a rise in overall income inequality (cf. Piketty, 2014; Krusell and Smith, 2015). At the same time, low-skilled workers are still more susceptible to automation than high-skilled workers such that automation leads to a rising skill premium and thereby raises wage inequality (Hémous and Olsen, 2016; Acemoglu and Restrepo, 2016; Prettnner and Strulik, 2017; Lankisch et al., 2017).

While there seems to be a consensus that automation will lead to higher inequality, the effects on unemployment are still subject to considerable debates. To gain deeper insights from a theoretical perspective on the endogenous evolution of involuntary unemployment, it is necessary to consider the search and matching model à la Mortensen and Pissarides (1994) and Pissarides (2000). In this type of models, unemployment emerges due to search frictions in the labor market. Assuming such a search and matching based perspective allows us to derive the effects of an increase in the stock of robots on the employment structure via its impact on job creation and the job search behavior of workers that responds endogenously. To our best knowledge, this is the first paper that studies the effects of automation on skill-specific involuntary frictional unemployment.

The contributions of Chassamboulli and Palivos (2013, 2014), Fadinger and Mayr (2014), and Battisti et al. (2017) are related to ours because they use a similar methodological framework. While Fadinger and Mayr (2014) endogenize the state of technology and study the effects of a change in skill endowments, the other articles analyze the impact of skill-specific immigration. All of these articles share important elements with our paper, such as the existence of two separate labor markets, one for high-skilled workers and one for low-skilled workers, and a similar production structure according to which

the final good is produced based on a CES production function, while the intermediate goods are produced by high-skilled and low-skilled labor based on a linear technology. The decisive difference to these contributions lies at the level of the exogenous shock. While low-skilled immigration substitutes for low-skilled natives in the production of the low-skill intermediate good in Chassamboulli and Palivos (2013, 2014) and Battisti et al. (2017), automation capital appears in the production function of the final good and substitutes for the low-skilled intensive intermediate good in our paper. Taking taxi drivers as an example, low-skilled immigrants may substitute for low-skilled natives as drivers. However, self-driving cars (automation capital) will be able to replace the occupation group of taxi drivers altogether in the not too distant future. This aspect cannot be analyzed without the presence of the new production factor of automation capital.

3 The Model

Consider an economy in which workers have two different skill levels $i = \{L, H\}$, where L denotes low-skilled individuals and H denotes high-skilled individuals. The skills are distributed exogenously on a two-point distribution: the fraction λ of the population is low skilled, while the remaining fraction $1 - \lambda$ is high skilled. Normalizing the population size to unity implies that the population shares of a particular skill level are equal to the numbers of low-skilled workers and high-skilled workers, respectively. Time evolves continuously and workers can be in either of two states: employed or unemployed. Workers live indefinitely, are risk neutral, discount the future at the constant rate $r > 0$, and cannot choose to switch their skill level, i.e., education is exogenous and fixed.

3.1 Production Technology

Three goods are produced in the economy. A final consumption good Y and two intermediate goods Y_H and Y_L that are used in the production of the final good. Each high-skilled worker produces one unit of the intermediate good Y_H and each low-skilled worker produces one unit of the intermediate good Y_L . Due to this structure, there is no

need to distinguish between the employment level of a given skill type i and the output of the corresponding intermediate good i , thus, $Y_H \equiv H$ and $Y_L \equiv L$. From now on, we refer to the intermediate goods produced by low-skilled workers as low-skilled intensive and to the intermediate goods produced by high-skilled workers as high-skilled intensive.

Apart from high-skilled and low-skilled labor, there are two other production factors: traditional physical capital in the form of machines, assembly lines, and factory buildings, which is denoted by K , and automation capital in the form of industrial robots, self-driving cars, 3D printers, etc. which is denoted by P for “programmable labor.” Automation capital is a perfect substitute for low-skilled workers and an imperfect substitute for high-skilled workers (cf. Lankisch et al., 2017). The CES production function of the final good is given by

$$Y = AK^\alpha[\gamma(L + P)^\sigma + (1 - \gamma)H^\sigma]^{\frac{1-\alpha}{\sigma}}, \quad (1)$$

where α denotes the elasticity of output with respect to traditional capital, $\gamma \in (0, 1)$ refers to the production weight of low-skilled intermediates and of programmable labor, $\sigma \in (-\infty, 1]$ determines the substitutability between both types of workers, and A is an efficiency parameter. From now on, we focus on the empirically relevant case $\sigma \in (0, 1)$, in which low-skilled and high-skilled workers are gross substitutes (Autor, 2002; Acemoglu, 2009).

All of the three goods are sold in competitive markets and we use the price of the final good as the numéraire, implying that the prices of the two intermediate goods p_H and p_L are equal to their marginal products. Hence, we have $p_H = \partial Y / \partial H$ and $p_L = \partial Y / \partial L$. Furthermore, firms can buy and sell traditional capital on a competitive capital market without delay. Thus, it holds that $p_K = \partial Y / \partial K = r + \delta$, where δ denotes the depreciation rate of traditional capital. Differentiating Equation (1) and using $p_K = \partial Y / \partial K = r + \delta$,

the prices of the two intermediate goods are given by¹

$$p_L = (1 - \alpha)\gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r + \delta} \right)^{\frac{\alpha}{1-\alpha}} \left[(1 - \gamma) \left(\frac{H}{L + P} \right)^\sigma + \gamma \right]^{\frac{1-\sigma}{\sigma}}, \quad (2)$$

$$p_H = (1 - \alpha)(1 - \gamma) A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r + \delta} \right)^{\frac{\alpha}{1-\alpha}} \left[(1 - \gamma) + \gamma \left(\frac{L + P}{H} \right)^\sigma \right]^{\frac{1-\sigma}{\sigma}}. \quad (3)$$

If the rate of return on automation capital would be lower than the rate of return on traditional capital, rational investors would only invest in traditional capital, and vice versa. For an interior equilibrium to exist, it needs to be the case that both types of investments deliver the same rate of return. Thus, it holds that $p_K = p_P = r + \delta$, with p_P being the price of automation capital.

We immediately see that – for the empirically relevant range of σ – an increase in the number of high-skilled workers increases the price of the goods produced by low-skilled workers and reduces the price of the goods produced by high-skilled workers. In case of an increase in the number of low-skilled workers, the reverse is true. We show later how an increase in P affects the prices of the high-skilled and low-skilled intensive good.

3.2 Labor Market

There are two separate labor markets, one for high-skilled labor and one for low-skilled labor. High-skilled workers direct their job search only to the high-skill intensive sector, while low-skilled workers direct their search only to the low-skill intensive sector (see, for example, Belan et al., 2010; Chassamboulli and Palivos, 2013, 2014; Hagedorn et al., 2016; Battisti et al., 2017; Liu et al., 2017). The matching function of firm i can be formally described by

$$M_i = M(V_i, U_i), \quad (4)$$

where M_i denotes the instantaneous flow of hires, V_i refers to the number of vacancies that are posted, U_i is the number of job-searchers, which equals the number of unemployed

¹In Appendix A.1, we provide the detailed calculations.

workers, and the function $M(\cdot, \cdot)$ exhibits constant returns to scale, is increasing in both arguments, at least twice differentiable, and satisfies the Inada conditions. The arrival rate of any worker per vacancy is $M(V_i, U_i)/V_i \equiv m(\theta_i)$, where $\theta_i \equiv V_i/U_i$ measures the labor market tightness in terms of the number of vacancies per unemployed person in the economy. From these expressions it follows immediately that the arrival rate of any vacancy per unemployed worker is $M(V_i, U_i)/U_i \equiv \theta_i m(\theta_i)$. As a consequence, the arrival rate for firms decreases in θ_i , whereas the arrival rate for workers increases in θ_i .

3.3 Firms

In line with the literature, the firms that produce in the intermediate goods sector are small and each firm offers only one job (see, for example, Mortensen and Pissarides, 1994; Albrecht and Vroman, 2002; Dolado et al., 2009; Gautier et al., 2010).² The number of firms is determined endogenously in equilibrium. Firms $i = \{H, L\}$ can either post a high-tech vacancy, which is only suited for high-skilled workers, or a low-tech vacancy, which is only suited for low-skilled workers. The value functions of the firms differ according to whether the firm has filled the vacancy or not. If the firm has filled the vacancy, it produces the corresponding good $i = \{H, L\}$ and sells it on the market for the price p_i . The firm pays the wage w_i to its workers and with a probability $(1 - s_i)$ the vacancy is still filled in the next period, such that s_i is the exogenous rate of job destruction. With this structure it is obvious that the value function of a firm with a filled vacancy is given by

$$r\Pi_i^F = p_i - w_i + s_i(\Pi_i^V - \Pi_i^F). \quad (5)$$

By contrast, a firm that does not fill the vacancy has no labor costs and no revenues but has to pay costs for a vacancy (e.g., job advertisement cost), which are denoted by h_i . With the probability $m(\theta_i)$ the firm manages to fill the vacancy such that its value

²Pissarides (2000) shows that the outcome of the single-worker model is equivalent to a model with large firms that face adjustment costs of employment.

function is given by

$$r\Pi_i^V = -h_i + m(\theta_i)(\Pi_i^F - \Pi_i^V). \quad (6)$$

3.4 Workers

The behavior of workers can be analyzed in a similar vein as the behavior of firms. Workers who are employed receive the wage w_i and become unemployed in the next instant with the probability s_i . Thus, the value function of an employed worker is given by

$$r\Psi_i^E = w_i + s_i(\Psi_i^U - \Psi_i^E). \quad (7)$$

An unemployed person receives a flow benefit z_i while being unemployed. This flow benefit includes the opportunity costs of employment such as unemployment benefits, leisure, and the potential income generated by home production. With the probability of finding a job being equal to $\theta_i m(\theta_i)$, the value function of an unemployed person is given by

$$r\Psi_i^U = z_i + \theta_i m(\theta_i)(\Psi_i^E - \Psi_i^U). \quad (8)$$

4 Solution of the Model

In this section, we solve the model, describe the steady-state solution, and provide the comparative statics analysis with respect to the effects of the accumulation of automation capital on unemployment and wages of high-skilled and low-skilled workers, respectively.

4.1 Wage Determination

Since the workers strictly prefer being employed to being unemployed and the firms strictly prefer a filled vacancy to the situation of an unfilled vacancy, there is a surplus to be gained from a successful match. We follow the literature and assume that the firm and the worker bargain over the distribution of the surplus from the match in a cooperative bargaining process (see, for example, Mortensen and Pissarides, 1994, 1999; Pissarides, 2000; Gautier,

2002). Once a worker of type i and a firm with the same skill requirements meet each other, they solve a generalized Nash bargaining problem given by

$$\max_{w_i} \left\{ \Psi_i^E - \Psi_i^U \right\}^\beta \cdot \left\{ \Pi_i^F - \Pi_i^V \right\}^{1-\beta}, \quad (9)$$

where $\beta \in (0, 1)$ represents the bargaining power of the worker. Maximizing the Nash product provides us with the equilibrium expression for the wage rate as given by

$$w_i = z_i + (p_i - z_i) \cdot \Gamma(\theta_i), \quad (10)$$

with

$$\Gamma(\theta_i) = \beta \frac{r + s_i + \theta_i m(\theta_i)}{r + s_i + \theta_i m(\theta_i) \beta}.$$

Thus, the wage is set as a mark-up over the income enjoyed while being unemployed. The mark-up itself consists of two parts. The first part is the profit that a firm earns if it fills a vacancy with an employee who only earns the outside option z_i . This is the largest possible overall profit a firm could make. Second, the term $\Gamma(\theta_i)$ provides the effective bargaining power of the workers as described by Cahuc et al. (2014). This term refers to those part of the largest possible overall profit that a firm can make by filling a vacancy that the workers are able to appropriate by negotiation. As is intuitive, this bargaining power rises with the bargaining weight of the workers (β) and with the labor market tightness (θ), whereas it decreases with the job destruction rate (s_i). Appendix A.2 provides the detailed calculations regarding the derivation of the wage rate.

4.2 Labor Demand and Employment

Firms enter the market and open their vacancies as long as the expected profit of posting a vacancy is positive. Free market entry drives the expected profit of a vacancy down to zero such that

$$\Pi_i^V = 0 \quad (11)$$

holds at the long-run equilibrium. Further, the present value function of a filled job, Equation (5), is used and combined with the equilibrium wage level w_i to obtain the

following labor demand:

$$\frac{h_i}{m(\theta_i)} = (1 - \beta) \frac{(p_i - z_i)}{r + s_i + \theta_i m(\theta_i) \beta}. \quad (12)$$

Thus, the expected costs of creating a vacancy equal the expected profit of a filled job.

At a steady-state equilibrium, the flows in and out of unemployment have to be equal, i.e., $\dot{U}_i = 0$. Using that the number of low-skilled workers in the economy is given by $\lambda = U_L + L$, with U_L being the number of unemployed low-skilled workers, while the number of high-skilled workers is given by $1 - \lambda = U_H + H$, with U_H being the number of unemployed high-skilled workers, the steady-state unemployment rates u_i are given by

$$\frac{U_L}{\lambda} = u_L = \frac{s_L}{s_L + \theta_L m(\theta_L)} \quad (13)$$

and

$$\frac{U_H}{1 - \lambda} = u_H = \frac{s_H}{s_H + \theta_H m(\theta_H)}. \quad (14)$$

Analogously, the employment levels are

$$L = \lambda \frac{\theta_L m(\theta_L)}{s_L + \theta_L m(\theta_L)} \quad (15)$$

and

$$H = (1 - \lambda) \frac{\theta_H m(\theta_H)}{s_H + \theta_H m(\theta_H)}. \quad (16)$$

4.3 Effects of the Accumulation of Automation Capital

Before we start deriving and discussing the central results, we define the steady-state equilibrium of the economy.

Definition 1. *A steady-state equilibrium of our search and matching model with automation and skill heterogeneity is characterized by a stationary economy in which the key endogenous variables $\{\theta_i, p_i, p_k, w_i, H, L, K, u_i\}$ are determined by the following equations:*

(i) the flow Equations (13) to (16),

- (ii) the prices of the two intermediates as given by Equations (2) and (3) and of capital as given by $p_k = r + \delta = \alpha Y/K$,
- (iii) the wage rates as given by Equation (10),
- (iv) labor demand for each skill level as given by Equation (12).

Next, we state the central results of our model in the following three propositions. The first proposition describes the effects of automation capital on labor market tightness in the low-skilled labor market and in the high-skilled labor market, respectively.

Proposition 1. *The accumulation of automation capital P decreases the labor market tightness in the low-skilled labor market and increases the labor-market tightness in the high-skilled labor market.*

Proof. See Appendix A.3.1 for the formal proof. □

To provide an intuition for this result, we make use of the fact that an increase in the stock of robots P reduces the price of goods produced by low-skilled workers and raises the price of the goods produced by high-skilled workers. This gives rise to the following lemma.

Lemma 1. *An increase in the stock of robots P reduces the price of goods produced by low-skilled workers and raises the price of the goods produced by high-skilled workers.*

Proof. See Appendix A.3.2 for the formal proof. □

An increase in the number of robots leads to a substitution of the goods that are produced with low-skilled labor by robots in final goods production. Thus, the price of the goods produced by low-skilled workers decreases, which leads to lower profits of the firms that produce low-skilled intensive goods. This in turn reduces the number of firms that produce low-skilled intensive goods at the steady-state equilibrium and therefore reduces the overall flow of low-skilled vacancies for a given number of low-skilled workers. Thus, labor market tightness decreases for low-skilled workers. By contrast, the demand of the

final goods sector for intermediate goods produced by high-skilled workers increases, which raises the price of high-skilled intensive goods and hence the profits of firms producing these goods. The reason is that H and P are imperfect substitutes, implying that the price of the high-skilled intermediate good depends positively on the amount of automation and negatively on the amount of high-skilled labor. At the steady-state equilibrium, there will then be firm entry into the high-skilled intensive goods production such that the flow of vacancies for a given number of high-skilled workers increases. This, in turn, raises the tightness of the high-skilled labor market.

The second proposition describes the effects of automation capital on the unemployment rates of both types of skills.

Proposition 2. *The accumulation of automation capital P increases the unemployment rate of low-skilled workers and decreases the unemployment rate of high-skilled workers.*

Proof. See Appendix A.3.3 for the formal proof. □

This result is a consequence of the results obtained in Proposition 1. Labor market tightness increases for high-skilled workers as automation progresses, while labor market tightness decreases for low-skilled workers. As a consequence, the job finding probability of high-skilled workers increases, while that of low-skilled workers decreases, which, in turn, lowers the unemployment rate of low-skilled workers and increases the unemployment rate of high-skilled workers.

The third proposition describes the effects of automation capital on the wage rates of both types of workers.

Proposition 3. *The accumulation of automation capital P decreases the wage rate of low-skilled workers and increases the wage rate of high-skilled workers.*

Proof. See Appendix A.3.4 for the formal proof. □

This result is a consequence of the previously obtained results. We have seen already that the marginal product of the low-skilled intensive good in final goods production

decreases once that automation is accounted for, while the marginal product of the high-skilled intensive good in final goods production increases. The increase in the price of the goods produced by high-skilled workers leads to a higher match surplus for high-tech firms, which induces vacancy posting and raises labor market tightness in that sector. The so induced increase in the job-finding probability of high-skilled workers improves their outside option and strengthens their bargaining position, which in turn raises their wage rate. For low-skilled workers, the opposite results emerge. This channel is known from the immigration literature, where a similar production function of the final good implies that low-skilled immigrants are perfect substitutes for low-skilled natives and imperfect substitutes for high-skilled native workers (see, for example, Chassamboulli and Palivos, 2013, 2014; Chassamboulli and Peri, 2015; Liu et al., 2017).

5 Conclusions

We use automation capital as an additional production factor and embed it in the standard search and matching model augmented by skill heterogeneity, imperfect substitutability between high-skilled workers and low-skilled workers, and different search costs and job destruction rates across skill levels. In our setting, automation capital is a perfect substitute for low-skilled labor and an imperfect substitute for high-skilled labor. Using this structure, we are able to analyze how an increase in the stock of robots effects wage inequality and involuntary unemployment across skill levels. We show that the accumulation of automation capital decreases the labor market tightness in the low-skilled labor market and increases the labor-market tightness in the high-skilled labor market. This leads to a rising unemployment rate of low-skilled workers and a falling unemployment rate of high-skilled workers. In addition, automation leads to falling wages of low-skilled workers and rising wages of high-skilled workers.

Previous contributions have clarified that higher unemployment due to automation could come in the form of i) higher voluntary unemployment if the wages of low-skilled workers stagnate in the wake of automation, while welfare benefits rise with the average

wage, and ii) in the form of higher involuntary unemployment if low-skilled workers perceive their wage as unfair and react by exerting less effort. Then firms would need to raise the wages for low-skilled workers above their marginal productivity to induce low-skilled workers to exert full effort. In this situation, equilibrium unemployment would result. In our contribution, we clarify that also higher frictional unemployment might be a result of automation.

From a policy perspective, the issue of higher frictional unemployment could be addressed by i) raising the efficiency of the search process, ii) making sure to raise the fraction of individuals who are skilled by investing in higher education and retraining programs, and iii) potentially one could think about public employment programs for low-skilled workers who are negatively affected by automation and for whom retraining programs do not work appropriately. Such a program might put long-term unemployed into publicly paid jobs at the community level that would not be profitable for private firms like cleaning parks, spending time with the elderly, etc. These programs might be a good alternative for the long-term unemployed who are cut off of the labor market, because the net costs are just the top-up on the unemployment benefits and there might be positive side effects apart from the benefit of the work done for the community. These positive side effects might come in the form of higher levels of self-esteem of the persons enrolled in such schemes, staying better integrated in the society via the connections in the community and at the workplace, and of not losing certain basic skills.

In the current setting, we abstract from endogenous education decisions such that individuals cannot switch from being low skilled to being high skilled subject to investment costs as in Prettnner and Strulik (2017). Introducing such an endogenous education decision could yield additional insights into the long-run adjustment dynamics to rising technological unemployment. In addition, it might be interesting to introduce a service sector in which low-skilled workers could also find work and might not yet be threatened to get replaced by automation capital to a similar extent as in manufacturing. Another promising avenue for further research would be to introduce the search and matching structure into an R&D-based growth model to endogenize the evolution of automation.

A Appendix

A.1 Prices of the Intermediate Goods

Differentiating the production function, Equation (1), with respect to the number of high-skilled workers, with respect to the number of low-skilled workers, and with respect to traditional capital yields

$$\frac{\partial Y}{\partial H} = p_H = Y(1 - \alpha)(1 - \gamma)H^{\sigma-1} \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{-1}, \quad (17)$$

$$\frac{\partial Y}{\partial L} = p_L = Y(1 - \alpha)\gamma(L + P)^{\sigma-1} \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{-1}, \quad (18)$$

$$\frac{\partial Y}{\partial K} = p_K = \alpha AK^{\alpha-1} \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{\frac{1-\alpha}{\sigma}}. \quad (19)$$

Solving Equation (19) for K and using $p_K = r + \delta$ provides us with

$$K = \left(\frac{\alpha A}{r + \delta} \right)^{\frac{1}{1-\alpha}} \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{\frac{1}{\sigma}}. \quad (20)$$

Next, we divide Equations (17) and (18) by $p_K = \alpha Y/K$, which can be derived by collecting terms in Equation (19). This yields

$$\frac{p_H}{p_K} = \frac{1 - \alpha}{\alpha} (1 - \gamma)H^{\sigma-1}K \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{-1}, \quad (21)$$

$$\frac{p_L}{p_K} = \frac{1 - \alpha}{\alpha} \gamma(L + P)^{\sigma-1}K \left[(1 - \gamma)H^\sigma + \gamma(L + P)^\sigma \right]^{-1}. \quad (22)$$

Substituting Equation (20) in Equations (21) and (22), using $p_K = r + \delta$, and rearranging leads to the prices of the two intermediate goods as given by Equations (2) and (3):

$$p_L = (1 - \alpha)\gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r + \delta} \right)^{\frac{\alpha}{1-\alpha}} \left[(1 - \gamma) \left(\frac{H}{L + P} \right)^\sigma + \gamma \right]^{\frac{1-\sigma}{\sigma}},$$

$$p_H = (1 - \alpha)(1 - \gamma) A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r + \delta} \right)^{\frac{\alpha}{1-\alpha}} \left[(1 - \gamma) + \gamma \left(\frac{L + P}{H} \right)^\sigma \right]^{\frac{1-\sigma}{\sigma}}.$$

A.2 Wage Determination

Once a worker and a firm with the same skill requirements meet, they bargain over the wage rate. They solve the generalized Nash-bargaining problem given by

$$\max_{w_i} \left\{ \Psi_i^E - \Psi_i^U \right\}^\beta \cdot \left\{ \Pi_i^F - \Pi_i^V \right\}^{1-\beta}. \quad (23)$$

Maximization of the Nash product delivers the sharing rule

$$\beta[\Pi_i^F - \Pi_i^V] = (1 - \beta)[\Psi_i^E - \Psi_i^U]. \quad (24)$$

Using the present value functions, Equations (5) and (7), together with the free entry condition $\Pi_i^V = 0$, the rents of firms and workers can be derived as

$$\Psi_i^E - \Psi_i^U = \frac{w_i - r\Psi_i^U}{r + s_i} \quad \text{and} \quad \Pi_i^F - \Pi_i^V = \frac{p_i - w_i}{r + s_i}. \quad (25)$$

Substituting Equation (25) in Equation (24) and rearranging leads to

$$w_i = \beta p_i + (1 - \beta)r\Psi_i^U. \quad (26)$$

The wages are the weighted sum of the worker's productivity and the value of unemployment. The weights are given by the bargaining power of the respective participant in the negotiations. Next, $\Psi_i^E - \Psi_i^U$ has to be substituted in the present value function for unemployed workers, Equation (8). For the substitution, the sharing rule (24) is used. This yields

$$\Psi_i^E - \Psi_i^U = \beta \cdot S, \quad (27)$$

with $S = (\Psi_i^E - \Psi_i^U) + (\Pi_i^F - \Pi_i^V)$ being the surplus of a match of the respective bargaining parties. Using Equation (25), it turns out that

$$\Psi_i^E - \Psi_i^U = \beta \left(\frac{p_i - r\Psi_i^U}{r + s_i} \right). \quad (28)$$

Substituting Equation (28) in Equation (8), the expected value of being unemployed is

$$r\Psi_i^U = \frac{z_i(r + s_i) + p_i\theta_i m(\theta_i)\beta}{r + s_i + \theta_i m(\theta_i)\beta}. \quad (29)$$

Finally, inserting Equation (29) into Equation (26) and rearranging leads to the wage rate given in Equation (10)

$$w_i = z_i + (p_i - z_i) \cdot \Gamma(\theta_i),$$

with

$$\Gamma(\theta_i) = \beta \frac{r + s_i + \theta_i m(\theta_i)}{r + s_i + \theta_i m(\theta_i) \beta}.$$

A.3 Effects of the Accumulation of Automation Capital P

To see how the wage rates of workers, their employment levels, and their unemployment rates change due to the accumulation of automation capital, it is necessary to derive how the labor market tightness in each labor market is affected by an increase in P . We do this by calculating the total differential of Equation (12) for each labor market and thereby proof Proposition 1 in Section A.3.1. Afterwards, we proof Propositions 2 and 3. However, before we can derive the change in wage rates in Section A.3.3, it is first necessary to derive the change in the prices of the two intermediate goods as given by Equations (2) and (3) and as stated in Lemma 1. Section A.3.2 contains the corresponding proof.

A.3.1 Proof of Proposition 1

Proof of Proposition 1. In the low-skilled labor market we obtain

$$\underbrace{h_L \frac{m(\theta_L) \beta \frac{\partial \theta_L m(\theta_L)}{\partial \theta_L} - [r + s_L + \beta \theta_L m(\theta_L)] m'(\theta_L)}{m(\theta_L)^2}}_{C > 0} \frac{d\theta_L}{dP} =$$

$$\left[\frac{dH}{d\theta_H} \frac{d\theta_H}{dP} - \frac{H}{L + P} \left(\frac{dL}{d\theta_L} \frac{d\theta_L}{dP} + 1 \right) \right] \times$$

$$\underbrace{(1 - \beta)(1 - \alpha) \gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r + \delta} \right)^{\frac{\alpha}{1-\alpha}} (1 - \sigma)(1 - \gamma) \left[(1 - \gamma) \left(\frac{H}{L + P} \right)^\sigma + \gamma \right]^{\frac{1-2\sigma}{\sigma}} \frac{H^{\sigma-1}}{(L + P)^\sigma}}_{B > 0}.$$
(30)

Rearranging yields

$$\left[C + B \frac{H}{L+P} \frac{dL}{d\theta_L} \right] \frac{d\theta_L}{dP} = B \left[\frac{dH}{d\theta_H} \frac{d\theta_H}{dP} - \frac{H}{L+P} \right]. \quad (31)$$

Analogously, the total differential in the high-skilled labor market is given by

$$\underbrace{h_H \frac{m(\theta_H) \beta \frac{\partial \theta_H m(\theta_H)}{\partial \theta_H} - [r + s_H + \beta \theta_H m(\theta_H)] m'(\theta_H)}{m(\theta_H)^2}}_{D > 0} \frac{d\theta_H}{dP} =$$

$$\left[- \frac{L+P}{H} \frac{dH}{d\theta_H} \frac{d\theta_H}{dP} + \left(\frac{dL}{d\theta_L} \frac{d\theta_L}{dP} + 1 \right) \right] \times$$

$$\underbrace{(1-\beta)(1-\alpha)\gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r+\delta} \right)^{\frac{\alpha}{1-\alpha}} (1-\sigma)(1-\gamma) \left[(1-\gamma) + \gamma \left(\frac{L+P}{H} \right)^\sigma \right]^{\frac{1-2\sigma}{\sigma}} \frac{(L+P)^{\sigma-1}}{H^\sigma}}_{B_1 > 0}. \quad (32)$$

Rearranging yields

$$\frac{d\theta_H}{dP} = \frac{B_1}{D + B_1 \frac{L+P}{H} \frac{dH}{d\theta_H}} \left[\frac{dL}{d\theta_L} \frac{d\theta_L}{dP} + 1 \right]. \quad (33)$$

Substituting Equation (33) in Equation (31) and simplifying yields

$$\frac{d\theta_L}{dP} = - \frac{BD}{C \left(D + B_1 \frac{L+P}{H} \frac{dH}{d\theta_H} \right) + BD \frac{H}{L+P} \frac{dL}{d\theta_L}} \frac{H}{L+P} < 0. \quad (34)$$

In the next step, we substitute Equation (34) in Equation (33) to obtain

$$\frac{d\theta_H}{dP} = \frac{B_1 C}{C \left(D + B_1 \frac{L+P}{H} \frac{dH}{d\theta_H} \right) + BD \frac{H}{L+P} \frac{dL}{d\theta_L}} > 0. \quad (35)$$

Equations (34) and (35) prove Proposition 1. \square

A.3.2 Proof of Lemma 1

Proof of Lemma 1. For the price of the low-skill intensive intermediate good we obtain

$$\begin{aligned} \frac{dp_L}{dP} = & \left[\frac{dH}{d\theta_H} \frac{d\theta_H}{dP} - \frac{H}{L+P} \left(\frac{dL}{d\theta_L} \frac{d\theta_L}{dP} + 1 \right) \right] \times \\ & \underbrace{(1-\alpha)\gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r+\delta} \right)^{\frac{\alpha}{1-\alpha}} (1-\sigma)(1-\gamma) \left[(1-\gamma) \left(\frac{H}{L+P} \right)^\sigma + \gamma \right]^{\frac{1-2\sigma}{\sigma}} \frac{H^{\sigma-1}}{(L+P)^\sigma}}_{B_2 > 0}. \end{aligned} \quad (36)$$

Inserting Equations (34) and (35) and simplifying yields

$$\frac{dp_L}{dP} = - \frac{B_2 C D}{C \left(D + B_1 \frac{L+P}{H} \frac{dH}{d\theta_H} \right) + B D \frac{H}{L+P} \frac{dL}{d\theta_L}} \frac{H}{L+P} < 0. \quad (37)$$

The procedure for the price of the high-skill intensive intermediate good is similar. Total differentiation yields

$$\begin{aligned} \frac{dp_H}{dP} = & \left[- \frac{L+P}{H} \frac{dH}{d\theta_H} \frac{d\theta_H}{dP} + \left(\frac{dL}{d\theta_L} \frac{d\theta_L}{dP} + 1 \right) \right] \times \\ & \underbrace{(1-\alpha)\gamma A^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{r+\delta} \right)^{\frac{\alpha}{1-\alpha}} (1-\sigma)(1-\gamma) \left[(1-\gamma) + \gamma \left(\frac{L+P}{H} \right)^\sigma \right]^{\frac{1-2\sigma}{\sigma}} \frac{(L+P)^{\sigma-1}}{H^\sigma}}_{B_3 > 0}. \end{aligned} \quad (38)$$

Substituting in Equations (34) and (35) and simplifying provides

$$\frac{dp_H}{dP} = \frac{B_3 C D}{C \left(D + B_1 \frac{L+P}{H} \frac{dH}{d\theta_H} \right) + B D \frac{H}{L+P} \frac{dL}{d\theta_L}} > 0. \quad (39)$$

Equations (37) and (39) prove Lemma 1. □

A.3.3 Proof of Proposition 2

Proof of Proposition 2. Using the change in labor-market tightness in each labor market, the change in the respective employment levels and unemployment rates, as given by

Equations (13) - (16), can be easily derived as follows:

$$\frac{dL}{dP} = \lambda \frac{s_L}{[s_L + \theta_L m(\theta_L)]^2} \frac{\partial \theta_L m(\theta_L)}{\partial \theta_L} \underbrace{\frac{d\theta_L}{dP}}_{<0} < 0 \quad (40)$$

$$\frac{du_L}{dP} = - \frac{s_L}{[s_L + \theta_L m(\theta_L)]^2} \frac{\partial \theta_L m(\theta_L)}{\partial \theta_L} \frac{d\theta_L}{dP} > 0 \quad (41)$$

$$\frac{dH}{dP} = (1 - \lambda) \frac{s_H}{[s_H + \theta_H m(\theta_H)]^2} \frac{\partial \theta_H m(\theta_H)}{\partial \theta_H} \underbrace{\frac{d\theta_H}{dP}}_{>0} > 0 \quad (42)$$

$$\frac{du_H}{dP} = - \frac{s_H}{[s_H + \theta_H m(\theta_H)]^2} \frac{\partial \theta_H m(\theta_H)}{\partial \theta_H} \frac{d\theta_H}{dP} < 0. \quad (43)$$

Equations (41) and (43) prove Proposition 2. \square

A.3.4 Proof of Proposition 3

Proof of Proposition 3. Finally, we are able to derive the change in the wage rates. The total differential of the wage rate [as given by Equation (10)] in each labor market is

$$\frac{dw_L}{dP} = \Gamma(\theta_L) \underbrace{\frac{dp_L}{dP}}_{<0} + (p_L - z_L)(1 - \beta) \frac{r + s_L}{[r + s_L + \beta \theta_L m(\theta_L)]^2} \frac{\partial \theta_L m(\theta_L)}{\partial \theta_L} \underbrace{\frac{d\theta_L}{dP}}_{<0} < 0, \quad (44)$$

$$\frac{dw_H}{dP} = \Gamma(\theta_H) \underbrace{\frac{dp_H}{dP}}_{>0} + (p_H - z_H)(1 - \beta) \frac{r + s_H}{[r + s_H + \beta \theta_H m(\theta_H)]^2} \frac{\partial \theta_H m(\theta_H)}{\partial \theta_H} \underbrace{\frac{d\theta_H}{dP}}_{>0} > 0. \quad (45)$$

This proves Proposition 3. \square

References

- Abeliansky, A., Martinez-Zarzoso, I., and Prettnner, K. (2015). The Impact of 3D Printing on Trade and FDI. cege Discussion Paper 262.
- Acemoglu, D. (2009). *Introduction to Modern Economic Growth*. Princeton University Press.
- Acemoglu, D. and Restrepo, P. (2016). The Race Between Man and Machine: Implications of Technology for Growth, Factor Shares and Employment. NBER Working Paper No. 22252.
- Acemoglu, D. and Restrepo, P. (2017). Robots and Jobs: Evidence from US Labor Markets. NBER Working Paper No. 23285.
- Akerlof, G. and Jellen, J. (1990). The fair wage-effort hypothesis and unemployment. *Quarterly Journal of Economics*, Vol. 105(N0. 2):255–283.
- Albrecht, J. and Vroman, S. (2002). A Matching Model with Endogenous Skill Requirements. *International Economic Review*, 43(1):282–305.
- Arntz, M., Gregory, T., and Zierahn, U. (2016). The Risk of Automation for Jobs in OECD Countries. A Comparative Analysis. OECD Social, Employment and Migration Working Papers, No. 189, OECD Publishing, Paris.
- Autor, D. (2002). Skill Biased Technical Change and Rising Inequality: What is the Evidence? What are the Alternatives? url: <https://economics.mit.edu/files/558>. [accessed on 03/01/2018].
- Barrie, J. (2014). Computers Are Writing Novels: Read A Few Samples Here. Available at <http://www.businessinsider.com/novels-written-by-computers-2014-11?IR=T> [Accessed on January 22, 2017].

- Battisti, M., Felbermayr, G., Peri, G., and Poutvaara, P. (2017). Immigration, Search and Redistribution: A Quantitative Assessment of Native Welfare. *Journal of the European Economic Association*.
- Belan, P., Carré, M., and Gregoir, S. (2010). Subsidizing Low-skilled Jobs in a Dual Labor Market. *Labour Economics*, 17(5):776–788.
- Benzell, S. G., Kotlikoff, L. J., LaGardia, G., and Sachs, J. D. (2015). Robots are us: Some economics of human replacement. NBER Working Paper 20941.
- Bloom, D., McKenna, M., and Prettnner, K. (2018). Demography, Unemployment, Automation, and Digitalization: Implications for the Creation of (Decent) Jobs, 2010–2030. NBER Working Paper 24835.
- Cahuc, P., Carcillo, S., and Zylberberg, A. (2014). *Labor Economics*. The MIT Press, second edition edition.
- Cass, D. (1965). Optimum growth in an aggregative model of capital accumulation. *The Review of Economic Studies*, Vol. 32(No. 3):233–240.
- Chassamboulli, A. and Palivos, T. (2013). The Impact of Immigration on the Employment and Wages of Native Workers. *Journal of Macroeconomics*, 38(Part A):19–34.
- Chassamboulli, A. and Palivos, T. (2014). A Search Equilibrium Approach to the Effects of Immigration on Labor Market Outcomes. *International Economic Review*, 55(1):111–129.
- Chassamboulli, A. and Peri, G. (2015). The Labor Market Effects of Reducing the Number of Illegal Immigrants. *Review of Economic Dynamics*, 18(4):792–821.
- Davison, N. (2017). 3D-printed cities: is this the future? <https://www.theguardian.com/cities/2015/feb/26/3d-printed-cities-future-housing-architecture>. *The Guardian*.

- Diamond, P. A. (1965). National debt in a neoclassical growth model. *American Economic Review*, Vol. 55(No. 5):1126–1150.
- Dolado, J. J., Jansen, M., and Jimeno, J. F. (2009). On-the-Job Search in a Matching Model with Heterogeneous Jobs and Workers. *The Economic Journal*, 119(534):200–228.
- Elsby, M. W. L., Hobijn, B., and Şahin, A. (2013). The Decline of the U.S. Labor Share. *Brookings Papers on Economic Activity*, Fall 2013:1–63.
- Fadinger, H. and Mayr, K. (2014). Skill-Biased Technological Change, Unemployment, and Brain Drain. *Journal of the European Economic Association*, 12(2):397–431.
- Ford, M. (2015). *Rise of the Robots: Technology and the Threat of a Jobless Future*. Basic Books, NY, USA.
- Frey, C. B. and Osborne, M. A. (2013). The Future of Employment: How Susceptible are Jobs to Computerisation? available at https://web.archive.org/web/20150109185039/http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.
- Frey, C. B. and Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, Vol. 114(Issue C):254–280.
- Gasteiger, E. and Prettnner, K. (2017). A Note on Automation, Stagnation, and the Implications of a Robot Tax. Free University of Berlin, School of Business & Economics Discussion Paper 17/2017.
- Gautier, P. A. (2002). Unemployment and Search Externalities in a Model with Heterogeneous Jobs and Workers. *Economica*, 69(273):21–40.
- Gautier, P. A., Teulings, C. N., and van Vuuren, A. (2010). On-the-Job Search, Mismatch and Efficiency. *The Review of Economic Studies*, 77(1):245–272.

- Hagedorn, M., Manovskii, I., and Stetsenko, S. (2016). Taxation and Unemployment in Models with Heterogeneous Workers. *Review of Economic Dynamics*, 19:161–189.
- Hémous, D. and Olsen, M. (2016). The Rise of the Machines: Automation, Horizontal Innovation and Income Inequality. Mimeo.
- International Federation of Robotics (2017). Executive summary world robotics 2017 industrial robots. https://ifr.org/downloads/press/Executive_Summary_WR_2017_Industrial_Robots.pdf.
- Karabarbounis, L. and Neiman, B. (2014). The Global Decline of the Labor Share. *The Quarterly Journal of Economics*, Vol. 129(No. 1):61–103.
- Koopmans, T. C. (1965). On the concept of optimal economic growth. In *The Econometric Approach to Development Planning*. Amsterdam: North Holland.
- Krusell, P. and Smith, A. (2015). Is piketty’s “second law of capitalism” fundamental? *Journal of Political Economy*, Vol. 123(No. 4):725–748.
- Lankisch, C., Prettnner, K., and Prskawetz, A. (2017). Robots and the skill premium: an automation-based explanation of wage inequality. Hohenheim Discussion Papers in Business, Economics and Social Sciences.
- Liu, X., Palivos, T., and Zhang, X. (2017). Immigration, Skill Heterogeneity, and Qualification Mismatch. *Economic Inquiry*, 55(3):1231–1264.
- Mortensen, D. and Pissarides, C. (1994). Job creation and job destruction in the theory of unemployment. *Review of Economic Studies*, Vol. 61(No. 3):397–415.
- Mortensen, D. T. and Pissarides, C. A. (1999). Unemployment Responses to ‘Skill-Biased’ Technology Shocks: The Role of Labour Market Policy. *The Economic Journal*, 109(455):242–265.

- National Science Foundation (2009). Maybe robots dream of electric sheep, but can they do science? Press release. url: https://www.nsf.gov/news/news_summ.jsp?cntn_id=114495 [accessed on 01/01/2018].
- Piketty, T. (2014). *Capital in the Twenty-First Century*. The Belknap Press of Harvard University Press.
- Pissarides, C. A. (2000). *Equilibrium Unemployment Theory*. The MIT Press. 2nd ed.
- Prettner, K. (2018). A note on the implications of automation for economic growth and the labor share. *Macroeconomic Dynamics*. (forthcoming).
- Prettner, K. and Strulik, H. (2017). The Lost Race Against the Machine: Automation, Education, and Inequality in an R&D-Based Growth Model. Hohenheim Discussion Papers in Business, Economics, and Social Sciences 08-2017.
- Sachs, J. D., Benzell, S. G., and LaGardia, G. (2015). Robots: Curse or blessing? A basic framework. NBER Working Paper 21091.
- Sachs, J. D. and Kotlikoff, L. J. (2012). Smart machines and long-term misery. NBER Working Paper 18629.
- Schmidt, M. and Lipson, H. (2009). Distilling free-form natural laws from experimental data. *Science*, Vol. 324(No. 5923):81–85.
- Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, Vol. 70(No. 1):65–94.
- Steigum, E. (2011). *Frontiers of Economics and Globalization: Economic Growth and Development*, chapter 21: Robotics and Growth, pages 543–557. Emerald Group.
- The Economist (2014). Immigrants from the future. A special report on robots. *The Economist*, March 27th 2014.
- The Economist (2017). Ghost in the machine: Rio Tinto puts its faith in driverless trucks, trains and drilling rigs. *The Economist*, December 7th 2017.

Hohenheim Discussion Papers in Business, Economics and Social Sciences

The Faculty of Business, Economics and Social Sciences continues since 2015 the established “FZID Discussion Paper Series” of the “Centre for Research on Innovation and Services (FZID)” under the name “Hohenheim Discussion Papers in Business, Economics and Social Sciences”.

Institutes

510	Institute of Financial Management
520	Institute of Economics
530	Institute of Health Care & Public Management
540	Institute of Communication Science
550	Institute of Law and Social Sciences
560	Institute of Economic and Business Education
570	Institute of Marketing & Management
580	Institute of Interorganizational Management & Performance

Research Areas (since 2017)

INEPA	“Inequality and Economic Policy Analysis”
TKID	“Transformation der Kommunikation – Integration und Desintegration”
NegoTrans	“Negotiation Research – Transformation, Technology, Media and Costs”
INEF	“Innovation, Entrepreneurship and Finance”

Download Hohenheim Discussion Papers in Business, Economics and Social Sciences from our homepage: <https://wiso.uni-hohenheim.de/papers>

No.	Author	Title	Inst
01-2015	Thomas Beissinger, Philipp Baudy	THE IMPACT OF TEMPORARY AGENCY WORK ON TRADE UNION WAGE SETTING: A Theoretical Analysis	520
02-2015	Fabian Wahl	PARTICIPATIVE POLITICAL INSTITUTIONS AND CITY DEVELOPMENT 800-1800	520
03-2015	Tommaso Proietti, Martyna Marczak, Gianluigi Mazzi	EUROMIND-D: A DENSITY ESTIMATE OF MONTHLY GROSS DOMESTIC PRODUCT FOR THE EURO AREA	520
04-2015	Thomas Beissinger, Nathalie Chusseau, Joël Hellier	OFFSHORING AND LABOUR MARKET REFORMS: MODELLING THE GERMAN EXPERIENCE	520
05-2015	Matthias Mueller, Kristina Bogner, Tobias Buchmann, Muhammed Kudic	SIMULATING KNOWLEDGE DIFFUSION IN FOUR STRUCTURALLY DISTINCT NETWORKS – AN AGENT-BASED SIMULATION MODEL	520
06-2015	Martyna Marczak, Thomas Beissinger	BIDIRECTIONAL RELATIONSHIP BETWEEN INVESTOR SENTIMENT AND EXCESS RETURNS: NEW EVIDENCE FROM THE WAVELET PERSPECTIVE	520
07-2015	Peng Nie, Galit Nimrod, Alfonso Sousa-Poza	INTERNET USE AND SUBJECTIVE WELL-BEING IN CHINA	530

No.	Author	Title	Inst
08-2015	Fabian Wahl	THE LONG SHADOW OF HISTORY ROMAN LEGACY AND ECONOMIC DEVELOPMENT – EVIDENCE FROM THE GERMAN LINES	520
09-2015	Peng Nie, Alfonso Sousa-Poza	COMMUTE TIME AND SUBJECTIVE WELL-BEING IN URBAN CHINA	530
10-2015	Kristina Bogner	THE EFFECT OF PROJECT FUNDING ON INNOVATIVE PERFORMANCE AN AGENT-BASED SIMULATION MODEL	520
11-2015	Bogang Jun, Tai-Yoo Kim	A NEO-SCHUMPETERIAN PERSPECTIVE ON THE ANALYTICAL MACROECONOMIC FRAMEWORK: THE EXPANDED REPRODUCTION SYSTEM	520
12-2015	Volker Grossmann Aderonke Osikominu Marius Osterfeld	ARE SOCIOCULTURAL FACTORS IMPORTANT FOR STUDYING A SCIENCE UNIVERSITY MAJOR?	520
13-2015	Martyna Marczak Tommaso Proietti Stefano Grassi	A DATA–CLEANING AUGMENTED KALMAN FILTER FOR ROBUST ESTIMATION OF STATE SPACE MODELS	520
14-2015	Carolina Castagnetti Luisa Rosti Marina Töpfer	THE REVERSAL OF THE GENDER PAY GAP AMONG PUBLIC-CONTEST SELECTED YOUNG EMPLOYEES	520
15-2015	Alexander Opitz	DEMOCRATIC PROSPECTS IN IMPERIAL RUSSIA: THE REVOLUTION OF 1905 AND THE POLITICAL STOCK MARKET	520
01-2016	Michael Ahlheim, Jan Neidhardt	NON-TRADING BEHAVIOUR IN CHOICE EXPERIMENTS	520
02-2016	Bogang Jun, Alexander Gerybadze, Tai-Yoo Kim	THE LEGACY OF FRIEDRICH LIST: THE EXPANSIVE REPRODUCTION SYSTEM AND THE KOREAN HISTORY OF INDUSTRIALIZATION	520
03-2016	Peng Nie, Alfonso Sousa-Poza	FOOD INSECURITY AMONG OLDER EUROPEANS: EVIDENCE FROM THE SURVEY OF HEALTH, AGEING, AND RETIREMENT IN EUROPE	530
04-2016	Peter Spahn	POPULATION GROWTH, SAVING, INTEREST RATES AND STAGNATION. DISCUSSING THE EGGERTSSON- MEHROTRA-MODEL	520
05-2016	Vincent Dekker, Kristina Strohmaier, Nicole Bosch	A DATA-DRIVEN PROCEDURE TO DETERMINE THE BUNCHING WINDOW – AN APPLICATION TO THE NETHERLANDS	520
06-2016	Philipp Baudy, Dario Cords	DEREGULATION OF TEMPORARY AGENCY EMPLOYMENT IN A UNIONIZED ECONOMY: DOES THIS REALLY LEAD TO A SUBSTITUTION OF REGULAR EMPLOYMENT?	520

No.	Author	Title	Inst
07-2016	Robin Jessen, Davud Rostam-Afschar, Sebastian Schmitz	HOW IMPORTANT IS PRECAUTIONARY LABOR SUPPLY?	520
08-2016	Peng Nie, Alfonso Sousa-Poza, Jianhong Xue	FUEL FOR LIFE: DOMESTIC COOKING FUELS AND WOMEN'S HEALTH IN RURAL CHINA	530
09-2016	Bogang Jun, Seung Kyu-Yi, Tobias Buchmann, Matthias Müller	THE CO-EVOLUTION OF INNOVATION NETWORKS: COLLABORATION BETWEEN WEST AND EAST GERMANY FROM 1972 TO 2014	520
10-2016	Vladan Ivanovic, Vadim Kufenko, Boris Begovic Nenad Stanisic, Vincent Geloso	CONTINUITY UNDER A DIFFERENT NAME. THE OUTCOME OF PRIVATISATION IN SERBIA	520
11-2016	David E. Bloom Michael Kuhn Klaus Prettnner	THE CONTRIBUTION OF FEMALE HEALTH TO ECONOMIC DEVELOPMENT	520
12-2016	Franz X. Hof Klaus Prettnner	THE QUEST FOR STATUS AND R&D-BASED GROWTH	520
13-2016	Jung-In Yeon Andreas Pyka Tai-Yoo Kim	STRUCTURAL SHIFT AND INCREASING VARIETY IN KOREA, 1960–2010: EMPIRICAL EVIDENCE OF THE ECONOMIC DEVELOPMENT MODEL BY THE CREATION OF NEW SECTORS	520
14-2016	Benjamin Fuchs	THE EFFECT OF TEENAGE EMPLOYMENT ON CHARACTER SKILLS, EXPECTATIONS AND OCCUPATIONAL CHOICE STRATEGIES	520
15-2016	Seung-Kyu Yi Bogang Jun	HAS THE GERMAN REUNIFICATION STRENGTHENED GERMANY'S NATIONAL INNOVATION SYSTEM? TRIPLE HELIX DYNAMICS OF GERMANY'S INNOVATION SYSTEM	520
16-2016	Gregor Pfeifer Fabian Wahl Martyna Marczak	ILLUMINATING THE WORLD CUP EFFECT: NIGHT LIGHTS EVIDENCE FROM SOUTH AFRICA	520
17-2016	Malte Klein Andreas Sauer	CELEBRATING 30 YEARS OF INNOVATION SYSTEM RESEARCH: WHAT YOU NEED TO KNOW ABOUT INNOVATION SYSTEMS	570
18-2016	Klaus Prettnner	THE IMPLICATIONS OF AUTOMATION FOR ECONOMIC GROWTH AND THE LABOR SHARE	520
19-2016	Klaus Prettnner Andreas Schaefer	HIGHER EDUCATION AND THE FALL AND RISE OF INEQUALITY	520
20-2016	Vadim Kufenko Klaus Prettnner	YOU CAN'T ALWAYS GET WHAT YOU WANT? ESTIMATOR CHOICE AND THE SPEED OF CONVERGENCE	520

No.	Author	Title	Inst
01-2017	Annarita Baldanzi Alberto Bucci Klaus Prettner	CHILDRENS HEALTH, HUMAN CAPITAL ACCUMULATION, AND R&D-BASED ECONOMIC GROWTH	INEPA
02-2017	Julius Tennert Marie Lambert Hans-Peter Burghof	MORAL HAZARD IN VC-FINANCE: MORE EXPENSIVE THAN YOU THOUGHT	INEF
03-2017	Michael Ahlheim Oliver Frör Nguyen Minh Duc Antonia Rehl Ute Siepmann Pham Van Dinh	LABOUR AS A UTILITY MEASURE RECONSIDERED	520
04-2017	Bohdan Kukharskyy Sebastian Seiffert	GUN VIOLENCE IN THE U.S.: CORRELATES AND CAUSES	520
05-2017	Ana Abeliasky Klaus Prettner	AUTOMATION AND DEMOGRAPHIC CHANGE	520
06-2017	Vincent Geloso Vadim Kufenko	INEQUALITY AND GUARD LABOR, OR PROHIBITION AND GUARD LABOR?	INEPA
07-2017	Emanuel Gasteiger Klaus Prettner	ON THE POSSIBILITY OF AUTOMATION-INDUCED STAGNATION	520
08-2017	Klaus Prettner Holger Strulik	THE LOST RACE AGAINST THE MACHINE: AUTOMATION, EDUCATION, AND INEQUALITY IN AN R&D-BASED GROWTH MODEL	INEPA
09-2017	David E. Bloom Simiao Chen Michael Kuhn Mark E. McGovern Les Oxley Klaus Prettner	THE ECONOMIC BURDEN OF CHRONIC DISEASES: ESTIMATES AND PROJECTIONS FOR CHINA, JAPAN, AND SOUTH KOREA	520
10-2017	Sebastian Till Braun Nadja Dwenger	THE LOCAL ENVIRONMENT SHAPES REFUGEE INTEGRATION: EVIDENCE FROM POST-WAR GERMANY	INEPA
11-2017	Vadim Kufenko Klaus Prettner Vincent Geloso	DIVERGENCE, CONVERGENCE, AND THE HISTORY-AUGMENTED SOLOW MODEL	INEPA
12-2017	Frank M. Fossen Ray Rees Davud Rostam-Afschar Viktor Steiner	HOW DO ENTREPRENEURIAL PORTFOLIOS RESPOND TO INCOME TAXATION?	520
13-2017	Steffen Otterbach Michael Rogan	SPATIAL DIFFERENCES IN STUNTING AND HOUSEHOLD AGRICULTURAL PRODUCTION IN SOUTH AFRICA: (RE-) EXAMINING THE LINKS USING NATIONAL PANEL SURVEY DATA	INEPA
14-2017	Carolina Castagnetti Luisa Rosti Marina Töpfer	THE CONVERGENCE OF THE GENDER PAY GAP – AN ALTERNATIVE ESTIMATION APPROACH	INEPA

No.	Author	Title	Inst
15-2017	Andreas Hecht	ON THE DETERMINANTS OF SPECULATION – A CASE FOR EXTENDED DISCLOSURES IN CORPORATE RISK MANAGEMENT	510
16-2017	Mareike Schoop D. Marc Kilgour (Editors)	PROCEEDINGS OF THE 17 TH INTERNATIONAL CONFERENCE ON GROUP DECISION AND NEGOTIATION	NegoTrans
17-2017	Mareike Schoop D. Marc Kilgour (Editors)	DOCTORAL CONSORTIUM OF THE 17 TH INTERNATIONAL CONFERENCE ON GROUP DECISION AND NEGOTIATION	NegoTrans
18-2017	Sibylle Lehmann-Hasemeyer Fabian Wahl	SAVING BANKS AND THE INDUSTRIAL REVOLUTION IN PRUSSIA SUPPORTING REGIONAL DEVELOPMENT WITH PUBLIC FINANCIAL INSTITUTIONS	520
19-2017	Stephanie Glaser	A REVIEW OF SPATIAL ECONOMETRIC MODELS FOR COUNT DATA	520
20-2017	Dario Cords	ENDOGENOUS TECHNOLOGY, MATCHING, AND LABOUR UNIONS: DOES LOW-SKILLED IMMIGRATION AFFECT THE TECHNOLOGICAL ALIGNMENT OF THE HOST COUNTRY?	INEPA
21-2017	Micha Kaiser Jan M. Bauer	PRESCHOOL CHILD CARE AND CHILD WELL-BEING IN GERMANY: DOES THE MIGRANT EXPERIENCE DIFFER?	INEPA
22-2017	Thilo R. Huning Fabian Wahl	LORD OF THE LEMONS: ORIGIN AND DYNAMICS OF STATE CAPACITY	520
23-2017	Matthias Busse Ceren Erdogan Henning Mühlen	STRUCTURAL TRANSFORMATION AND ITS RELEVANCE FOR ECONOMIC GROWTH IN SUB-SHARAN AFRICA	INEPA
24-2017	Sibylle Lehmann-Hasemeyer Alexander Opitz	THE VALUE OF POLITICAL CONNECTIONS IN THE FIRST GERMAN DEMOCRACY – EVIDENCE FROM THE BERLIN STOCK EXCHANGE	520
25-2017	Samuel Mburu Micha Kaiser Alfonso Sousa-Poza	LIVESTOCK ASSET DYNAMICS AMONG PASTORALISTS IN NORTHERN KENYA	INEPA
26-2017	Marina Töpfer	DETAILED RIF DECOMPOSITION WITH SELECTION – THE GENDER PAY GAP IN ITALY	INEPA
27-2017	Robin Jessen Maria Metzger Davud Rostam-Afschar	OPTIMAL TAXATION UNDER DIFFERENT CONCEPTS OF JUSTNESS	INEPA
28-2017	Alexander Kressner Katja Schimmelpfeng	CLUSTERING SURGICAL PROCEDURES FOR MASTER SURGICAL SCHEDULING	580
29-2017	Clemens Lankisch Klaus Prettnner Alexia Prskawetz	ROBOTS AND THE SKILL PREMIUM: AN AUTOMATION-BASED EXPLANATION OF WAGE INEQUALITY	INEPA

No.	Author	Title	Inst
30-2017	Ann-Sophie Adelhelm Melanie Bathelt Mirjam Bathelt Bettina Bürkin Sascha Klein Sabrina Straub Lea Wagner Fabienne Walz	ARBEITSWELT: DIGITAL – BELASTUNG: REAL? DER ERLEBTE WANDEL DER ARBEITSWELT INNERHALB DER IT-BRANCHE AUS SICHT DER ARBEITNEHMER	550
31-2017	Annarita Baldanzi Klaus Prettner Paul Tscheuschner	LONGEVITY-INDUCED VERICAL INNOVATION AND THE TRADEOFF BETWEEN LIFE AND GROWTH	520
32-2017	Vincent Dekker Kristina Strohmaier	THE EFFECT OF TRANSFER PRICING REGULATIONS ON INTRA-INDUSTRY TRADE	520
01-2018	Michael D. Howard Johannes Kolb	FOUNDER CEOS AND NEW VENTURE MEDIA COVERAGE	INEF
02-2018	Peter Spahn	UNCONVENTIONAL VIEWS ON INFLATION CONTRAIOL: FORWARD GUIDANCE, THE NEO- FISHERIAN APPROACH, AND THE FISCAL THEORY OF THE PRICE LEVEL	520
03-2018	Aderonke Osikominu Gregor Pfeifer	PERCEIVED WAGES AND THE GENDER GAP IN STEM FIELDS	INEPA
04-2018	Theresa Grafeneder- Weisssteiner Klaus Prettner Jens Südekum	THREE PILLARS OF URBANIZATION: MIGRATION, AGING, AND GROWTH	INEPA
05-2018	Vadim Kufenko Vincent Geloso Klaus Prettner	DOES SIZE MATTER? IMPLICATIONS OF HOUSEHOLD SIZE FOR ECONOMIC GROWTH AND CONVERGENCE	INEPA
06-2018	Michael Trost	THE WHOLE IS GREATER THAN THE SUM OF ITS PARTS – PRICING PRESSURE INDICES FOR MERGERS OF VERTICALLY INTEGRATED FIRMS	520
07-2018	Karsten Schweikert	TESTING FOR COINTEGRATION WITH TRESHOLD ADJUSTMENT IN THE PRESENCE OF STRUCTURAL BREAKS	520
08-2018	Evanthia Fasoula Karsten Schweikert	PRICE REGULATIONS AND PRICE ADJUSTMENT DYNAMICS: EVIDENCE FROM THE AUSTRIAN RETAIL FUEL MARKET	520
09-2018	Michael Ahlheim Jan Neidhardt Ute Siepmann Xiaomin Yu	WECHAT – USING SOCIAL MEDIA FOR THE ASSESSMENT OF TOURIST PREFERENCES FOR ENVIRONMENTAL IMPROVEMENTS IN CHINA	520

No.	Author	Title	Inst
10-2018	Alexander Gerybadze Simone Wiesenauer	THE INTERNATIONAL SALES ACCELERATOR: A PROJECT MANAGEMENT TOOL FOR IMPROVING SALES PERFORMANCE IN FOREIGN TARGET MARKETS	570
11-2018	Klaus Prettner Niels Geiger Johannes Schwarzer	DIE WIRTSCHAFTLICHEN FOLGEN DER AUTOMATISIERUNG	INEPA
12-2018	Martyna Marczak Thomas Beissinger	COMPETITIVENESS AT THE COUNTRY-SECTOR LEVEL: NEW MEASURES BASED ON GLOBAL VALUE CHAINS	520
13-2018	Niels Geiger Klaus Prettner Johannes Schwarzer	AUTOMATISIERUNG, WACHSTUM UND UNGLEICHHEIT	INEPA
14-2018	Klaus Prettner Sebastian Seiffert	THE SIZE OF THE MIDDLE CLASS AND EDUCATIONAL OUTCOMES: THEORY AND EVIDENCE FROM THE INDIAN SUBCONTINENT	INEPA
15-2018	Marina Töpfer	THE EFFECT OF WOMEN DIRECTORS ON INNOVATION ACTIVITY AND PERFORMANCE OF CORPORATE FIRMS - EVIDENCE FROM CHINA –	INEF
16-2018	Timo Walter	TRADE AND WELFARE EFFECTS OF A POTENTIAL FREE TRADE AGREEMENT BETWEEN JAPAN AND THE UNITED STATES	INEPA
17-2018	Jonas Frank	THE EFFECTS OF ECONOMIC SANCTIONS ON TRADE: NEW EVIDENCE FROM A PANEL PPML GRAVITY APPROACH	INEPA
18-2018	Jonas Frank	THE EFFECT OF CULTURE ON TRADE OVER TIME – NEW EVIDENCE FROM THE GLOBE DATA SET	520
19-2018	Dario Cords Klaus Prettner	TECHNOLOGICAL UNEMPLOYMENT REVISITED: AUTOMATION IN A SEARCH AND MATCHING FRAMEWORK	INEPA

FZID Discussion Papers

(published 2009-2014)

Competence Centers

IK	Innovation and Knowledge
ICT	Information Systems and Communication Systems
CRFM	Corporate Finance and Risk Management
HCM	Health Care Management
CM	Communication Management
MM	Marketing Management
ECO	Economics

Download FZID Discussion Papers from our homepage: https://wiso.uni-hohenheim.de/archiv_fzid_papers

Nr.	Autor	Titel	CC
01-2009	Julian P. Christ	NEW ECONOMIC GEOGRAPHY RELOADED: Localized Knowledge Spillovers and the Geography of Innovation	IK
02-2009	André P. Slowak	MARKET FIELD STRUCTURE & DYNAMICS IN INDUSTRIAL AUTOMATION	IK
03-2009	Pier Paolo Saviotti, Andreas Pyka	GENERALIZED BARRIERS TO ENTRY AND ECONOMIC DEVELOPMENT	IK
04-2009	Uwe Focht, Andreas Richter and Jörg Schiller	INTERMEDIATION AND MATCHING IN INSURANCE MARKETS	HCM
05-2009	Julian P. Christ, André P. Slowak	WHY BLU-RAY VS. HD-DVD IS NOT VHS VS. BETAMAX: THE CO-EVOLUTION OF STANDARD-SETTING CONSORTIA	IK
06-2009	Gabriel Felbermayr, Mario Larch and Wolfgang Lechthaler	UNEMPLOYMENT IN AN INTERDEPENDENT WORLD	ECO
07-2009	Steffen Otterbach	MISMATCHES BETWEEN ACTUAL AND PREFERRED WORK TIME: Empirical Evidence of Hours Constraints in 21 Countries	HCM
08-2009	Sven Wydra	PRODUCTION AND EMPLOYMENT IMPACTS OF NEW TECHNOLOGIES – ANALYSIS FOR BIOTECHNOLOGY	IK
09-2009	Ralf Richter, Jochen Streb	CATCHING-UP AND FALLING BEHIND KNOWLEDGE SPILLOVER FROM AMERICAN TO GERMAN MACHINE TOOL MAKERS	IK

Nr.	Autor	Titel	CC
10-2010	Rahel Aichele, Gabriel Felbermayr	KYOTO AND THE CARBON CONTENT OF TRADE	ECO
11-2010	David E. Bloom, Alfonso Sousa-Poza	ECONOMIC CONSEQUENCES OF LOW FERTILITY IN EUROPE	HCM
12-2010	Michael Ahlheim, Oliver Frör	DRINKING AND PROTECTING – A MARKET APPROACH TO THE PRESERVATION OF CORK OAK LANDSCAPES	ECO
13-2010	Michael Ahlheim, Oliver Frör, Antonia Heinke, Nguyen Minh Duc, and Pham Van Dinh	LABOUR AS A UTILITY MEASURE IN CONTINGENT VALUATION STUDIES – HOW GOOD IS IT REALLY?	ECO
14-2010	Julian P. Christ	THE GEOGRAPHY AND CO-LOCATION OF EUROPEAN TECHNOLOGY-SPECIFIC CO-INVENTORSHIP NETWORKS	IK
15-2010	Harald Degner	WINDOWS OF TECHNOLOGICAL OPPORTUNITY DO TECHNOLOGICAL BOOMS INFLUENCE THE RELATIONSHIP BETWEEN FIRM SIZE AND INNOVATIVENESS?	IK
16-2010	Tobias A. Jopp	THE WELFARE STATE EVOLVES: GERMAN KNAPPSCHAFTEN, 1854-1923	HCM
17-2010	Stefan Kirn (Ed.)	PROCESS OF CHANGE IN ORGANISATIONS THROUGH eHEALTH	ICT
18-2010	Jörg Schiller	ÖKONOMISCHE ASPEKTE DER ENTLOHNUNG UND REGULIERUNG UNABHÄNGIGER VERSICHERUNGSVERMITTLER	HCM
19-2010	Frauke Lammers, Jörg Schiller	CONTRACT DESIGN AND INSURANCE FRAUD: AN EXPERIMENTAL INVESTIGATION	HCM
20-2010	Martyna Marczak, Thomas Beissinger	REAL WAGES AND THE BUSINESS CYCLE IN GERMANY	ECO
21-2010	Harald Degner, Jochen Streb	FOREIGN PATENTING IN GERMANY, 1877-1932	IK
22-2010	Heiko Stüber, Thomas Beissinger	DOES DOWNWARD NOMINAL WAGE RIGIDITY DAMPEN WAGE INCREASES?	ECO
23-2010	Mark Spoerer, Jochen Streb	GUNS AND BUTTER – BUT NO MARGARINE: THE IMPACT OF NAZI ECONOMIC POLICIES ON GERMAN FOOD CONSUMPTION, 1933-38	ECO

Nr.	Autor	Titel	CC
24-2011	Dhammika Dharmapala, Nadine Riedel	EARNINGS SHOCKS AND TAX-MOTIVATED INCOME-SHIFTING: EVIDENCE FROM EUROPEAN MULTINATIONALS	ECO
25-2011	Michael Schuele, Stefan Kirn	QUALITATIVES, RÄUMLICHES SCHLIEßEN ZUR KOLLISIONSERKENNUNG UND KOLLISIONSVERMEIDUNG AUTONOMER BDI-AGENTEN	ICT
26-2011	Marcus Müller, Guillaume Stern, Ansger Jacob and Stefan Kirn	VERHALTENSMODELLE FÜR SOFTWAREAGENTEN IM PUBLIC GOODS GAME	ICT
27-2011	Monnet Benoit, Patrick Gbakoua and Alfonso Sousa-Poza	ENGEL CURVES, SPATIAL VARIATION IN PRICES AND DEMAND FOR COMMODITIES IN CÔTE D'IVOIRE	ECO
28-2011	Nadine Riedel, Hannah Schildberg- Hörisch	ASYMMETRIC OBLIGATIONS	ECO
29-2011	Nicole Waidlein	CAUSES OF PERSISTENT PRODUCTIVITY DIFFERENCES IN THE WEST GERMAN STATES IN THE PERIOD FROM 1950 TO 1990	IK
30-2011	Dominik Hartmann, Atilio Arata	MEASURING SOCIAL CAPITAL AND INNOVATION IN POOR AGRICULTURAL COMMUNITIES. THE CASE OF CHÁPARRA - PERU	IK
31-2011	Peter Spahn	DIE WÄHRUNGSKRISENUNION DIE EURO-VERSCHULDUNG DER NATIONALSTAATEN ALS SCHWACHSTELLE DER EWU	ECO
32-2011	Fabian Wahl	DIE ENTWICKLUNG DES LEBENSSTANDARDS IM DRITTEN REICH – EINE GLÜCKSÖKONOMISCHE PERSPEKTIVE	ECO
33-2011	Giorgio Triulzi, Ramon Scholz and Andreas Pyka	R&D AND KNOWLEDGE DYNAMICS IN UNIVERSITY-INDUSTRY RELATIONSHIPS IN BIOTECH AND PHARMACEUTICALS: AN AGENT-BASED MODEL	IK
34-2011	Claus D. Müller- Hengstenberg, Stefan Kirn	ANWENDUNG DES ÖFFENTLICHEN VERGABERECHTS AUF MODERNE IT SOFTWAREENTWICKLUNGSVERFAHREN	ICT
35-2011	Andreas Pyka	AVOIDING EVOLUTIONARY INEFFICIENCIES IN INNOVATION NETWORKS	IK
36-2011	David Bell, Steffen Otterbach and Alfonso Sousa-Poza	WORK HOURS CONSTRAINTS AND HEALTH	HCM
37-2011	Lukas Scheffknecht, Felix Geiger	A BEHAVIORAL MACROECONOMIC MODEL WITH ENDOGENOUS BOOM-BUST CYCLES AND LEVERAGE DYNAMICS	ECO
38-2011	Yin Krogmann, Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN THE GLOBAL PHARMACEUTICAL BIOTECHNOLOGY INDUSTRY DURING 1985–1998: A CONCEPTUAL AND EMPIRICAL ANALYSIS	IK

Nr.	Autor	Titel	CC
39-2011	Michael Ahlheim, Tobias Börger and Oliver Frör	RESPONDENT INCENTIVES IN CONTINGENT VALUATION: THE ROLE OF RECIPROCITY	ECO
40-2011	Tobias Börger	A DIRECT TEST OF SOCIALLY DESIRABLE RESPONDING IN CONTINGENT VALUATION INTERVIEWS	ECO
41-2011	Ralf Rukwid, Julian P. Christ	QUANTITATIVE CLUSTERIDENTIFIKATION AUF EBENE DER DEUTSCHEN STADT- UND LANDKREISE (1999-2008)	IK

Nr.	Autor	Titel	CC
42-2012	Benjamin Schön, Andreas Pyka	A TAXONOMY OF INNOVATION NETWORKS	IK
43-2012	Dirk Foremny, Nadine Riedel	BUSINESS TAXES AND THE ELECTORAL CYCLE	ECO
44-2012	Gisela Di Meglio, Andreas Pyka and Luis Rubalcaba	VARIETIES OF SERVICE ECONOMIES IN EUROPE	IK
45-2012	Ralf Rukwid, Julian P. Christ	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: PRODUKTIONSCLUSTER IM BEREICH „METALL, ELEKTRO, IKT“ UND REGIONALE VERFÜGBARKEIT AKADEMISCHER FACHKRÄFTE IN DEN MINT-FÄCHERN	IK
46-2012	Julian P. Christ, Ralf Rukwid	INNOVATIONSPOTENTIALE IN BADEN-WÜRTTEMBERG: BRANCHENSPEZIFISCHE FORSCHUNGS- UND ENTWICKLUNGSAKTIVITÄT, REGIONALES PATENTAUFKOMMEN UND BESCHÄFTIGUNGSSTRUKTUR	IK
47-2012	Oliver Sauter	ASSESSING UNCERTAINTY IN EUROPE AND THE US - IS THERE A COMMON FACTOR?	ECO
48-2012	Dominik Hartmann	SEN MEETS SCHUMPETER. INTRODUCING STRUCTURAL AND DYNAMIC ELEMENTS INTO THE HUMAN CAPABILITY APPROACH	IK
49-2012	Harold Paredes- Frigolett, Andreas Pyka	DISTAL EMBEDDING AS A TECHNOLOGY INNOVATION NETWORK FORMATION STRATEGY	IK
50-2012	Martyna Marczak, V́ctor Ǵmez	CYCLICALITY OF REAL WAGES IN THE USA AND GERMANY: NEW INSIGHTS FROM WAVELET ANALYSIS	ECO
51-2012	André P. Slowak	DIE DURCHSETZUNG VON SCHNITTSTELLEN IN DER STANDARDSETZUNG: FALLBEISPIEL LADESYSTEM ELEKTROMOBILITÄT	IK
52-2012	Fabian Wahl	WHY IT MATTERS WHAT PEOPLE THINK - BELIEFS, LEGAL ORIGINS AND THE DEEP ROOTS OF TRUST	ECO
53-2012	Dominik Hartmann, Micha Kaiser	STATISTISCHER ÜBERBLICK DER TÜRKISCHEN MIGRATION IN BADEN-WÜRTTEMBERG UND DEUTSCHLAND	IK
54-2012	Dominik Hartmann, Andreas Pyka, Seda Aydin, Lena Klauß, Fabian Stahl, Ali Santircioglu, Silvia Oberegelsbacher, Sheida Rashidi, Gaye Onan and Suna Erginkoç	IDENTIFIZIERUNG UND ANALYSE DEUTSCH-TÜRKISCHER INNOVATIONSNETZWERKE. ERSTE ERGEBNISSE DES TGIN- PROJEKTES	IK
55-2012	Michael Ahlheim, Tobias Börger and Oliver Frör	THE ECOLOGICAL PRICE OF GETTING RICH IN A GREEN DESERT: A CONTINGENT VALUATION STUDY IN RURAL SOUTHWEST CHINA	ECO

Nr.	Autor	Titel	CC
56-2012	Matthias Strifler Thomas Beissinger	FAIRNESS CONSIDERATIONS IN LABOR UNION WAGE SETTING – A THEORETICAL ANALYSIS	ECO
57-2012	Peter Spahn	INTEGRATION DURCH WÄHRUNGSUNION? DER FALL DER EURO-ZONE	ECO
58-2012	Sibylle H. Lehmann	TAKING FIRMS TO THE STOCK MARKET: IPOS AND THE IMPORTANCE OF LARGE BANKS IN IMPERIAL GERMANY 1896-1913	ECO
59-2012	Sibylle H. Lehmann, Philipp Hauber and Alexander Opitz	POLITICAL RIGHTS, TAXATION, AND FIRM VALUATION – EVIDENCE FROM SAXONY AROUND 1900	ECO
60-2012	Martyna Marczak, V́ctor Ǵmez	SPECTRAN, A SET OF MATLAB PROGRAMS FOR SPECTRAL ANALYSIS	ECO
61-2012	Theresa Lohse, Nadine Riedel	THE IMPACT OF TRANSFER PRICING REGULATIONS ON PROFIT SHIFTING WITHIN EUROPEAN MULTINATIONALS	ECO

Nr.	Autor	Titel	CC
62-2013	Heiko Stüber	REAL WAGE CYCLICALITY OF NEWLY HIRED WORKERS	ECO
63-2013	David E. Bloom, Alfonso Sousa-Poza	AGEING AND PRODUCTIVITY	HCM
64-2013	Martyna Marczak, V́ctor Ǵmez	MONTHLY US BUSINESS CYCLE INDICATORS: A NEW MULTIVARIATE APPROACH BASED ON A BAND-PASS FILTER	ECO
65-2013	Dominik Hartmann, Andreas Pyka	INNOVATION, ECONOMIC DIVERSIFICATION AND HUMAN DEVELOPMENT	IK
66-2013	Christof Ernst, Katharina Richter and Nadine Riedel	CORPORATE TAXATION AND THE QUALITY OF RESEARCH AND DEVELOPMENT	ECO
67-2013	Michael Ahlheim, Oliver Frör, Jiang Tong, Luo Jing and Sonna Pelz	NONUSE VALUES OF CLIMATE POLICY - AN EMPIRICAL STUDY IN XINJIANG AND BEIJING	ECO
68-2013	Michael Ahlheim, Friedrich Schneider	CONSIDERING HOUSEHOLD SIZE IN CONTINGENT VALUATION STUDIES	ECO
69-2013	Fabio Bertoni, Tereza Tykvová	WHICH FORM OF VENTURE CAPITAL IS MOST SUPPORTIVE OF INNOVATION? EVIDENCE FROM EUROPEAN BIOTECHNOLOGY COMPANIES	CFRM
70-2013	Tobias Buchmann, Andreas Pyka	THE EVOLUTION OF INNOVATION NETWORKS: THE CASE OF A GERMAN AUTOMOTIVE NETWORK	IK
71-2013	B. Vermeulen, A. Pyka, J. A. La Poutré and A. G. de Kok	CAPABILITY-BASED GOVERNANCE PATTERNS OVER THE PRODUCT LIFE-CYCLE	IK
72-2013	Beatriz Fabiola López Ulloa, Valerie Møller and Alfonso Sousa- Poza	HOW DOES SUBJECTIVE WELL-BEING EVOLVE WITH AGE? A LITERATURE REVIEW	HCM
73-2013	Wencke Gwozdz, Alfonso Sousa-Poza, Lucia A. Reisch, Wolfgang Ahrens, Stefaan De Henauw, Gabriele Eiben, Juan M. Fernández-Alvira, Charalampos Hadjigeorgiou, Eva Kovács, Fabio Lauria, Toomas Veidebaum, Garrath Williams, Karin Bammann	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY – A EUROPEAN PERSPECTIVE	HCM

Nr.	Autor	Titel	CC
74-2013	Andreas Haas, Annette Hofmann	RISIKEN AUS CLOUD-COMPUTING-SERVICES: FRAGEN DES RISIKOMANAGEMENTS UND ASPEKTE DER VERSICHERBARKEIT	HCM
75-2013	Yin Krogmann, Nadine Riedel and Ulrich Schwalbe	INTER-FIRM R&D NETWORKS IN PHARMACEUTICAL BIOTECHNOLOGY: WHAT DETERMINES FIRM'S CENTRALITY-BASED PARTNERING CAPABILITY?	ECO, IK
76-2013	Peter Spahn	MACROECONOMIC STABILISATION AND BANK LENDING: A SIMPLE WORKHORSE MODEL	ECO
77-2013	Sheida Rashidi, Andreas Pyka	MIGRATION AND INNOVATION – A SURVEY	IK
78-2013	Benjamin Schön, Andreas Pyka	THE SUCCESS FACTORS OF TECHNOLOGY-SOURCING THROUGH MERGERS & ACQUISITIONS – AN INTUITIVE META- ANALYSIS	IK
79-2013	Irene Prostolupow, Andreas Pyka and Barbara Heller-Schuh	TURKISH-GERMAN INNOVATION NETWORKS IN THE EUROPEAN RESEARCH LANDSCAPE	IK
80-2013	Eva Schlenker, Kai D. Schmid	CAPITAL INCOME SHARES AND INCOME INEQUALITY IN THE EUROPEAN UNION	ECO
81-2013	Michael Ahlheim, Tobias Börger and Oliver Frör	THE INFLUENCE OF ETHNICITY AND CULTURE ON THE VALUATION OF ENVIRONMENTAL IMPROVEMENTS – RESULTS FROM A CVM STUDY IN SOUTHWEST CHINA –	ECO
82-2013	Fabian Wahl	DOES MEDIEVAL TRADE STILL MATTER? HISTORICAL TRADE CENTERS, AGGLOMERATION AND CONTEMPORARY ECONOMIC DEVELOPMENT	ECO
83-2013	Peter Spahn	SUBPRIME AND EURO CRISIS: SHOULD WE BLAME THE ECONOMISTS?	ECO
84-2013	Daniel Guffarth, Michael J. Barber	THE EUROPEAN AEROSPACE R&D COLLABORATION NETWORK	IK
85-2013	Athanasios Saitis	KARTELLBEKÄMPFUNG UND INTERNE KARTELLSTRUKTUREN: EIN NETZWERKTHEORETISCHER ANSATZ	IK

Nr.	Autor	Titel	CC
86-2014	Stefan Kirn, Claus D. Müller-Hengstenberg	INTELLIGENTE (SOFTWARE-)AGENTEN: EINE NEUE HERAUSFORDERUNG FÜR DIE GESELLSCHAFT UND UNSER RECHTSSYSTEM?	ICT
87-2014	Peng Nie, Alfonso Sousa-Poza	MATERNAL EMPLOYMENT AND CHILDHOOD OBESITY IN CHINA: EVIDENCE FROM THE CHINA HEALTH AND NUTRITION SURVEY	HCM
88-2014	Steffen Otterbach, Alfonso Sousa-Poza	JOB INSECURITY, EMPLOYABILITY, AND HEALTH: AN ANALYSIS FOR GERMANY ACROSS GENERATIONS	HCM
89-2014	Carsten Burhop, Sibylle H. Lehmann-Hasemeyer	THE GEOGRAPHY OF STOCK EXCHANGES IN IMPERIAL GERMANY	ECO
90-2014	Martyna Marczak, Tommaso Proietti	OUTLIER DETECTION IN STRUCTURAL TIME SERIES MODELS: THE INDICATOR SATURATION APPROACH	ECO
91-2014	Sophie Urmetzer, Andreas Pyka	VARIETIES OF KNOWLEDGE-BASED BIOECONOMIES	IK
92-2014	Bogang Jun, Joongho Lee	THE TRADEOFF BETWEEN FERTILITY AND EDUCATION: EVIDENCE FROM THE KOREAN DEVELOPMENT PATH	IK
93-2014	Bogang Jun, Tai-Yoo Kim	NON-FINANCIAL HURDLES FOR HUMAN CAPITAL ACCUMULATION: LANDOWNERSHIP IN KOREA UNDER JAPANESE RULE	IK
94-2014	Michael Ahlheim, Oliver Frör, Gerhard Langenberger and Sonna Pelz	CHINESE URBANITES AND THE PRESERVATION OF RARE SPECIES IN REMOTE PARTS OF THE COUNTRY – THE EXAMPLE OF EAGLEWOOD	ECO
95-2014	Harold Paredes-Frigolett, Andreas Pyka, Javier Pereira and Luiz Flávio Autran Monteiro Gomes	RANKING THE PERFORMANCE OF NATIONAL INNOVATION SYSTEMS IN THE IBERIAN PENINSULA AND LATIN AMERICA FROM A NEO-SCHUMPETERIAN ECONOMICS PERSPECTIVE	IK
96-2014	Daniel Guffarth, Michael J. Barber	NETWORK EVOLUTION, SUCCESS, AND REGIONAL DEVELOPMENT IN THE EUROPEAN AEROSPACE INDUSTRY	IK

IMPRINT

University of Hohenheim
Dean's Office of the Faculty of Business, Economics and Social Sciences
Palace Hohenheim 1 B
70593 Stuttgart | Germany
Fon +49 (0)711 459 22488
Fax +49 (0)711 459 22785
wiso@uni-hohenheim.de
wiso.uni-hohenheim.de