Essays in Empirical Analysis of Economic Policy

by
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I dedicate my thesis to the memory of my mother and father.

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DISCLOSURE OF CO-AUTHORS CONTRIBUTION

Title of paper: Real exchange rate misalignment and growth in the European Union

Co-author: Gábor Oblath

The nature of the cooperation and the roles of the individual co-authors and approximate share of each co-author in the joint work: The paper was developed in close cooperation with Gábor Oblath throughout all stages. Gábor contributed to the main question and the main theoretical arguments of the paper. I contributed to the detailed empirical strategy and implemented the econometric estimations. We shared the tasks during the literature review, interpretation of the results and writing.

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Abstract

Two of the three essays investigate the role of employment policies in labor market outcomes of disabled persons, focusing on Hungarian policy reforms and using administrative data. The first chapter explores the effect of the disability quota-levy system. The chapter concludes that firms react sensitively to the financial incentive, however, low effective labor supply hampers the effectiveness of the quota regulation. The second chapter focuses on the effects of earnings limit accompanied to disability benefits and it demonstrates that a low earnings limit might reduce earnings and employment rate of partially disabled beneficiaries. The third chapter (with Gábor Oblath) investigates the relationship between economic growth and real exchange rate misalignment within the European Union, using panel econometric techniques. In this essay we find that deviation in the price level of GDP and the internal relative price from levels consistent with economic development affects economic growth in the EU and analyze the role of different factors influencing this effect.

Chapter 1: Effect of employment tax incentives: the case of disability quota in Hungary

The first chapter evaluates the effect of the Hungarian disability quota - levy system on disabled employment and firm behavior, and also aims to shed light on factors influencing the effectiveness of employment tax incentives. According to the quota rule, firms above a certain size threshold, have to employ at least five percent disabled employees or pay a levy in case of non-compliance. The special feature of the Hungarian quota system is the uniquely high levy, which is accompanied by poor labor market integration of the disabled. The estimation exploits two significant policy changes: the drastic increase in the levy in 2010 and the increase in the firm size threshold from 20 to 25 employees in 2012. The policy effect on disabled employment is estimated on firm level data with regression discontinuity

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design (RDD). The baseline RDD results are adjusted to account for the potential bias arising from non-random firm selection, as many firms adjust their size to avoid the quota. The estimated disabled employment effect is high in international comparison, however, almost three-quarter of the quota is not fulfilled. I find evidence that the ratio of disabled population influences the disabled employment effect of the quota. This suggests that low effective labor supply is a factor behind low quota fulfillment.

Chapter 2: Earnings limit for disability benefits: is it really a cash-cliff?

The second chapter aims to evaluate the effect of disability benefit earnings limits on labor supply of moderately disabled individuals. Earnings limits accompanied to disability benefits are often blamed for their negative work incentive, though their impact on labor supply is ambiguous even a priori and the empirical evidence is mixed. This paper adds to this debate by analyzing the effect of a policy reform which decreased the earnings ceiling accompanied to the main benefit of moderately disabled persons in Hungary, the regular social assistance (RSA), from 80% of the pre-disability wage to 80% of the statutory minimum wage. The impact of tighter restrictions is estimated in a regression discontinuity (RD) design and in a difference in difference (DiD) framework, using administrative data. Both RD and DiD results confirm that the lower earnings ceiling has not induced more beneficiaries to exit the benefit and take a job paid above the new limit. However, it reduced both earnings and employment of beneficiaries. The results suggest that the substitution effect dominates the income effect in labor supply reactions to the new earnings limit. The results suggest that the substitution effect dominates the income effect the labor supply reactions to the new wage limit. Despite the low wage ceiling and the low amount of the benefit, many RSA recipients choose staying below the threshold rather than leaving the benefit and take a better paid job under the stricter wage restrictions, resulting in discontinuously lower income of new entrants.

Chapter 3: Economic growth and real exchange rate misalignments in the European Union

(joint with Gábor Oblath)

In this chapter we investigate the relationship between economic growth and real exchange rate (RER) misalignments within the European Union (EU) during the period 1995-

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2016. In addition to the relative price level of GDP, we quantify an alternative indicator for the RER: the internal relative price of services to goods. We interpret RER-misalignments as deviations from levels consistent with levels of economic development among EU countries. Using pooled OLS and dynamic panel techniques, we find that within the EU over- (under-) valuations, both in the relative price level of GDP and the internal relative price indicator are associated with lower (higher) growth. This is mainly due to developments in countries operating under fixed exchange rate regimes. Our results indicate that the level of development does not influence the strength of the growth-misalignment relationship within the EU. Regarding the price level of GDP, we find that the positive relationship between undervaluation and growth diminishes with the degree of undervaluation. We find that overvaluation has a statistically significant negative effect on export market shares and private investments, indicating that both the competitiveness and the investment channels play a role in the relationship between growth and RER misalignments. The policy implications of the analysis point to the importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other.

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Introduction

Sound economic policies should be built upon deep knowledge about the impact mechanism of policy interventions, drawing on both theory and empirical evidence. My thesis aims to contribute to the literature by providing insights into potential impacts and - sometimes unintended - consequences of economic policies, based on econometric analysis of past interventions and data.

Two of the three essays investigate the role of employment policies in labor market outcomes of disabled persons. In the last few decades, the recognition increased that labor market policies might enhance labor market integration of the disabled population, by providing financial incentives and specific help to both disabled jobseekers and potential employers. However, many details regarding the factors influencing the size, and sometimes even the direction of a policy is still unclear.

Increasing access to and improving technical background of analyzing large administrative databases provide opportunity for a better understanding of the contribution of policies to labor market outcomes. Nevertheless, uncovering the causal impact of economic policies is always challenging from observational data, as the counterfactual world is not observable and different variables are interrelated in multiple ways. My goal is to rely on exogenous changes in disabled employment policies that enlighten decisions of individuals and firms. One contribution of the thesis is to exploit two sizable and unusual reforms of disabled employment policies in Hungary, which considerably changed the rules of the game and compelled the affected participants to react. These exogenous policy changes provide an opportunity to reveal the causal impacts of the policies on the behavior of the affected participants and labor market outcomes of disabled population. However, the two chapters aim to go beyond evaluating past policies. My goal is to provide new insights from past reforms that that can be instructive when designing future policies.

The first chapter, which explores the effect of the disability quota-levy system in Hungary, demonstrates that employment policies aim to influence the labor demand for disabled population, might interfere with labor supply factors, diverting the policy effects. I find that though the obligatory employment quota considerably increases disabled employment, the majority of the affected firms rather pays the noncompliance levy instead of hiring a disabled person. I argue that high (perceived) adjustment costs, labor supply shortage and discrimination might hamper the effectiveness of the quota regulation, even if firms react sensitively to the financial incentive created by the obligatory employment quota and the accompanied levy. My empirical evidence points to the importance of the low effective disabled labor supply that is constrained by multiple factors, such as low capacity of rehabilitation services, dominance of sheltered workplace, disincentive scheme of disabled allowances, lack of support in transportation.

My second chapter aims to shed some light on the factors influencing the labor supply of disabled individuals, specifically, the incentive effect of the design and the scheme of disability benefits. Rules of gaining and keeping eligibility to disability benefits might have unintended consequences on beneficiaries' employment outcomes by penalizing earning activity. My study focuses on the earnings limit accompanied to disabled benefits that results in losing the entire benefit if the beneficiary's earnings exceed a limit. Earnings limits are imposed in many disability systems and aim to curb excessive reliance and misuse of benefits. However, with analyzing a Hungarian policy reform I present empirical evidence that earnings limit might be counterefective as prevent partially disabled beneficiaries from fully use of their remaining working capacity. My results indicate that strengthening polices that help disabled people to return the labor market would boost the effect of the employment quota and other financial incentives and could enhance labor market integration of the disabled population.

The third chapter (with Gábor Oblath) investigates a macroeconomic question: the relationship between economic growth and real exchange rate misalignment within the European Union, using panel econometric techniques on yearly aggregate data for the 1995-2016 period. Connection to economic policy is less direct in case of this chapter, as the real exchange rate is an endogenous variable, which is not under direct policy control. However, there are several policy instruments that indirectly influence the real exchange rate. Our empirical results indicate that not only the deviation in the price level of the GDP, but also the internal relative price from levels consistent with economic development do affect economic growth in EU countries. The link between our real exchange rate indicators and economic growth was found even stronger in countries operating under fixed exchange rate regime and members of the Eurozone, highlighting that real exchange rate stays a crucial factor even if the nominal exchange rate is of less prominence. Our results point to the

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importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other.

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Chapter 1

Effect of employment tax incentives: the case of disability quota in Hungary

1.1 Introduction

The labor market integration of disabled population is a great challenge in all countries. In labor market context, the concept of disability refers to a long term physical or mental health problem that causes serious work limitation, and the employment rate of the disabled is usually well below the non-disabled population. Developed countries usually apply an arsenal of different, supply and demand side policies to boost the labor market integration of disabled individuals. Disability quota system is a commonly used element of the toolkit that concentrates on the demand side. Firms, usually above a certain size threshold have an obligation to employ a certain number of disabled employees or pay a tax in case on non-compliance. Thus, the aim of quota-levy systems is to enhance the labor market demand by increasing the relative cost of employing non-disabled employees.

This paper evaluates the effects of the Hungarian disability quota-levy system on employment of disabled persons and firm behavior. In addition, exploiting the special features of the Hungarian quota-levy system, the paper also aims to reveal factors influencing the effectiveness of the policy. The Hungarian quota-levy system is peculiar in terms of the amount of the levy compared to wages, which has become one of the highest in the world

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after a dramatic, 454 percent increase in the middle of the financial crisis in 2010. A unique feature of the system is that the levy is higher than the minimum wage cost of fulfilling the quota. Nevertheless, the quota fulfillment can be considered rather low: more than 70 percent of the firms above the threshold chooses paying the levy instead of hiring a disabled employee. This paper aims to shed light on the roots of this contradiction.

In addition to the drastic levy hike in 2010, the identification of the quota employment effect exploits another policy change: the increase in the firm size threshold from 20 to 25 employees in 2012. Similarly to Lalive et al. (2013), Mori and Sakamoto (2017), Malo and Pagán (2014), in the first step the employment effect of the quota was estimated by applying regression discontinuity design (RDD), focusing on the years before and after the two reforms. I find that firms react quickly and intensively to the policy changes. Basic sharp RDD estimations show no significant discontinuity before the levy hike. However, in 2010, when the increase came into effect, more than a quarter of the quota is fulfilled thanks to the regulation. A similarly large discontinuity is estimated in 2012 at the increased, 25-employee threshold, while the discontinuity at the old threshold disappears within a single year.

However, probably attributable to the exceptionally high levy, Hungarian firms are more inclined to change the size of their workforce in order to avoid the regulation than in other countries, resulting in a solid bunching in firms' distribution below the quota threshold. The bunching shifts upward with increasing the firm size threshold, confirming that the observed discontinuity in firms' distribution is related to the disability quota. As the assumption of random firm selection around the quota threshold is violated, baseline RDD might produce an upward biased estimation of the treatment effect. Firm size manipulation was also detected in the Austrian case by Lalive et al. (2013), and they calculate lower and upper bounds for the treatment effect. For the Hungarian case, where bunching is more spectacular, I estimate the potential magnitude of the bias using an estimated counterfactual distribution to calculate the mass of firms that keep their size below the threshold on account of the levy, based on the idea of Lalive et al. (2013). The lower bound of the quota effect is estimated on the simulated sample in which the firm distribution is smooth and created by assigning randomly selected firms from below to just the threshold.

The results show that the bias caused by the bunching accounts for at most 40% of the estimated disabled employment effect, the quota strongly increases disabled employment even after controlling for the potential endogeneity bias. The estimated elasticity of substitution between disabled and non-disabled employees is also much higher than found in other countries, suggesting that firms react very sensitively to financial incentives. Regres-

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sion discontinuity estimations on firm characteristics and the composite covariate index indicates that selection of firms between the treatment and control groups is based on unobserved firm characteristics.

However, the RD estimations on different subgroups of firms indicate that the disabled employment effect at the threshold strongly depends on firm characteristics. Specifically, firms with lower average wages are more inclined to hire disabled as an effect of the quota, confirming that the level of the levy compared to the average wages influences the reaction of firms.

I also find evidence that the employment effect of the quota is stronger in regions where the ratio of disabled population is higher. This result sheds some light on the contradiction that majority of firms choose paying the levy instead of hiring disabled despite the very strong financial incentive. Specifically, the results indicate that low effective labor supply might be an important factor behind low quota fulfillment. The effective labor supply of disabled is constrained by many factors, for example lack of capacity in rehabilitation services or high opportunity cost of working.

The empirical results point to the importance of labor supply in the effect of the quota rule. However, there might be substantial problems also on the demand side: high one-off costs of hiring (for example cost of recruiting, workplace and job accommodation, integration and training) and discrimination might be important barriers to employing disabled employees. In a simple framework I show that labor supply shortage, non-wage labor costs of hiring disabled and discrimination may also play a role.

The few papers in the literature that study the effects of disabled employment quota usually find positive, but moderate or insignificant effect on disabled employment around the threshold, however, in these cases, the levy is also moderate. The quota system is found to significantly increase disabled employment in Austria (Lalive et al. (2013), Wuellrich (2010)) and Japan (Mori and Sakamoto (2017)). Malo and Pagán (2014) find small positive employment effect for Spain that is significant only at 10 % level,[1] and Nazarov et al. (2015) conclude that changes in the quota system in South-Korea (decrease in employment threshold and increase in fine) have increased labor market participation of disabled, but after controlling for selection into the labor market, had only a limited impact on the probability of being employed.

This paper primarily contributes to the quota literature by analyzing the effects of a

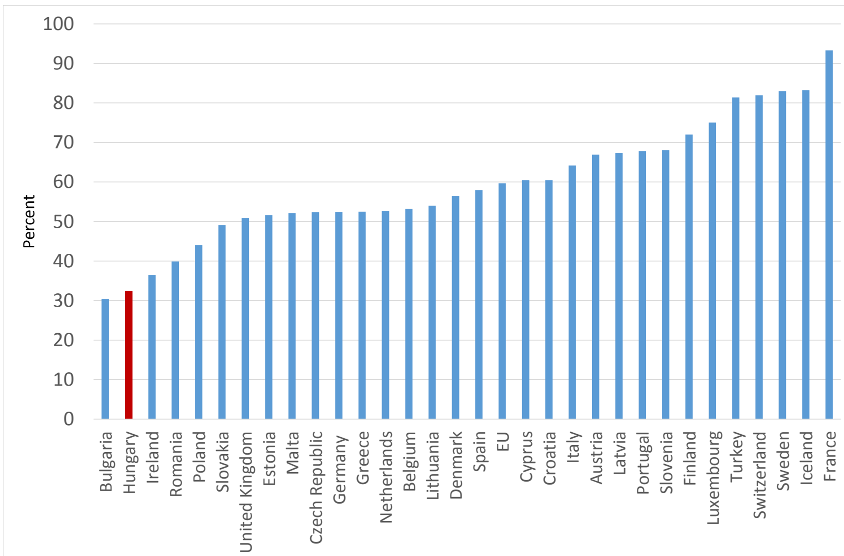
[1]However, there is no levy accompanied to the quota in the Spain case.

disability quota, when the financial incentive is particularly strong. In addition to the significant increase in the levy, I can exploit another significant policy change, the increase in the firm size threshold from 20 to 25. The second policy change serves as a robustness check and strengthen the main findings, as the policy effect changes along with the shift in the threshold.

The paper is also related to the literature that analyzes the effects of demand side employment policies, for example employer-side wage subsidies and other tax incentives, as the basic mechanism of quota-levy systems is similar. Specifically, all these policies operate by decreasing the relative wage cost of disadvantaged groups, thus the quota-levy system can be regarded as a negative subsidy or tax incentive. Empirical evidence on wage subsidies is mixed: there is some evidence that wage subsidies can be effective in enhancing employment of disabled (Datta Gupta et al. (2015)) and disadvantaged unemployed (Kluve (2010)), other papers find that wage subsidies have modest (Katz (1996), Hamersma (2008)) or no effect (Baert (2016)). Katz (1996) highlights that the elasticity of labor supply and other factors, such as administration costs, stigmatization effect and employer awareness also influence the employment and wage effects of wage subsidies. However, little is known about the relevance of the different factors empirically. This paper contributes by showing that other factors beyond labor demand elasticity, such as labor supply constraints and labor market frictions might have a great influence on employment outcomes. The example of Hungarian quota-levy suggests that applying strong financial incentives is not sufficient for achieving policy goals even if firms react sensitively to changes in relative wage costs. Without addressing the underlying frictions on disabled labor market, the quota-levy system behaves rather like a size-related tax that puts a disproportional burden on low-wage firms.

The remaining of the paper is structured as follows. The second section describes the institutional setup and mechanism of quota-levy system in Hungary. Section 3 describes the data that are used for the empirical analysis. Section 4 shows the empirical strategy and results of regression discontinuity estimations. Section 5 shows firm heterogeneity in employment effect and provides evidence for the role of labor supply in the disabled employment effect. Section 6 concludes.

Figure 1.1: Employment rate of disabled/employment of total working age population,2011



Source:Eurostat

1.2 Institutional background

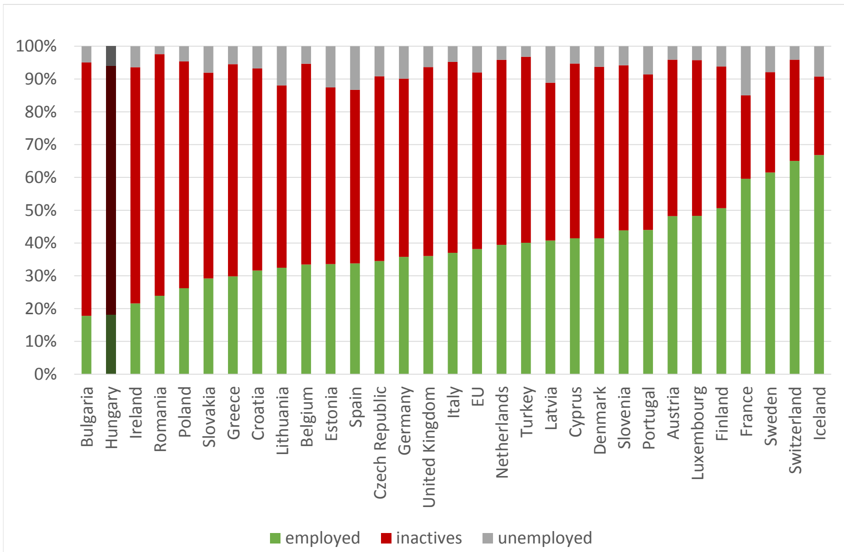
1.2.1 Disabled employment at a glance

The labor market position of disabled individuals in Hungary seems to be particularly poor in international comparison.[2] The employment rate of the disabled population in Hungary is one of the lowest in the EU, and the employment rate is only one third of that of the total working age population (see Figure 1.1). In the meantime, the share of disabled in the total working age population (11,3%) is close to the EU average (11%).[3]

[2]International data are not completely comparable with the data of our econometric analysis. Eurostat data are based on the Labor Force Survey and the disabled status is assessed on the basis of self assessment and does not imply official qualification automatically. However, these data give a picture about the magnitude of the problem.

[3]The employment rate is very low even after controlling for age and education differences between the disabled and non-disabled population (Source: Central Statistical Office).

Figure 1.2: Decomposition of working age disabled population by activity, 2011



Source:Eurostat

The large discrepancy with other EU countries mainly comes from the very low disabled activity rate, though the disabled unemployment rate is also excessive (see Figure 1.2 and 1.3).

1.2.2 Disability quota system in Hungary

Similarly to other countries, the Hungarian disabled employment policy applies a set of different tools: sheltered and subsidized employment, education, rehabilitation services (for a detailed review, see for example Scharle and Varadi (2013), Scharle and Csillag (2016)). Disabled employment quota is one of the most common tools, which is applied in about one third of OECD countries OECD (2010a). Firms, usually above a certain size threshold have an obligation to employ a certain number of disabled employees or pay a levy in case on non-compliance. The details - size threshold, levy compared to wages, quota - differ across countries.

The aim of the quota-levy systems is to enhance the labor demand for disabled by increasing the relative cost of employing non-disabled employees. The main mechanism

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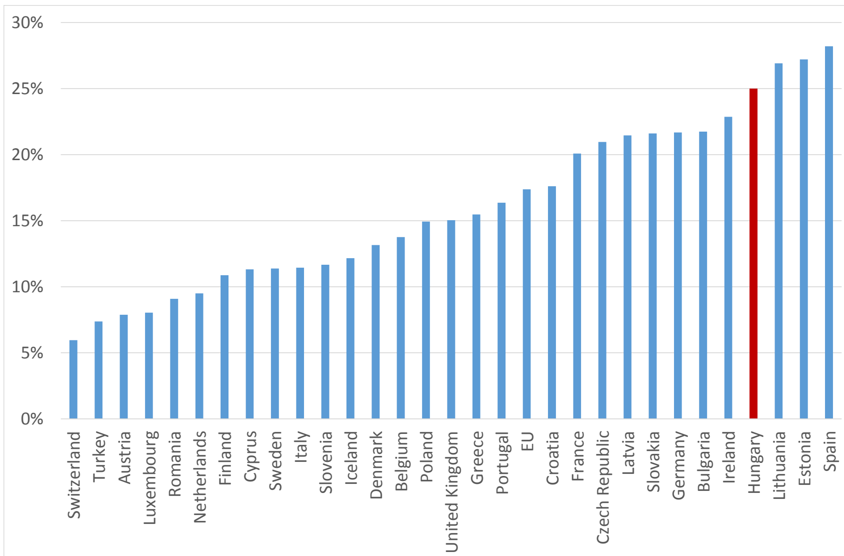
Figure 1.3: Unemployment rate of working age disabled population,2011



Source:Labour Force Survey,Eurostat

of the quota-levy system - directing labor demand toward a specific group by influencing relative labor costs - links the system to wage subsidies and other tax credits and allowances. Thus, it can be regarded as negative subsidy or tax incentive. However, taxes might be perceived in a different way than subsidies by firms, especially in the short term. It is a well known fact in behavioral economics that consumers are more averse to losing money than are happy because of gaining money, for example as actual status serves as a reference point (e.g. Tversky and Kahneman (1991)). If these behavioral considerations are relevant also to firms, a quota, with similar effect on relative labor costs might exert a stronger impact than a wage subsidy.

Employment quota has been in force in Hungary since 1991. According to the regulation, practically all employers, firms and public institutions above a size threshold are obliged to employ disabled individuals in at least 5 percent of their average statistical headcount.[4] The official disabled status (in Hungarian terminology: status of changed

[4]There are only a few exemptions, for example the organizations of Armed Forces. Additionally those

working capacity) is attained through a complex assessment process implemented by the rehabilitation authority.[5]In the period 2008-2011, a person was qualified with changed working capacity if her or his overall health impairment is assessed at least 40 percent by the assessment process.[6]The official disabled status also implies eligibility to some kind of rehabilitation or disability benefit, depending on the degree and type of disability, working history and the prospect for rehabilitation. It is important to note that persons who qualify to the quota constitute a heterogeneous pool. The official status refer to disabled individuals with degree of health impairment from 40% to 100% from various health diagnosis and different expected gain from rehabilitation.

If the number of employed disabled is lower than the quota requirement, the firm is obliged to pay a levy (in Hungarian terminology: rehabilitation contribution) for the missing persons from the quota. The quota is 5 percent of the yearly average statistical headcount (for the details of the yearly average statistical headcount calculation, see Appendix A.2). The rehabilitation contribution has to be paid for the difference between the number of disabled employees at the firm and the obligatory employment level implied by the quota.

Working time of disabled employees must reach or exceed 20 hours per week to be considered in the quota. However, once this minimum is attained, the working time is not relevant: a half-time disabled employee is treated in a same way as a full-time disabled employee, that is regarded as a full person in the quota.[7]

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who employed in some special forms of communal and temporary employment also do not count toward the headcount of the company, that is, the base of the rehabilitation contribution. First, the rehabilitation contribution was regulated in the ACT IV. of 1991 on Job Assistance and Unemployment Benefits. Since 2011, the quota rules are encoded in Act CXCI of 2011 on Allowances for Persons with Disabilities and the Amendment of Certain Legislation.

[5]National Office for Rehabilitation and Social Affairs, previously Institute of National Rehabilitation and Social Experts.

[6]The classification of the status *changed working capacity* changed several times. Until end of 2007, the health status was expressed in terms of loss in the working capacity, and those with at least 50% decrease gained official status of changed working capacity. Between 2008-2011, the health status was expressed in terms of health impairment, and the official limit was set to 40%. Starting from 2012, the health status has being assessed by an extended committee of health and labor market experts, and has being assessed in terms of % of remaining health.

[7]Note the discrepancy in recognition of part-time between total staff and disabled workers: a disabled employee is counted in the quota only if her contractual working time is minimum 20 hours per week, that is, roughly 80 hours per month, compared to the 60 hours/month lower limit in case of average headcount.

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A specialty of the Hungarian regulation is that the quota is rounded not to an integer number, but to one decimal digit. This rule implies that once the minimum firm size is reached, the quota increases proportionately with firm size. For example, take a firm with 25 total employees and one disabled employee. If the quota threshold is 20 employees, this firm still has to pay the levy for a quarter missing person, or has to overfill the quota if wants to avoid paying the levy. An important implication for the estimation is that we can expect a discontinuity in the number of disabled workers only at the threshold (20 employees up to 2012 and 25 employees afterwards). Firms have to declare and pay their obligation to the national tax authority on a quarterly basis.

Employment outcomes of disabled are also influenced by rules on wages and employment protection. In Hungary, in line with the EU guidelines, the act on equal treatment and the promotion of equal opportunities [8] declares that same respect and circumspection shall be exercised regarding all persons. Discrimination against an employee for example in provisions of access to or termination of employment, on grounds of health status is regarded as a violation of the principle of equal treatment. The labor code[9] regulates principles of wage setting and declares that equal work has to be paid equally. However, these laws do not rule out that productivity differentials are reflected in wages and do not provide special employment protection for disabled employees. Moreover, dismissing a disability beneficiary in case of the most important benefits (e.g. disabled pension, and later disabled allowance) is even easier than dismissing a healthy employee: beneficiaries are regarded as pensioners in this case implying that no need for explanation in case of layoff. However, disabled employees are entitled for 5 extra holidays. Wage and employment protection legislation indicate that the reluctance to hiring disabled is not because the productivity differential can not be reflected in the wages or huge firing costs.

1.2.3 Policy changes

There analysis focuses on two major changes in the legislation of the disability quota in the last decade.

1. Starting from 2010, the amount of the levy was increased dramatically, by 454 percent, from HUF 174 thousand (about 837 USD) per year per missing employee from

[8] Act CXXV of 2003 on equal treatment and the promotion of equal opportunities

[9] Act XXII of 1992 On the Labor Code and from 2012, Act I of 2012 on Labor Code.

the quota to 964 thousand HUF (about 4635 USD). In 2010 the levy amounted to 86 percent of the total labor cost (gross wage plus employer's contributions) of a full-time non-disabled minimum wage earner, and 31 percent of the labor cost of an employee with average wage. The levy increase did not change the pool of disabled who qualified for the quota, hence the policy change affected the whole, heterogeneous group with official certificate of "changed working capacity".

The motivation behind the drastic increase was twofold. First of all, the reform aimed to improve poor labor market conditions of the disabled population and was an important step forward in complying with EU guidelines about enhancing open labor market employment of disabled.[10] However, the magnitude and the timing of the policy change in part might be explained by the economic and fiscal crisis starting from 2008 and the requirement to cut the budgetary deficit. The planned revenue from the increased burden amounted to 62 billion HUF (300 million USD) about 0,2% of the GDP in 2010.

After the 2010 increase Hungary became one of the top OECD countries in terms of the amount of the levy compared to average wages. In 2010, the levy amounted to about 2 percent of the average payroll, in contrast with the typical 0,25-1 percent in OECD countries (OECD (2003)). What makes the Hungarian system really unique is not the high levy compared to the average wage but the fact that it exceeds the minimum cost of fulfilling the quota. Note that the increase in the levy, which put a significant burden on firms, came into effect in the middle of the financial crisis, after a more than 6 percent GDP loss in 2009.

The first announcement about the increase was made in February 2009, and the law was signed in June of 2009. As a consequence, some firms already reacted in 2009, therefore the effects of the policy change are partly reflected in the 2009 data.

2. In 2012, the employment threshold was increased from 20 to 25 persons, while the amount of the levy remained unchanged.[11]

The empirical analysis relies on these two policy changes in order to reveal the effects of the disabled employment quota.

[10] Disability Action Plan, 2003-2010 and the European Disability Strategy 2010-2020

[11] see Act CXCI of 2011 on allowances for persons with disabilities

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1.3 Data

The empirical analysis is based on the corporate tax data set of Hungarian double-entry bookkeeping firms. The database contains administrative tax files data collected by the National Tax and Customs Administration (NAV) of all double-keeping Hungarian firms from 2006-2013. Tax files comprise detailed balance sheet and income statement data of firms as well as firm characteristics, such as industry, region, number of employees, ownership structure.

The corporate tax database does not contain information on the actual levy payment, as the rehabilitation contribution is filed in a different tax form on a quarterly basis. However, corporate tax files also contain number of disabled employees. As both tax statements are gathered, stored and processed by the NAV, we can expect that the data on disabled employees in the tax database is consistent with the information filed in the tax form of rehabilitation contribution.

In case of firms, for which data on number of disabled workers is missing, but data on total employment is available, I replace missing data to zero disabled employee. This imputation is based on the assumption that those firms leave this cell empty, which do not employ disabled employees. This assumption is plausible: if reported number of disabled employees and the noncompliance tax paid is not consistent with each other, the firm can expect an audit. However, as the imputation concerns a large number of observations, I addressed the question by comparing number of disabled employees with aggregate information on levy revenues. The comparison revealed that information on disabled employment in the tax database (after the imputation) and aggregate data on levy revenues yields very similar results for the number of missing persons from the quota (for the details, see Appendix A.3). This implies that the reliability of the data on the number of disabled persons is very high, and the imputations do not threaten the validity of the results. The correspondence of the levy revenue and disabled employment data also suggests that the enforcement of the regulation is strong; firms do in fact pay the levy if they do not meet the quota requirements.

The question arises whether tax evasion of firms may lower reliability of our data on disabled employment. Consistency of disabled employment and levy revenue data does not exclude the possibility that firms try to escape paying the levy by reporting false data on disabled employment. However, high cost of being found in fault in case of labor inspections is a serious disincentive. False number of disabled employees is very easy to detect, as a firm must be able to present a certificate of disability status. The internationally high levy revenues and the fact that revenue from disability contribution exceeds the target year by year also suggest high compliance. Therefore I disregard the possibility in the estimations.

Due to discrepancy in rounding rules, the calculated quota requirement based on NAV database data might differ from the actual quota requirement prescribed by the law. Implications of differences in rounding rules to the estimation are discussed in Section 4.

The basic descriptive statistics from the corporate tax database are summarized in Appendix A.5, Table A.4. The total number of disabled employees at firms does not exhibit much increase in 2010, after the significant increase in the levy. However, it seems that the majority of disabled employees is employed in sheltered employment, at special accredited firms. Firms, with share of disabled employees at least 40 percent of total work force, have the possibility to apply for a special status that implies wage and other subsidies. This status can be achieved through a process of accreditation, in which the firms have to meet some criteria and prove that they are able to rehabilitate disabled employees. As the analysis focuses on the open labor market, I excluded firms from the estimations in which the share of disabled employees exceeded 40 percent.

Disability quota in macro perspective

In 2010, the levy amounted to 86% of total labor cost of a full-time minimum wage earner, 170% of a half time minimum wage earner, and 31% of a full-time average wage earner. As the quota can be fulfilled also with a part-time (minimum half-time) employee, hiring a disabled minimum wage earner even with zero productivity would incur lower cost by 70 % than paying the levy, if we disregarded adjustment costs of employment and assumed that the firms are able to hire disabled employees on this wage level. Despite the strong financial incentive, the majority of firms chose not to employ disabled workers but paying the non-compliance levy instead. The quota fulfillment, that is, the ratio of the quota that is filled with disabled employees is less than 30 % even after the levy hike (see Table A.4).[12] The quota fulfillment can be assessed as low in international comparison, as usually

[12]The quota fulfillment can be measured in different ways, depending on the assessment of overfilling the quota. The lowest estimation for quota fulfillment is given by comparing empty positions to the quota: (1–missing employees from the/quota)as this method disregards number of disabled employees who are employed above the quota requirement (11. and 15. row in table A.4. Relating the number of employees in non-special firms to the quota yields a somewhat higher quota fulfillment, as disabled employees in firms that employ more disabled that required by the quota also are taken into consideration in this case (12-16. rows in the table).

50-90% of the quota is filled with disabled employees.[13]

The low quota fulfillment is also reflected in the high aggregate levy revenue which increased from 0,06 percent of the GDP in 2009 to 0,24 percent of the GDP in 2011, around 65 billion HUF (313 million USD). As a comparison: the total revenue from corporate tax was approximately 2 percent of the GDP in 2011, thus the revenue from the non-compliance levy can be considered as substantial. Although new international comparison is not available, 2015 Labor Force Survey data indicate no improvement in relative employment rate of disabled compared to 2011.[14] One of the main questions of the following analysis is whether the low performance is due to the fact that firms are not sensitive to the strong financial incentive, or other factors impede disabled employment.

1.4 Empirical strategy

1.4.1 Firms' options

Firms that are subject the regulation and do not employ enough disabled workers to fill the quota face the following choices. They can hire additional disabled worker(s) by (1) increasing total employment or by (2) substituting non-disabled employees with a disabled employee. If a firm does not want to comply with the quota, it can choose between (3) paying the levy and (4) avoiding the regulation by reducing or keeping employment below the threshold. The last case includes manipulating only the official size while the true employment remains the same. This can happen for example by contracting out employees, employing unreported workers or increasing the working time, that is, decrease employment on the extensive margin while increase it in the intensive margin.

[13] In OECD (2003), the quota fulfillment was estimated to 64% in Austria, at least 50% in Italy, 46-72% in Korea, 57% in Germany, 64% in France. Close to 90% of the quota is fulfilled in Japan Mori and Sakamoto (2017). The most similar case to Hungary is Poland, where quota fulfillment was similarly low at around 30% and the levy was relatively high above 2% of average payroll OECD (2010a)).

[14] Source: Central Statistical Office, 2015.

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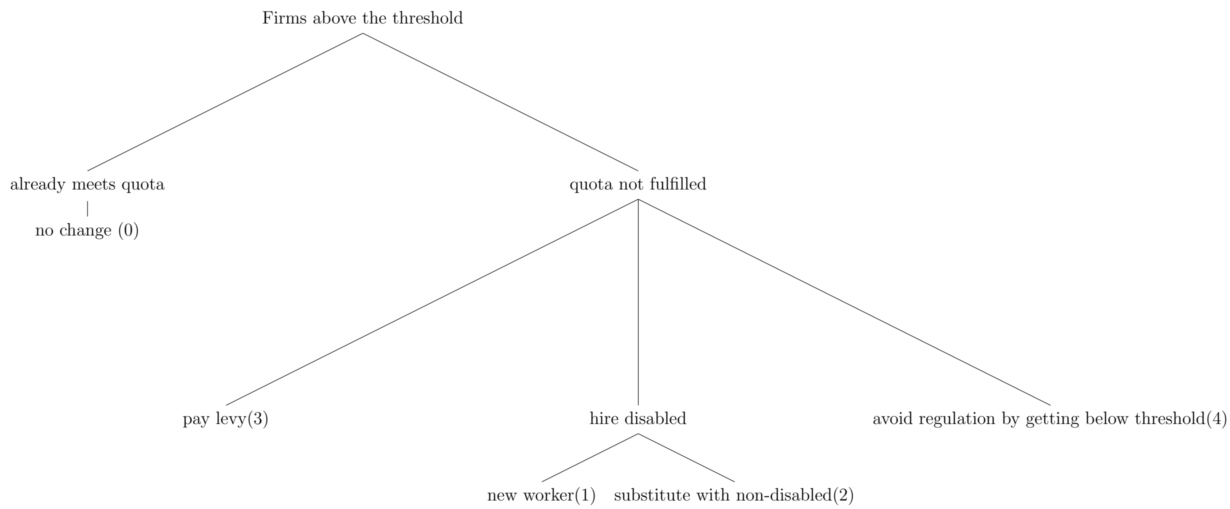

Firms' choice first of all depends on the amount of the levy compared to the labor costs of disabled and non-disabled employees, the substitutability between disabled and non-disabled employees and the marginal revenue product of disabled and non-disabled. A firm of which optimal size without the quota is above the threshold, will choose its size below the threshold if the loss from employing less than optimal employees is lower than both the cost of hiring a disabled (either as a new hire or substitution) and the levy. Clearly, this choice is relevant only for firms for which the non-quota optimum is not far above the threshold. A firm will choose paying the levy instead of employing a disabled, if the profit loss of employing a disabled worker (either with or without substitution) is higher than the levy. The lower is the levy compared to non-disabled wages, the labor costs of hiring disabled compared to the labor costs of non-disabled, and the lower is the relative (perceived) productivity of disabled compared to non-disabled employees, the more probable is that a firm will choose paying the levy. Regarding the labor costs of disabled employees, both wages and non-wage costs might differ from those of non-disabled employees.

Following from the potential responses of firms, the empirical analysis aims to identify the causal effect of the quota - levy system on the employment of disabled persons. As the quota-levy poses non-negligible burden on firms, the analysis also aims to reveal the impact of the quota system on firm behavior. In addition, I also aim to reveal the factors influencing the effectiveness of the policy by analyzing the contradiction between the low quota fulfillment and the high levy.

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1.4.2 Disabled employment effect with sharp discontinuity design

As a starting point, the effect of the quota-levy system on disabled employment is estimated using sharp regression discontinuity design framework (RDD). The RDD is estimated separately for every single year from 2007 to 2012. These regressions show how the effect of the policy changes year to year around the threshold.

Firms with at least 40 % share of disabled employee are presumably special accredited firms (for the details, see Section 3), hence these firms are excluded from the econometric analysis.

In the sharp regression discontinuity design, the observed outcome is:

$$Y_{it} = \begin{cases} Y_{it}(1), & \text{if } emp_{it} >= c_t \\ Y_{it}(0), & \text{if } emp_{it} < c_t \end{cases}$$

$Y_{it}(1)$ = outcome for a randomly chosen population unit if the treatment is imposed exogenously
$Y_{it}(0)$ = outcome for a randomly chosen population unit if excluded from the treatment exogenously.

The main outcome variable, Y, is the number of disabled employees (*disemp*), but later I also look for discontinuities in variables of firm performance, such a wages, productivity and profitability at the quota threshold. *emp* is the variable that divides the population into treated and control groups, the running variable, in our case the number of employees at the firm. c is the cutoff value of emp_{it}, that is, firms with number of employees with or above the cutoff belong to the treated group.

We are looking for the treatment effect at the threshold, that is:

$$\tau = E(Y_i(1) - Y_i(0) | X_i = c)$$

$$\tau = \mu_+ - \mu_-$$

where

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$\mu_{+} = \lim_{x \downarrow c}$, $\mu_{-} = \lim_{x \uparrow c}$, $\mu(x) = E(Y_i|X_i = c)$

Firms' potential strategies are reflected in the outcomes in the following way. If a firm employs a disabled only under the quota (complier), either as a new hire, either as a substitution: $Y_i(1) - Y_i(0) >= 1$. However, if a firm does not hire disabled employees neither under nor without the quota (never taker): $Y_i(1) - Y_i(0) = 0$. This is also true for firms, which employ disabled employees, regardless the quota (always takers.)

The strategy of avoiding the quota (strategy 4) is not reflected in the RDD framework, as a crucial identifying assumption of the RDD is the exogeneity of selection into the treatment group. However, firms with employees close to the threshold employment level have an incentive to stay or get below the threshold, that is, to keep their employment under 20 and under 25 employees after 2012 and avoid the regulation completely. Thus, the firm size is endogenous, as firms close to the cutoff might self-select themselves between the treatment and control groups. Non-random firm selection might distort the estimated treatment effect. In the following, I am going to present the results from the baseline (naive) specification, then I am going to adjust the results to account for the potential bias arising from the firm size manipulation.

Figure 2.9 and 1.5 show the average number of disabled employees in the firms by number of employees in different years and the fitted 4th order polynomial on both sides of the cutoff, using the plotting method of Calonico et al. (2015). The charts indicate intensive and quick firm reaction to changes in the quota rules. Figure 2.9 displays reaction to levy increase in 2008. While the average number of disabled employees below the threshold is almost the same before and after the policy change, disabled employment increases significantly above the threshold after the levy hike. Figure 1.5 suggests that reaction is also remarkable and quick to the second policy change in 2012, when the threshold was increased to 25 from 20 employees. The average number of disabled employees reduces between the new and the old cutoff, that is between 20 and 25 employees and a new discontinuity emerges above the new cutoff.

Note that firms with number of employees exactly at the threshold (20 or 25 employees) are excluded from the charts. This is because there is a discrepancy in accounting rounding rules between the NAV database and the administrative calculation of the quota. Specifically, the average headcount is rounded to an integer number in the NAV database, while the quota regulation is based on the average headcount that is rounded to one decimal digit (for the details, see Section 2). Consequently, the category of the firms with exactly 20, or after 2012, 25 employees in the database is a mixture of treated and non-treated

Figure 1.4: Average number of disabled employees by firm size, 2008 and 2010

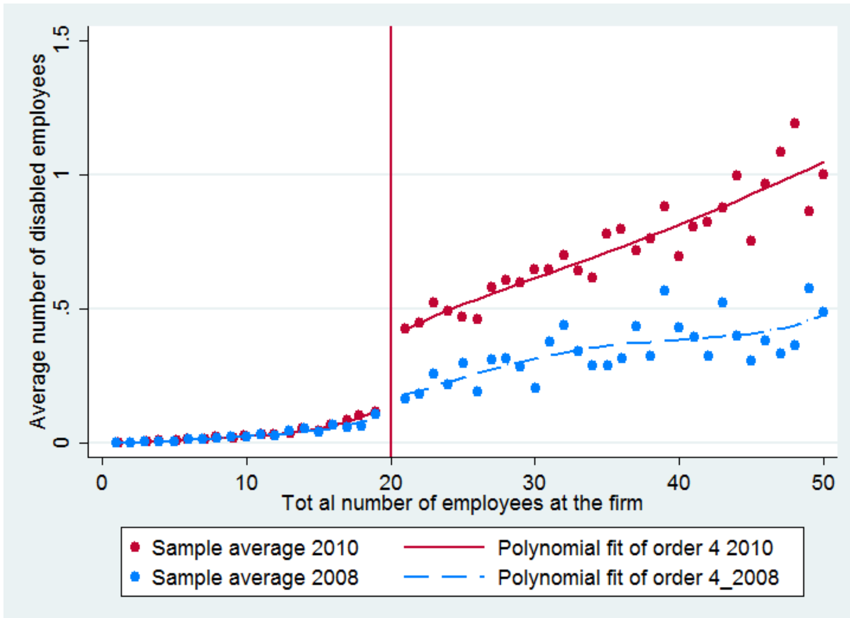
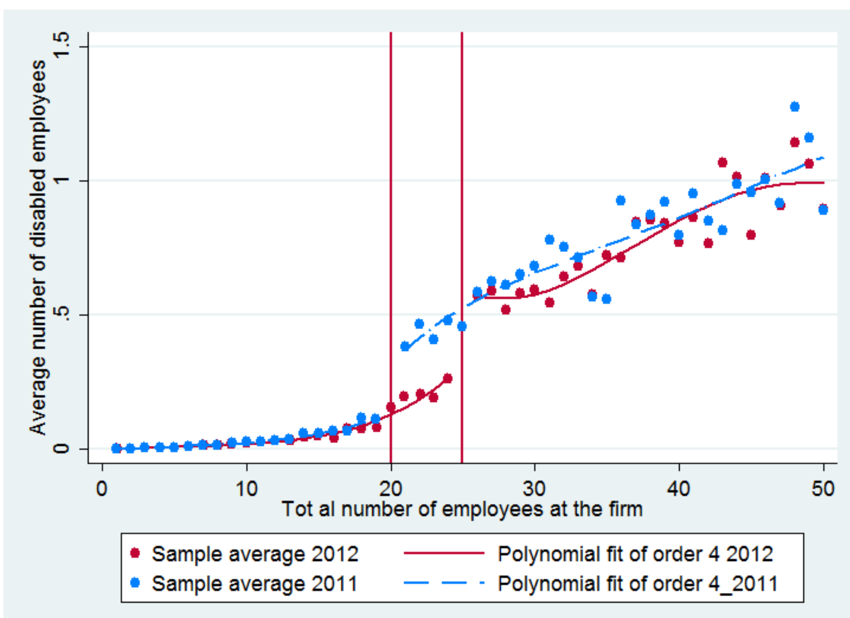


Figure 1.5: Average number of disabled employees by firm size, 2011-2012



firms.[15] Therefore, the firms for which the number of employees in the database equals

[15]This group contains firms with average size between 19.5 and 20.4 employees. These firms show up

the legal threshold, are excluded from the estimations, as those firms might be both above and below the legal threshold.

The treatment effect is identified nonparametrically, by using the method of Calonico et al. (2014a), that applies kernel-based local polynomials on both sides of the threshold. Specifically,

$$\hat{\tau_p} = \hat{\mu}_{p,+}(h_n) - \hat{\mu_{p,-}}(h_n)$$

Where $\hat{\mu}_{p,+}(h_n) = \mathbf{e}_0^{'}\hat{\beta}_{p,+}(h_n)$ and $\hat{\mu}_{p,-}(h_n) = \mathbf{e}_0^{'}\hat{\beta}_{p,-}(h_n)$.

with:

$$\hat{\beta}_{p,+}(h_n) = argmin \sum_{i=1}^{n} \mathbb{1}(emp_i >= c)(Y_i - \mathbf{r}_p(emp_i - c)^{'}\beta)^2 \mathbf{K}_{h_n}((emp_i - c)$$

and

$$\hat{\beta}_{p,-}(h_n) = argmin \sum_{i=1}^{n} \mathbb{1}(emp_i < c)(Y_i - \mathbf{r}_p(emp_i - c)^{'}\beta)^2 \mathbf{K}_{h_n}((emp_i - c)$$

Where $\mathbf{r}_p = (1, x, ...x^p)$, $\mathbf{e}_0 = (1, 0, ..0) \in \mathbb{R}$, $K()$ is a kernel function, h_n is the bandwidth.

The advantage of this method compared to the OLS is its flexibility: it allows for non-linear relationship between the running and the dependent variables and the bandwidth is also estimated by minimizing the mean squared error instead of an arbitrary choice. (The specification and the results from the OLS model can be found in the Appendix A.4.)

As the method of computing optimal bandwidth (see Calonico et al. (2014a)) does not work because of discrete running variable, I make the running variable continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees

with 20 employees in the database as their size is rounded to an integer number. However, firms with average number of employees between 19.5 and 19.9 are not subject of the quota regulation, as rounded to one decimal digit, their headcount is below 20 employees, consequently these firms are below the legal threshold. However, firms between 20.0 and 20.4 employees are already required to meet the quota or pay the levy.

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emp and estimated the RDD with this created running variable. The running variable is simulated 100 times and the the estimated parameter, the τ is the average of the 100 estimations. However, as this method adds a measurement error to the running variable, the standard errors of the estimated treatment effect are adjusted to account for this extra uncertainty. The adjusted standard errors are computed by adding the standard deviation of the simulation to the average standard error of the parameter estimations with simulated continuous running variable.

1.4.3 Estimation results for the baseline RD

The estimation results for the 20-employee and 25-employee threshold are summarized in Table 1.1 and 1.2 respectively. In addition to the average of the standard errors of the 100 estimations, the table also contains the adjusted standard error.

The estimation results confirm very strong firm reaction to changes in the levy and the quota threshold. There is no significant discontinuity in disabled employment in 2008, when the levy was very low. The treatment effect is already weakly significant in 2009, denoting that the expected number of employed disabled is higher above the quota threshold as firms have already started adjustment in 2009. The estimated parameter is much higher in 2010, after the dramatic hike in the non-compliance levy that came into effect in 2010. Strikingly, in 2012, when the threshold was increased from 20 to 25 employees, the discontinuity at the old threshold disappeared, but a new discontinuity of a similar magnitude emerged above the new threshold, 25 employees, that was missing in 2011. Estimations for the increased threshold in 2012 serve as a placebo test and confirm that the estimated discontinuity is indeed related to the disability quota.

The parameter can be interpreted as firms just above the threshold employ 0.244-0.285 additional disabled workers on account of the quota-levy regulation in 2010-2011, that is roughly 24.4-28.9 percent of the quota is fulfilled because of the levy. It is important to note that this number can be regarded large compared to the few other estimations in the literature, for example Lalive et al. (2013) estimate that 4 percent of the quota is fulfilled thanks to the regulation.

Table 1.1: RD estimation: effect of the disability quota on the number of disabled employees at the firm, c=20

	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
τ **robust**	0.086	0.079	0.017	0.099*	0.285***	0.244***	0.063
robust SE	(0.034)	(0.042)	(0.041)	(0.04)	(0.046)	(0.043)	(0.035)
adj SE robust	(0.044)	(0.052)	(0.061)	(0.05)	(0.056)	(0.053)	(0.055)
bandwidth	6.55	3.365	5.135	6.144	7.086	6.788	5.668
eff. # of obs(l)	7563	3004	5294	6672	8819	8188	5663
eff. # of obs(r)	3137	1711	2545	2766	2815	2733	2572

The table contains RD estimation results, using *rdrobust*. The outcome variable is the number of disabled employees at the firm, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1. *** p<0.01, ** p<0.05, * p<0.1.

Table 1.2: RD estimation: effect of the disability quota on the number of disabled employees at the firm, c=25

	2010	**2011**	**2012**
τ **robust**	-0.145	0.034	0.289***
robust SE	(0.092)	(0.088)	(0.057)
adj SE robust	(0.122)	(0.118)	(0.067)
bandwidth	4.792	5.203	8.163
eff. # of obs(l)	2000	2344	5461
eff. # of obs(r)	1501	1570	2269

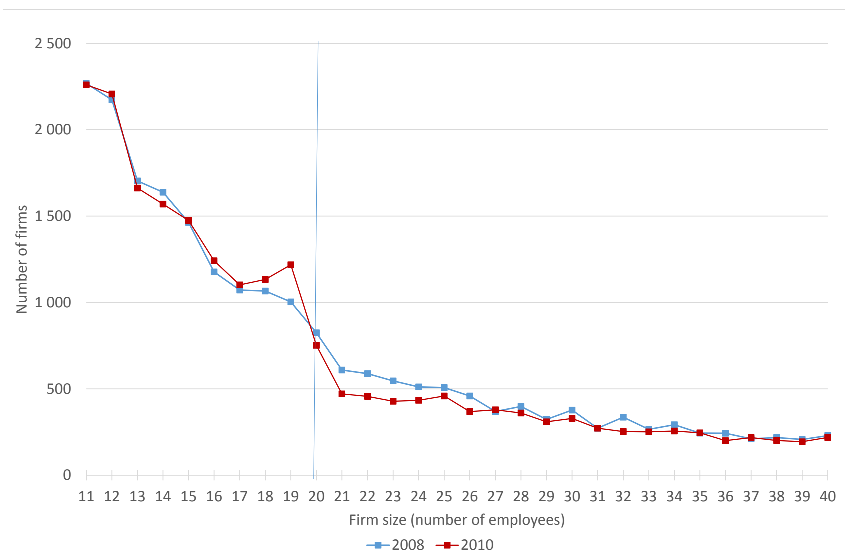
The table contains RD estimation results, using *rdrobust*. The outcome variable is the number of disabled employees at the firm, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1. *** p<0.01, ** p<0.05, * p<0.1.

1.4.4 Endogeneity of the firm size

Given the firms' incentive to avoid the quota-levy by keeping their size below the threshold, the assumption of random firm selection between the treatment and the control groups might be violated. Malo and Pagán (2014) and Mori and Sakamoto (2017) do not find evidence for significant firm size manipulation around the disability quota threshold in Spain and Japan respectively. However, as Garicano et al. (2016) shows, size-related regulations might have a strong distorting effect around the threshold, if the regulation poses substantial costs to firms. In France, the labor costs increase considerably for firms above 50 employees due to various administrative requirements. This huge jump in marginal labor costs prevents many firms from growing, resulting in a bunching in the distribution of firms below the threshold.

In the Hungarian data, the distribution of firms around the threshold shows the effort of firms to keep their size below 20 employees in 2010, that is reflected in a noteworthy, though not a huge bunching (see Figure 1.6).

Figure 1.6: Distribution of firms by number of employees, 2008-2010



However, as the new threshold increases from 20 to 25 persons in 2012, a new bunching emerges at the old threshold, while the old bunching below 20 employees disappears (Figure 1.7).

Figure 1.7: Distribution of firms by number of employees, 2011-2013

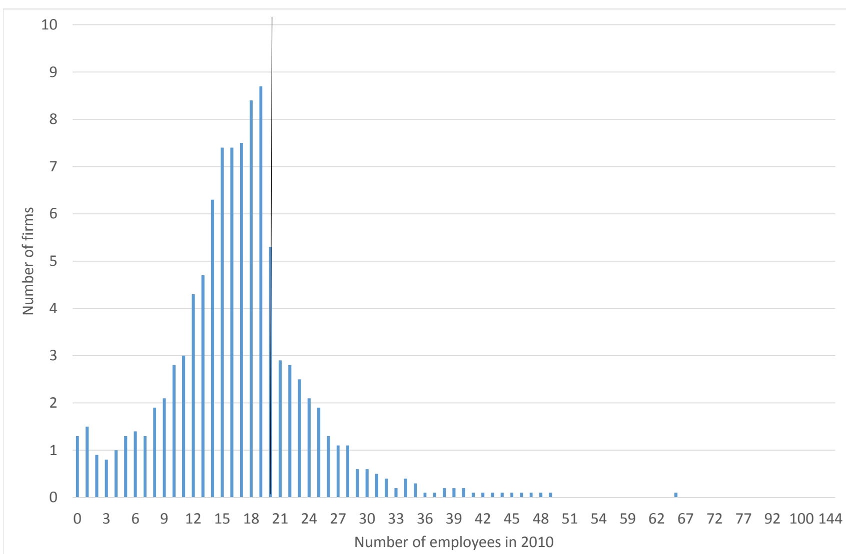
To study more closely the effect of the policy change on firm behavior, I also look at the distribution of firms around the threshold, with 15-24 employees before the levy hike. First, the distribution of these firms is compared with the firm distribution around a placebo threshold, 35 employees. The assumption here is that in case of firm size manipulation induced by the reform, the distribution of the firms being around the quota threshold before the levy hike should be more skewed than a similar distribution at a placebo threshold. Figure 1.8 and 1.9 confirm this assumption as that the distribution around the real threshold is more skewed, and the probability that the number of employees of a given firm is below the threshold is much higher than in case of the placebo threshold. However, the small peak at 20 employees suggests that a fraction of firms with 30-39 employees before the reform chose to decrease their size below the quota threshold even from this size. A similar conclusion arises from the comparison of firms near the threshold with no disabled employees before the policy change with firms that already had employed disabled ex-ante, thus already fulfilled the quota. The firms in the latter group do not have to pay the levy, thus practically are not affected by levy increase. The probability that the number of employees is below the threshold after the levy increase is much higher in case of the affected than in case of the non-affected firms. However, no significant difference can be observed between the distribution of firms with and without

Table 1.3: Probability that the firm size is below the quota threshold and at a placebo threshold in 2010 for firms with and without disabled employees

threshold	20	35
# of employees in 2008	15-24	30-39
$Prob(emp_{2010} < c \mid emp_{2008} \in [c-h, c+h])$		
No disabled employees in 2008	74.8	65.7
At least 1 disabled employee in 2008	63.3	64.5

disabled employees at the placebo threshold (35 employees). Table 1.3 summarizes the relevant probabilities.

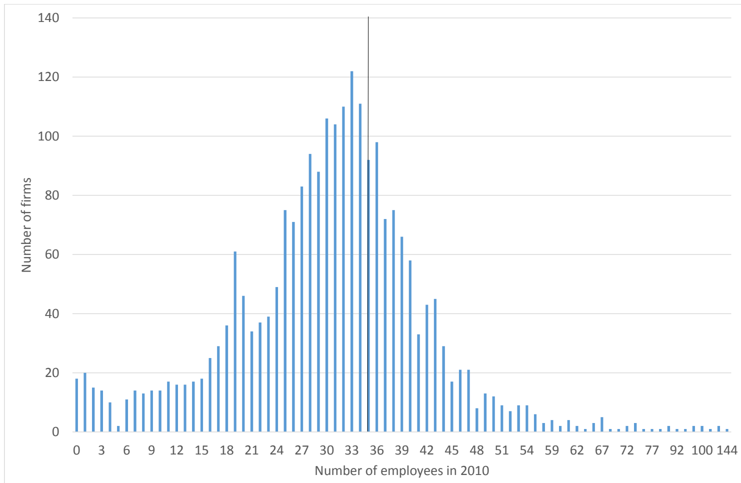
Figure 1.8: Distribution of firms in 2010 around the real threshold (20 employees), with 15-24 employees in 2008



Non-random firm selection was investigated formally using a nonparametric manipulation test of Cattaneo et al. (2018). The test is based on the consideration that manipulation of the the running variable might be captured by a discontinuity in the distribution of the running variable around the cutoff. The test uses local polynomial distribution estimators and based on a Wald-type statistic where the null hypothesis is the continuity of the running variable at the cutoff:

Ho: $\lim_{emp \downarrow c} f(emp) = \lim_{emp \uparrow c} f(emp)$, vs H1: $\lim_{emp \downarrow c} f(emp) \neq \lim_{emp \uparrow c} f(emp)$

Figure 1.9: Distribution of firms in 2010 around a placebo threshold (35 employees), with 30-39 employees in 2008



The test statistic is the following:

$$T_p(h) = \frac{\hat{f}_{+,p}(h) - \hat{f}_{-,p}(h)}{\hat{V}_p(h)}$$

Where:

$$V_p^2(h) = V[\hat{f}_{+,p}(h) - \hat{f}_{-,p}(h)];$$

The test rejects H_0 at α level iff $T_p^2 > \chi^2_{\alpha-1}$

The authors emphasize that the test can be used also for discrete running variables. The results of the density test are summarized in Table 1.4.[16] The density test suggests manipulation of the running variable at $c = 20$ in 2010 and 2011 after increasing the threshold. However, in 2012, the test statistics looses significance at $c = 20$ and becomes significant at 5 % significance level at $c = 25$ in line with the increase in the threshold. As

[16]I also run the test with predefined bandwidth $h = 5$, with no restrictions imposed on the shape of the c.d.f and it yielded similar results.

a robustness check, the test is implemented for placebo thresholds for 2010 and the test shows size manipulation only at the quota threshold, $c = 20$.

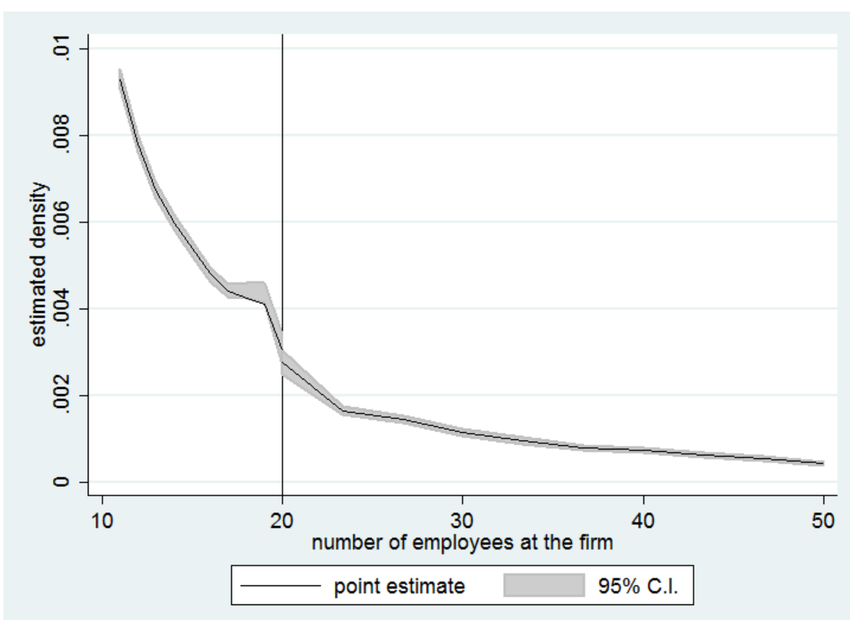
Table 1.4: Results of nonparametric manipulation test for different years and placebo cutoffs

	c=20			c=25			2010	
		at different years					at different cutoffs	
	T	P>—T —		T	P>—T—	c	T	P>—T—
2007	-2.447	.014	2007	-0.032	0.974	15	1.373	0.17
2008	-1.837	.066	2008	0.447	0.655	20	-4.989***	0.00
2009	-1.969	.049	2009	-0.628	0.53	25	-0.693	0.488
2010	-4.989***	0.00	2010	-0.693	0.488	30	-0.465	0.642
2011	-3.69***	0.00	2011	-0.101	0.919			
2012	-1.726	.084	2012	-2.301**	.021			

The calculations are based on *rddensity* package by Cattaneo et al. (2018). T test statistic measures discontinuity in distribution of firm size at a threshold (c). *** p<0.01, ** p<0.05, * p<0.1. Restriction: equal c.d.f. and higher order derivatives assumed on the two sides of the cutoff.Bandwidth selection is based on MSE of difference and sum of densities,assuming one common bandwidth. Optimal bandwidth is selected as the lower of the two above criteria

Figure 1.10 shows the estimated density function on the two sides of the cutoff. In 2010, discontinuity is observed at $c = 20$, while in 2012, at $c = 25$

Figure 1.10: Estimated firm density and discontinuity at the threshold,2010



The calculations are implemented with *rddensity* package by Cattaneo et al. (2018).

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1.4.5 Discontinuity in firm characteristics

Manipulation check confirmed that some firms strategically choose their size below the threshold to avoid the quota. In the following, I analyze whether this choice can be explained by firm characteristics. Table 1.5 displays covariate balance of regional, industry composition and some predetermined firm specific variables between firms above and below the threshold in 2010. The table indicates that sectoral and regional composition of the firms below and above the threshold is similar on the two sides of the threshold. Although the t-test indicates significant difference in firm age and ownership structure of the firm, the standardized percentage bias is below 12 in case of all variables. The total effect of all potential covariates, including pre-treatment firm outcomes on firm size manipulation is assessed with the composite covariate index (see Card et al. (2007)). The number of disabled employees in 2010 are regressed on a set of covariates and the predicted value from this regression is plotted against the firm size (Figure 1.11). The following covariates are added as right hand side variables: firm age, dummy for state and foreign ownership, sectoral and regional dummies, lagged values of productivity, average wages, profit ratio, change in the total employment in the two years before the levy increase (2007-2009). The lack of discontinuity in the predicted value around the threshold shows the lack of relationship between firm characteristics and firm size manipulation. For the variables of firm's performance (productivity, average wages, profit ratio, change in the total employment) lagged values show up in the composite covariate index, as the contemporaneous values already include effects of the regulation, and the aim of the exercise is to find factors determining firm's choice to keep their size below the threshold.The results suggest that the bunching is not systematic, firms' selection into the treatment group is based on unobserved firm characteristics. Discontinuity in the contemporenous values of firm performance is also investigated. As Garicano et al. (2016) shows, if many firms choose to avoid the size related regulation by keeping their size below the threshold, we can expect a spike in the productivity distribution of firms at the threshold, and he finds empirical support for these predictions in the case of French firms. I test congestion in productivity and other firm specific variables by running an RD on these variables.

I test the following outcome variables. $profitratio$: profit ratio (pretax profit/number of employees), *lnaverwage*: logarithm of total wage bill/number of employees, *lnprod*: logarithm of sales/number of employees *lnprod_gdp*: logarithm of labor productivity (value

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Table 1.5: Covariate balance of firms above and below the threshold (2010, c=20)

Variable	Mean Firms above t. (20 < *emp* <= 25)	Firms below t. (15 <= *emp* < 20)	t-test % bias	t	p¿—t—
Emp.change 2007-2009	-0.070	0.045	-0.8	-0.35	0.729
Regions					
Central Transdanubia	0.091	0.097	-1.9	-0.78	0.436
Western Transdanubia	0.084	0.090	-1.8	-0.72	0.473
South Transdanubia	0.084	0.078	2.1	0.87	0.385
North Hungary	0.067	0.068	-0.5	-0.18	0.854
North Great Plain	0.115	0.102	4.4	1.8	0.073
South Great Plain	0.119	0.110	3	1.24	0.216
Industries					
Mining and quarrying	0.001	0.001	0.9	0.37	0.713
Manufacturing	0.004	0.001	4.9	2.24	0.025
Electricity, gas, steam	0.237	0.211	6.3	2.59	0.010**
Water supply; sewerage	0.007	0.005	2.7	1.14	0.253
Construction	0.103	0.127	-7.5	-2.98	0.003***
Wholesale and retail trade	0.226	0.250	-5.7	-2.27	0.023**
Transporting and storage	0.054	0.076	-9.2	-3.6	0.000***
Accommodation	0.064	0.056	3.5	1.42	0.156
Information and comm.	0.013	0.012	1.4	0.56	0.574
Finance and insurance	0.170	0.168	0.7	0.27	0.786
Real estate activities	0.000	0.000	-1.8	-0.6	0.546
Professional, scientific act.	0.006	0.008	-3	-1.16	0.247
Administrative and support	0.017	0.014	2.6	1.06	0.288
Public administration	0.036	0.026	6.2	2.6	0.009***
Education	0.000	0.000	.	.	.
Health & social work	0.000	0.000	.	.	.
Firm age (years)	12.312	11.592	9.3	3.87	0.000***
State firm	0.026	0.014	8.5	3.72	0.000***
Foreign firm	0.132	0.095	11.6	4.86	0.000***
Number of firms	2237	6144			

The table shows mean, t-tests and standardized percentage bias of predetermined firm characteristics in 2010. Firms with at least 40% disabled employment ratio are excluded from the analysis. A firm with state or foreign ownership share above 50% are considered state or foreign respectively. *** p<0.01, ** p<0.05, * p<0.1.

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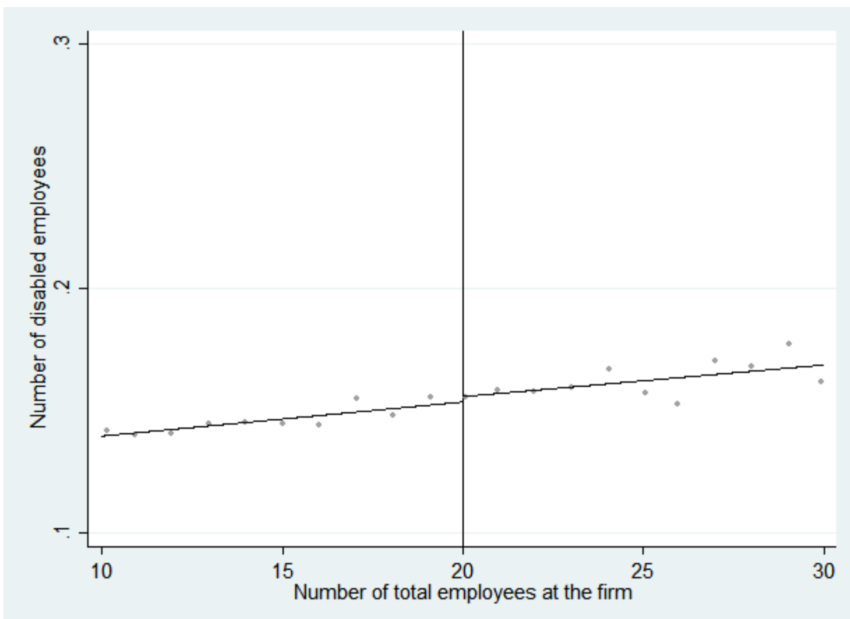
added/number of employees) *lnprod*: logarithm of sales/number of employees *lnsales*: logarithm of sales

I look for discontinuity in the deviations of the above variables from the industry average.

The results for 2010 are summarized in Table 1.6. While the disabled employment effect is significant in magnitude after the levy hike, the RD regressions show no discontinuity in the variables that capture firm outcomes and characteristics.[17] The results confirm that

Figure 1.11: Composite covariate index, 2010



The composite covariate index displays predicted values from a linear regression of disabled employees in 2010 are regressed on a set of covariates:firm age, dummy for state and foreign ownership, sectoral and regional dummies, lagged values of productivity, average wages, profit ratio, change in the total employment in the two years before the levy increase (2007-2009). The chart shows predicted values(dots) and a polynomial on order 1 fitted on both sides of the cutoff.

while a non-negligible fraction of firms chooses to avoid the regulation, this decision is not

[17]No discontinuity can be detected for 2011, for pooled estimation for 2010-2011 with a time dummy for 2011 and 2012 with c=25

reflected in difference in firm characteristics and performance just below and above the threshold neither before nor after the policy change.

Table 1.6: RD estimation: discontinuity in firm outcomes at the disability quota threshold (2010, c=20)

	profitratio	**lnaverwage**	**lnprod**	**lnprod_gdp**	**lnsales**
τ robust	0.012	0.011	0.051	0.025	0.092
robust SE	0.011	0.046	0.084	0.069	0.092
adj SE robust	0.011	0.056	0.114	0.089	0.122
bandwidth	4.847	5.349	6.155	6.175	5.534
eff. # of obs(l)	5223	5903	7063	6749	6113
eff. # of obs(r)	1931	2159	2436	2320	2206

The table contains RD estimation results, using *rdrobust*. The outcome variables are different firm outcomes, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1. *** p<0.01, ** p<0.05, * p<0.1.

1.4.6 Bunching and the estimation of the treatment effect

The number of employees is not exogenous as it might be a choice of an optimizing firm that can react to the regulation, and the bunching below the threshold suggests that the assumption of random firm selection between the treatment and the control groups is indeed violated. Therefore, even if firms' choice is based on unobserved characteristics, using the firm size as a running variable might produce a biased estimation of the treatment effect. The direction of the bias is not straightforward a priori. In our case, we can assume that "bunchers" have on average lower propensity to employ disabled individuals, than firms that do not manipulate their size. Consequently, the baseline RD estimations might produce an upward biased treatment effect.

The bias from manipulation is sometimes treated with the so-called doughnut-hole method, that is by dropping observations in the close neighborhood to the cutoff. However, by ignoring data close to the cutoff we lose important information. Another approach is implemented by Lalive et al. (2013) who calculate the bias arising from bunching with the following calculation. The basic idea is a thought experiment: what would be the difference in mean of disabled employees just above and just below the threshold if there were no

Table 1.7: RD estimation: discontinuity in firm characteristics at the disability quota threshold (2010, c=20)

	firmage	**foreign**	**state**
τ robust	0.806	0.016	0.004
robust SE	0.753	0.021	0.009
adj SE robust	1.157	0.021	0.009
bandwidth	4.149	6.927	6.243
eff. # of obs(l)	4257	8482	7342
eff. # of obs(r)	1631	2763	2509

The table contains RD estimation results, using *rdrobust*. The outcome variables are number are different firm characteristics, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1.*** p<0.01, ** p<0.05, * p<0.1.

bunching, that is firms simply would not have the possibility to avoid the regulation with size manipulation. Lalive et al. (2013) move the calculated number of bunchers from just below to just above the threshold, and recalculate the raw unconditional mean of disabled employees assuming that they continue to employ disabled.[18] Gerard et al. (2016) estimate lower and upper bounds by truncating the distribution of the outcome variable above the cutoff, where some units assumed to manipulate the running variable. In both applications, the share of manipulators is calculated using a non-parametric density test. I provide a lower bound to the treatment effect by reestimating the RD on a simulated sample with a

[18] Lalive et al. (2013) calculate also an upper bound in addition to the lower bound. However, in contrast to the Hungarian case, the quota threshold concerns the number of non-disabled employees in Austria. Consequently, there are firms which choose non-disabled employment below the threshold, but employ a disabled worker if this worker increases the profit. As the running variable in Lalive et al. (2013) is the number of non-disabled employees, this group of firms create a downward bias in the treatment effect, when estimated with baseline RD. In Hungary, the threshold refers the size of the total workforce, hence this downward bias is not relevant.

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novel method, that is related to the main idea of the Lalive et al. (2013) method.

The estimation consists of the following steps:

1. Construction of a counterfactual distribution by fitting a power law on firm distribution by size, omitting observations with number of employees $c+/-5$.

2. Calculating number of firms that are below the threshold to avoid the regulation ("bunchers") and missing firms from above the threshold by comparing the actual and the counterfactual distribution in the $c+/-5$ range. A similar method is used for example in Harasztosi and Lindner (2019).

3. Constructing a simulated sample such that the resulting firm distribution is smooth by moving the calculated number of randomly selected firms above the threshold into the $c+5$ range, while leaving the number of disabled employees unchanged.

4. Re-estimating the RD on the simulated sample and repeat this exercise many times.

The lower bound is the average of the treatment effects of the re-estimated RD from a simulation of 100 draws.[19].

This method is similar in its approach to the method of Lalive et al. (2013). However, the simulation uses observations not only just above and just below the cutoff, but in a wider range, and gives an RD estimation of the treatment effect on the simulated sample.

Figure 1.12 shows the estimated counterfactual distribution and Figure 1.13 displays the firm distribution of the simulated sample after moving randomly selected firms from below to above the cutoff in 2010. The results of the RD estimation with the simulated sample are summarized in Table 1.8. As a comparison, the table contains the treatment effect from the baseline RD estimations, which assume random firm selection. The results show that the lower bound of treatment effect is lower than the simple RD estimation by more than 40%, but it remains significantly high. However, in 2012, where the size of the bunching is much smaller, the lower bound is much closer to the estimated disabled employment effect from the baseline RD.

[19]Averaging 100 simulations seems to be sufficient as the results are almost invariant to repeating the 100 draws

Figure 1.12: Counterfactual distribution (fitted power law)

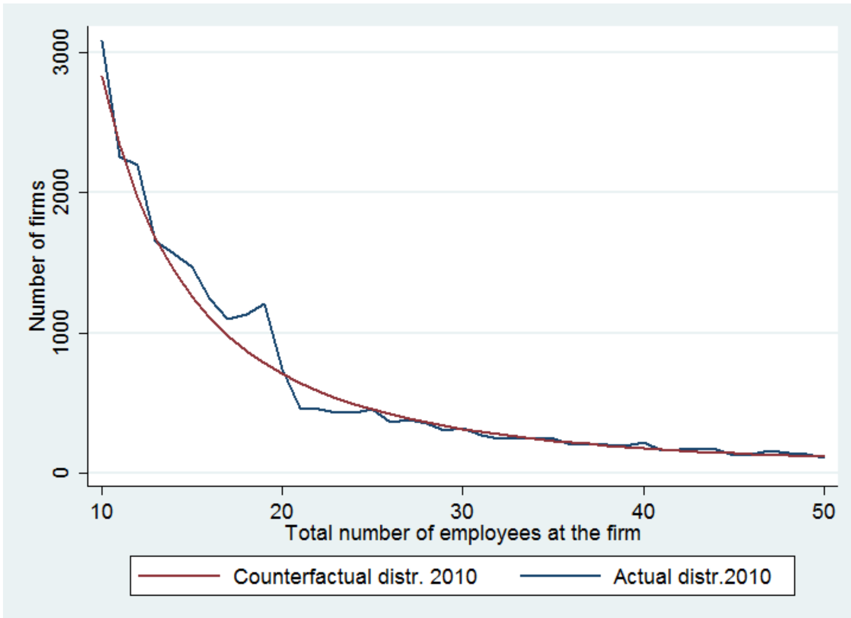

Figure 1.13: Firm size distribution in the simulated sample

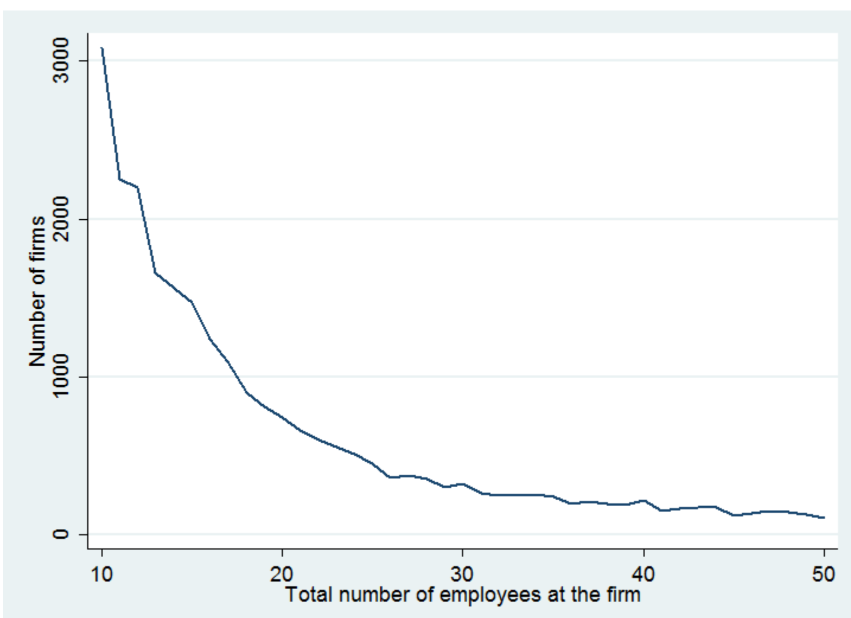

Table 1.8: RD estimation: the lower bounds of the effect of disability quota, estimated on the simulated sample and the baseline RD estimations for different years

	2008(c=20)	**2010** (c=20)	**2012** (c=25)
τ **robust baseline**	0.017	0.285***	0.289***
τ **robust, lower bound**	0.008	0.163***	0.259***
SE robust, lower bound	(0.063)	(0.051)	(0.077)

The table contains RD estimation results, using *rdrobust*. The outcome variable is the number of disabled employees at the firm, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1.

The reaction of firms is strong even if the magnitude of the levy compared to the wages is taken into account. The elasticity of substitution between disabled workers and non-disable workers, that is the percentage change in the relative employment of disabled to non-disabled divided by the percentage change of relative disabled/non-disabled relative labor cost, is the highest in Hungary among the comparable estimations, even if the bias arising from the bunching is taken into account (see Table 1.9).[20] However, the baseline (below threshold) ratio of disabled employees is the lowest in Hungary.

1.5 Firm heterogeneity in disabled employment effect

The above section concluded that firms' decision to stay below the threshold is not systematic: while the bunching clearly shows that a fraction of firms chooses keeping its size below the threshold, the selection of firms between the treatment and the control groups is based on unobservable firm characteristics. However, the disabled employment effect of the quota-levy regulation in the neighborhood to the threshold is influenced by observable firm characteristics. As firm selection between the control and the treatment groups does not

[20] Note that the elasticity of substitution can also be calculated by comparing the above-threshold employment before and after the levy increase. This is shown in the last row in Table 1.9. This calculation yields similar elasticity of substitution as the baseline RD estimations for 2010.

Table 1.9: Comparison of disabled employment effect estimations across countries

	Coeff (# dis emp)	Threshold (# emp)	Quota (%)	Quota fulfillment below threshold (%)	Elasticity of substitution
Japan*	1.42	300	1.8	87	-2.97
Austria**	0.04	25	5	25	-2.01
Hun,baseline,2010,	0.29	20	5	11	-11.06
Hun, lower bound,2010	0.18	20	5	11	-6.86
Hun(by 2008 to 2010)	0.27	20	5	11	-10.64

*Based on Mori and Sakamoto (2017) and own calculation. The source of average non-disabled wage is DIDA. **Based on Lalive et al. (2013) and own calculation. The elasticity of substitution differs from that of Lalive et al. (2013), as it contains obligatory employer social contributions to the nominal wage. The Source of the employer contributions data is the OECD Taxing Wages database. Average labor cost is calculated as average gross earnings plus employer contributions.

depend on firm characteristics, the comparison of the treatment effect in the RD regressions estimated on different subgroups captures well the heterogeneity in firms' reaction to the quota.

1.5.1 The effect of firm size

Note that the total quota fulfillment that considers all non-special firms above the threshold exhibit a much less favorable picture than the estimated treatment effect around the threshold plus the quota fulfillment below the threshold (see Table 1.10). This discrepancy arises from the fact that the ratio of disabled employees at the firm decreases with the firm size.

Table 1.10: The ratio of disabled employees and the average wages by firm size

		Disabled ratio		Average wage (th HUF)	
Firm size	Observations	Mean	Standard dev	Mean	Standard dev
0-19	249981	0.09%	1.38%	1186	1620
20-25	2983	1.82%	3.59%	1833	1657
26-49	5383	2.05%	3.54%	1979	1765
50-99	2857	1.93%	3.23%	2256	1903
100-499	2090	1.66%	2.92%	2591	1828
500-999	222	0.92%	1.77%	2963	1616
1000-	160	0.83%	1.42%	3076	1709

This is in part attributable to the much higher average wage level of larger firms, however, firm size remains significant in explaining the ratio of disabled employees at the firm even after controlling for the wage level (see Table 1.11). However, one might expect the opposite effect of the firm size. One-off costs of hiring disabled, for example accommodation of the workplace, per disabled worker are lower for larger firms with more disabled employees and the probability that a disabled employee can fulfill a given job might be higher at a larger firm with larger variety of jobs. The fact that the quota fulfillment is worse for larger firms indicates that there are other significant barriers to employing disabled individuals.

Table 1.11: Linear regression: the effect of the firm size on ratio of disabled employment above at firms above the threshold, 2010-2013

	(1)	(2)	(3)
VARIABLES	disemp_percent	disemp_percent	disemp_percent
number of employees (ln)	-0.248***	-0.134***	-0.137***
	(0.0204)	(0.0203)	(0.0208)
average wage (ln)		-0.815***	-0.650***
		(0.0322)	(0.0392)
productivity (ln)			-0.157***
			(0.0233)
Constant	2.919***	8.541***	8.826***
	(0.0916)	(0.245)	(0.259)
Year dummies	YES	YES	YES
Observations	46,372	46,276	44,952
R-squared	0.006	0.033	0.034

Standard errors are clustered by firm in parentheses,*** p<0.01, ** p<0.05, * p<0.1

1.5.2 The role of disabled labor supply

As discussed in Section 3, if take only the minimum labor cost fulfilling the quota into consideration, firms would be better off with hiring disabled employees even with zero productivity than paying the levy. The fact that the majority of firms choose paying the levy instead of hiring disabled workers might be explained by high (perceived) adjustment (hiring and firing) costs, labor supply shortage of disabled, or discrimination.

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One can argue that both hiring and firing costs might be higher in case of disabled employees. Accommodation of the workplace to be able to receive disabled workers might be costly. Searching costs are probably also much higher in case of disabled workers (see e.g. Silva and Vall-Castelló (2017)).[21] As discussed in Section 2, firing cost are probably not excessive in Hungary, as employment protection of disabled employees is not particularly strong, moreover, disability pension recipients can be dismissed without explanation.

However, labor supply shortage is probably a major obstacle to substantial rise in disabled employment. According to the labor force survey, the share of disabled population is roughly in line with the European average, but the activity rate of the disabled population is quite low, only around 25%. There were 48 thousand disabled unemployed in 2011, and an additional 30-40 thousand can be assessed as discouraged workers.[22] Meanwhile, in 2010 the levy was paid after 57 thousand, in 2011 63.5 thousand employees from the quota.[23] Assuming that the probability of matching is much lower in case of disabled employees, the magnitude of these numbers suggest that perhaps there are simply not enough disabled jobseekers who would accept a job at the offered wage in the given regions, industries, jobs.

The low effective labor supply might be related to the institutional environment of other disability policies. Around 2010, most disabled workers were employed in sheltered workplaces - at accredited special institutions and firms - and the empirical evidence suggests that sheltered employment does not facilitate integration into the open labor market. However, availability of personalized rehabilitation services and supported work is quite limited, though comprehensive support for working in the open labor market proved to be much more effective in integrating disabled employees than sheltered workplaces (Scharle and Váradi (2015), Scharle and Csillag (2016) Adamecz-Völgyi et al. (2017)).

Lack of support in getting to the workplace also might impede jobseeking of disabled. Opportunity costs of working might also constrain labor supply. Up to 2014, earning activity terminated eligibility to disability and rehabilitation benefits above a certain, relatively

[21]There are basically two organizations that mediated demand and supply of the disabled employees. The local agencies of National Office of Rehabilitation and Social Affairs, and the alternative suppliers. Additionally, public employment services (PES) also had a matching role. However, operation of these agencies can be characterized by uneven territorial distribution and scarcity.

[22]Source: Central Statistical Office

[23]The data from the database are not comparable in one to one with the unemployed data from the labor force survey.

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low earning level.[24]

I use regional variation in disabled employment and population to test the role of disabled labor supply and high adjustment costs in firms' reaction. Due to anecdotal evidence, firms in Central Hungary and Western Transdanubia face with disabled labor shortage, while less developed regions - such as South Transdanubia and regions of Great Plain - have excess disabled supply.[25]

Table 1.12 shows that the share of disabled in total working age population is indeed lower in the central and western regions.[26]

However, the Hungarian regions differ in many other important aspects, for example average productivity and general wage level. Underdeveloped Eastern regions can be characterized with generally lower wage and less productive firms, and presumably the ratio of wages to the levy might also influence the reaction of firms.

Against this background, I estimate the treatment effect within four subgroups. The regions are selected into two groups, the low supply regions (Central Hungary, Central Transdanubia and Western Transdanubia) and the high supply regions (South Transdanubia, North Great Plain, South Great Plain and North Hungary). The number of firms in the different regions are displayed in Table 1.14. Within each of the two groups, firms are divided into a low wage (below average wage of firms between 15-24 employees in

[24] The amount of rehabilitation and disability benefits has changed many times since 2010, it was linked to the previous income and depended on degree of health impairment. In case of the disability pension (for disabled with high capacity loss and no expected gain from rehabilitation) the eligibility terminated after 6 month of work, if the wage exceeded 70% of previous net wage or the minimum wage. The temporary rehabilitation allowance (for disabled whose working capacity can be restored or improved by rehabilitation, with health impairment 50-79%) was linked to the previous wage and was relatively generous (50-61% of previous wage, but in average close to the minimum wage), and the eligibility has terminated after 3 month if the wage exceeded 90% of previous wage. Disabled with low, 40-50% health impairment are entitled to the regular social allowance, which was flat and amounted about one third of the minimum wage. In case of the regular social allowance, the eligibility terminated after 6 month if the wage exceeded 80 % of the minimum wage. Between 2014 and 2016, eligibility to rehabilitation benefit is terminated above 20 working hours per week, regardless the earned amount. Since 2016, eligibility is linked to the earnings again in case of both rehabilitation and disability benefits. Specifically, eligibility terminates if earnings exceed 150% of the minimum wage for 3 consecutive month.

[25] for example see the analysis of a HR company, Trenkwalder. https://www.hrportal.hu/hr/megvaltozott-munkakepesseguek-foglalkoztatasa-ketteszakadt-az-orszag-20160203.html

[26] 2011 LFS data are based on a survey, so number of disabled does not coincide with the number of people with official status of changed working capacity, but can be used as an indicator.

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Table 1.12: Share of disabled population in regions

Region	Name	% of disabled in the working age pop.
1	Central Hungary	7.3
2	Central Transdanubia	9.2
3	Western Transdanubia	9.2
4	South Transdanubia	16.8
5	North Hungary	14.1
6	North Great Plain	14.7
7	South Great Plain	14.8

Source:Labor force survey 2011, Central Statistical Office

2010-2011) and a high wage group (above the average wage).

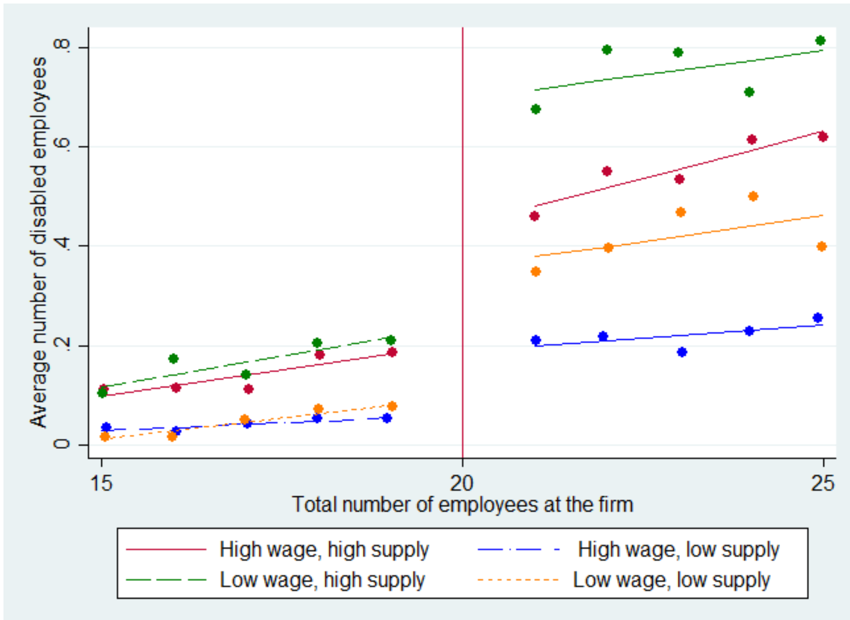
Figure 1.14 indicates that both the firm wage level and the ratio of the disabled population influences reaction of the firms. First, firms with lower average wage are more inclined to react to the quota in both low supply and high supply regions. Given that the levy is flat, the levy compared to the average wage level is lower for firms with higher average wages, hence the levy poses lower burden relative to other costs. Note that the wage does not influence disabled employment below the threshold, where the quota rule does not apply, but it interacts with the policy. This indicates that wage level matters exclusively because it determines the *relative burden* the levy poses on the firm.

The other conclusion is that firms in low supply regions employ less disabled in average even under the threshold and also react less to the quota. In low supply regions, treatment effect is lower at both low wage and high wage firms. This observation leads to the conclusion that labor supply problems might hamper the effectiveness of the quota even if firms react sensitively to financial incentives. Heterogeneity in the treatment effect is also reflected in the RD estimates implemented on the four different subgroups by wage level and regional supply of disabled (Table 1.13).

The findings that the effect of the quota depends on labor supply and average wage of the firms is interpreted a simple framework as follows in Appendix A.1.

The framework is consistent with the finding that the impact of the quota is stronger at lower average wage level of the firm and higher disabled labor supply. In addition, it sheds some light about the contradiction that majority of firms pay a levy instead of hiring a low wage disabled despite the obvious financial incentive. In case of labor supply shortage, firms might not find disabled employees at this low wage level, or high adjustment costs might turn disabled hiring too costly. Another possibility is discrimination, i.e. the firm

Figure 1.14: Average number of disabled employees by firm size in subgroups, 2010-2011



High wage firms: firm average wage is above the average wage of all firms between 15 and 25 employees. High supply regions are South Transdanubia, North Great Plain and North Hungary. The chart contains mean number of disabled employees by firm size and a first order polynomial by subgroups. Source:own calculation based on NAV database

does not hire a disabled employee despite the financial incentive, that is represented by negative productivity of a disabled employee in the framework. However, theoretically, a firm could hire a disabled employee on "paper", i.e. without actual work and share the saving on avoiding the levy. However, this can be regarded as a fraud and misuse of the quota rule. Another factor that might discourage firms from fake employment is that it hurts fairness with respect the other members of the staff.

Our estimation results point to the importance of the supply effect, nevertheless, the effect of the regional ratio of disabled population on firms' reaction may capture multiple problems. The supply might be constrained by the low capacity of rehabilitation services, dominance of sheltered workplace, disincentive scheme of disabled allowances, lack of support in transportation. The results suggest that efficiency of the quota system could be improved significantly by addressing the above frictions on disabled labor market.

First of all, capacity building in personalized rehabilitation services would be beneficial as based on empirical evidence, high quality and well targeted rehabilitation services are

Table 1.13: RD estimation: effect of the disability quota on the number of disabled employees at the firm for different subgroups, 2010-2011

Supply	low	low	high	high
Wage	low	high	low	high
τ robust	0.151	0.101**	0.628***	0.314***
se robust	0.136	0.029	0.284	0.073
adjusted se robust	0.156	0.029	0.304	0.073
mean bandwidth	4.268	21.071	6.779	27.965
eff number of obs left	1566	29213	1420	16150
eff number of obs right	499	3240	497	2367

The table contains RD estimation results, using *rdrobust*. The outcome variable is the number of disabled employees at the firm, the running variable is the number of all employees at the firm. The threshold (c) is 20 employees. The running variable is made continuous by adding a uniformly distributed random number $u \sim [-0.5, 0.5]$ to the number of employees *emp* and estimated the RDD with this created running variable. The τ the average of the 100 estimations. The standard error is the the average of the 100 standard errors and the adjusted standard errors were computed by adding the standard deviation of the simulation to the average standard error. The order of the local polynomial is 1. Source: own calculations based on NAV tax database

more effective in promoting transition to the open labor market than sheltered workplaces (see Adamecz-Völgyi et al. (2017) for a Hungarian evidence and Scharle and Csillag (2016) for a review. These services among others include supported employment, counseling, training, help in transportation. The results point to the role of labor supply in disabled employment effect of the quota rule. However, there might be substantial problems also on the demand side: high one-off costs of hiring (for example high searching, accommodating, training costs) and discrimination might be important barriers to employing disabled employees. Based on a Hungarian firm survey Szellő et al. (2013) emphasize the need for help in accommodation of the workplace, up-to date information and sensitization of firms on the demand size. The relative importance of the above factors is subject to further research.

1.6 Conclusion

This paper demonstrates intense reaction of Hungarian firms to the increased levy accompanied to the disability quota. In 2010, the Hungarian levy was increased drastically, by

Table 1.14: Number of firms in different regions in the NAV database (2010)

Region NUTS2	Freq (thousand)	Percent	Cum
Central Hungary	204	51.3	51.3
Central Transdanubia	34	8.7	60.0
Western Transdanubia	31	8.0	67.9
South Transdanubia	27	6.9	74.9
North Hungary	28	7.1	81.9
North Great Plain	36	9.1	91.0
South Great Plain	36	9.1	100
Total	398	100	

Source: NAV database

454 percent, reaching an exceptionally high level compared to average wages. This measure posed a significant burden on firms in the middle of the financial crisis.

There are a few papers in the literature that analyze the effect of the disability quota with a moderate levy and usually find moderate or insignificant effect. The Hungarian case demonstrates how firms can cope with the quota if the accompanied levy is really substantial and creates a strong financial incentive.

Many firms near the threshold clearly make an effort to avoid the regulation by keeping the size of their workforce below the quota threshold. This attempt results in a remarkable bunching in firms' distribution below the threshold employment level. Firm size endogeneity might compromise baseline regression discontinuity estimations as the random assignment of firms between treated and control groups is violated. However, I could not detect any discontinuity in firm specific variables and these variables do not seem to influence firms' choice to stay below the threshold, suggesting that the selection between the treatment and the control groups is based on unobservable firm characteristics. I add a lower band to the disabled employment effect by re-estimating the RD on a simulated sample. The results suggest that disabled employment effect of the quota-levy system is very high in international comparison even after controlling for the potential bias caused by the bunching.

Nevertheless, the effectiveness of the policy is questionable. Though the disabled employment policy effect and the estimated elasticity of substitution can be considered high, the majority of the affected firms pays the levy instead of hiring a disabled, resulting in a low fulfillment of the quota less than 30 percent. Taking into consideration the ex-

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ceptionally high level of the levy, the low fulfillment of the quota is surprising, as firms would incur lower wage cost if hired a part-time, low wage disabled employee even with zero productivity than paying the levy. This contradiction suggests that there are important factors beyond the relative productivity that constrain hiring of disabled employees. Specifically, it implies that an important barrier to employing disabled persons might be the low effective labor supply, high (perceived) non-wage costs of employing disabled or discrimination.

Exploiting regional differences in the ratio of disabled population, I find evidence that the disabled employment effect of the quota regulation varies with the share of the disabled population in the region. This implies that the effectiveness of the policy might be hampered by the the shortage of the effective disabled labor supply. As firms are not able to fulfill the quota, the regulation behaves like a tax that primarily hits low-wage firms. The results suggest that efficiency of the quota-levy system could be enhanced significantly by addressing the frictions on the disabled labor market.

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Chapter 2

Earnings limit for disability benefits: is it really a cash-cliff?

2.1 Introduction

Labor market situation of disabled individuals can be generally characterized by low employment rates: less than one person out of two with limitation in work caused by health conditions employed in the EU on average.[1] The disabled employment gap mainly comes from the low activity rate of disabled, highlighting the role of supply factors. One of the factors influencing the labor market supply of disabled persons is the design, availability and conditions of the disability benefit system. Disability benefit and related policies have to meet the dual goal of providing income security to persons who suffer earning losses because of their health impairment while encouraging and promoting the use of the remaining working capacity as much as possible and promoting labor market integration of partially disabled persons as their health status allows. However, the substantial increase in disability insurance participation worldwide in the past decades raised the question whether disability benefit systems might unduly keep away many partially disabled individuals from the labor force.[2]

[1]Labour Force Survey 2011, Eurostat

[2]For an early summary and survey, see e.g. Bound and Burkhauser (1999).

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This paper concentrates on the incentive effects of a common element of disability benefit schemes, the so called cash-cliff that results in disabled beneficiaries losing their entire benefit if their earnings exceed a fixed ceiling by even one cent. The term *cash-cliff* refers to the embedded earnings restrictions accompanied to disability or other social benefits. Disabled individuals are allowed to keep their benefit, or a part of it when entering the labor market and taking a job, but only if their earnings remain below a certain earnings limit. If earnings exceed this limit, the benefit is suspended or the eligibility is terminated completely, causing an abrupt and significant drop in income. Similar restrictions are inherent not only in the Hungarian disability benefit schemes, but applied in many other countries too. For example, the main disability benefit scheme in the US, the Social Security Disability Insurance (SSDI), contains a similar earnings restriction. This is the so called SGA (Substantial Gainful Activity) threshold. To be eligible for disability benefits in the US, a person must be unable to engage in substantial gainful activity. A person who is earning more than a certain monthly amount is considered to be engaging in SGA, therefore not eligible to disability benefit. [3]

The rationale behind imposing limitations on earnings is clear: a person should be provided by disability benefit if the health impairment prevents her from earning sufficient income. As actual disability is not perfectly observable, the level of earnings can serve as a signal. Still, eligibility earning thresholds are often blamed for their negative effects on the labor supply, based on the consideration that beneficiaries face a financial incentive to keep their earnings under the ceiling, probably resulting in a bunching in earnings under the threshold (Autor and Duggan (2007)).

However, the empirical evidence on the disincentive effect is mixed. This paper aims to contribute to the literature of cash-cliff labor supply effects by analyzing a policy change in the earnings ceiling accompanied to a low-value benefit of partially disabled persons, the regular social allowance (RSA hereafter) in 2008 in Hungary. The reform changed the earnings limit from 80% of the previous earnings to 80% of the statutory minimum wage for beneficiaries who submitted their application for RSA after 1 January 2008. The new legislation was in line with the strategy of the government to curb excessive reliance on disability benefit and reducing the costs of the program. The legislation of the change in RSA eligibility rules was enacted in late December of 2007 and was unexpected.

The reform provides a unique opportunity to investigate labor supply impact of earnings

[3]The monthly amount is 1220 USD in 2019 for non-blind disabled.

restrictions for various reasons. An interesting feature of this policy change is that it concerned moderately disabled working age individuals, who have some remaining working capacity and therefore might be more sensitive to financial incentives than severely disabled persons. Another special element of this policy change is that it explicitly tightens the cash-cliff to a very low level, below the statutory minimum wage that allows only a part-time, low paid job, while the existing evidence mainly relies on episodes of relaxing the cash-cliff.

As the new rules applied to benefit recipients who submitted their application after 1 January 2008 the causal inference relies on comparing labour market outcomes of beneficiaries entering before (old-entrants) and after (new-entrants) the policy change, 1 January 2008. The empirical strategy is based on two approaches. First, I apply sharp regression discontinuity where the running variable is the date of entrance into RSA. I estimate the effect of the policy change on the probability of staying in the program, employment rate, wages and total income. (Hereafter, the term *wage* used as a synonym of earnings, including all labor income). I look for discontinuity in the outcomes 12, 18 and 24 months after entering the RSA and at a fixed date, December of 2009 using a non-parametric regression discontinuity (RD) estimation by the method of Calonico et al. (2014b).

The policy change was introduced unexpectedly, so strategic manipulation of the entrance time is ruled out. However, the effect of the new rule was not set retroactively, raising the possibility that the pool of applicants might be different under the new rules. I find that new-entrants and old-entrants are similar in terms of some observable characteristics, such as pre-disability occupation, regional distribution, age. Moreover, the incentive to apply for the benefit has not decreased after the policy change, as RSA beneficiaries might have kept both their earnings and the RSA for a 6 months grace period. When comparing averages of new-entrants and old-entrants entering within one year relative to the policy change, wage to minimum wage 12 months before the reform does not differ significantly between the two groups. The employment probability one year before the policy change is significantly higher for new-entrants. However, mainly due to the pre-reform increasing trend, a significant negative discontinuity can be observe at the cutoff in both the pre-disability wage and the employment rate. Therefore, pre-disability labor market outcomes are are controlled for in the RD estimation.

In addition, the RD analysis is complemented by a DiD approach that addresses validity concerns by explicitly relying on comparing pre- and post reform outcomes. Specifically, the DiD framework compares old-entrants' and new-entrants' outcomes 12 months before and 12 and 24 months after the entrance. The DiD sample is constrained to those who entered RSA within 12 months before and after the policy change.

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The RD and DiD estimations point to the same direction and suggest that disabled persons do not fully use their earning capacity under the low earnings limit. Instead, beneficiaries constrain their labor supply and choose their amount of work to remain eligible to the benefit, possibly because leaving the RSA increases the risk of remaining without income. Specifically, I find no discontinuity in the RSA beneficiary rate in any of the specifications, implying that the lower earnings ceiling has not induced more beneficiaries to exit the transfer and take a better paid job, with a wage level above the new limit.

The estimations indicate both extensive and extensive margin responses to the tightened rules. Among those who work, I find that the probability of the earnings being above 80% of the minimum wage is lower for the new-entrants 12, 18 and 24 months after the entrance by 35-58%, regardless of whether they still receive the transfer or not. The wages expressed relative to the minimum wage are also lower for new entrants' by 13-30 % 12 months after entrance, but the results are less robust on the two year horizon. I also find that the employment rate is significantly lower for new-entrants in the DiD estimation on both one year and two years after gaining eligibility to RSA. The RD confirmed significant employment response on a longer horizon, 24 months after the entrance, but the employment effect is not robust to the chosen horizon.

The results suggest that the substitution effect dominates the income effect in labor supply reactions to the new earnings limit. Despite the low earnings ceiling and the low benefit, many RSA recipients choose staying below the threshold rather than leaving the benefit and taking a better paid job under the stricter earnings restrictions, resulting in discontinuously lower wage income of new-entrants.

The paper is related to the wide literature on labor supply effects of the disability insurance scheme. Many papers investigate the effect of the generosity, that is, the availability and the value of disability benefits (Bound (1989), Gruber (2000), Autor and G. Duggan (2003), Maestas et al. (2013), Borghans et al. (2014), Chen and van der Klaauw (2008), Mullen and Staubli (2016)). These papers lead to the relatively wide conclusion that generous disability insurance systems decrease the labor supply of disabled individuals, the higher the value (replacement rate) and the easier the access to the benefit, the lower the labor supply. This is mainly because high non-labor income reduces the incentive to work through the income effect, though the magnitude of the disincentive effect varies across papers.

Another branch of the literature deals with the rules that regulate conditions of employment during receiving the benefits, the embedded working incentives. The empirical evidence on this issue is scarcer and mixed. A large part of the evidence concentrates on earnings responses (e.g. Schimmel et al. (2011), Ruh and Staubli (2019)), some papers concentrate only on extensive margin response as labor force participation (e.g.Maestas and Yin (2008)), and a few papers deliver evidence on both earnings and employment rate, extended with total income and benefit participation rate (Kostøl and Mogstad (2014)) or with program costs (e.g Greenberg et al. (2018)) or degree of disability (Deuchert and Eugster (2019)).

Many papers come from the US, where the earnings limit, the SGA threshold have been functioning for decades and according to a common argument this is an important factor behind the low employment rate of disabled people. However, the existing evidence does not support this hypothesis. Analysing an exogenous change in the SGA threshold in 1999, Schimmel et al. (2011) finds that only a small fraction of all disability beneficiaries (0.2 to 0.4 percent) were parked below the SGA level and the SGA change did not yield any difference in average earnings. In 2010, the Social Security Administration initiated a pilot project, the Benefit Offset National Demonstration (BOND) to test alternative program rules in randomly chosen groups of beneficiaries in many states. The experimental benefit schedule eased the cash-cliff and eliminated the abrupt drop in income above a certain threshold by replacing the limit with a gradual offset of the benefit. The final evaluation report of the projects (Greenberg et al. (2018)) finds a small positive employment response. However, a some of those beneficiaries receiving windfall income responded by reducing their earnings, exerting a decreasing effect on earnings. Al in all, the paper finds no confirmatory evidence that the benefit offset policy increases earnings, but there is strong evidence that it increases the benefits and the program costs. Maestas and Yin (2008) estimate a relative increase in labor force participation for disability beneficiaries in the US of 10 percentage points when beneficiaries reach full retirement age (FRA) relative to non-DI participants, when the benefit is replaced by retirement benefit and the cash-cliff disappears completely. The authors assess this change as modest, taking into account the huge decrease in implicit tax on earnings. However, supply reactions are presumably lower close to retirement age that at younger ages.

According to a common argument (e.g. Romig (2015)) an important reason behind the low effect of work incentive programs is that eligibility rules are quite strict in the US and the majority of disability beneficiaries is unable to engage in substantial gainful activity at any work. However, Kostøl and Mogstad (2014) investigates a work incentive program of Norway that creates very similar rules to the BOND project and they conclusion contradicts the main findings of the BOND project. Specifically, they conclude that this gradual scheme improves work incentives and increases employment rate and wage of beneficiaries and moreover it reduces the program costs.

Two other papers analyze European DI reforms and find moderate effects of the cash-cliff. Deuchert and Eugster (2019) investigates the effect of a cash cliff using a Swiss policy reform, and they find no significant substitution effect. Ruh and Staubli (2019) find a relatively sizable bunching below the earnings threshold of the Austrian disability benefit, although the elasticity of earnings with respect to the net-of-tax rate that is calculated from the bunching is relatively small.

This paper contributes to the literature by analyzing an uncommon policy change that significantly confined earnings restrictions for moderately disabled beneficiaries. A new element of this approach is that the database allows following RSA beneficiaries' labor market activity after exiting the RSA therefore I can analyze labor supply choice together with decision about staying in or exiting the program.

As a contribution to the debate on the roots of low exit rate from disability benefits, the paper demonstrates that reducing the earnings limit after a grace period does not encourage beneficiaries to exit the benefit and take a job paid above the limit. There is a few evidence showing that exit rate has not decreased after replacing the cash-cliff by a gradual offset e.g. Kostøl and Mogstad (2014). Nevertheless, in that case, the exit rate was already very, leaving not much room for decreasing after the reform.

The paper is also related to the relatively small literature which analyzes labor market outcomes of disabled population in Hungary, using administrative data. Bíró and Elek (2019) investigate the causal effect of job loss on the disabled enrollment and find that being laid off significantly increases the inflow into disability benefits. Adamecz-Völgyi et al. (2017) analyze the effect of a personalized active labor market program for persons with disabilities in Hungary. However, this paper is a first attempt to analyze the 2008 disability benefit reform by an administrative database which distinguishes different types of disability benefits. Although the magnitude of the effect differs across specifications, the results show that both extensive and intensive margin reactions play an important role in the adjustment to the new earnings restrictions. The estimation on the employment and wage effect is relatively large compared to other estimations in the literature and indicates that a low earnings limit might prevent disabled beneficiaries from fully using their remaining working capacity even if the level of the benefit is very low.

The rest of the paper is structured as follows. Section 2 describes the data source and the institutional framework of different disability benefits, including the regular social assistance. Section 3 describes the theoretical effect of disability earnings limit in a simple static framework. Section 4 explains the empirical strategy and presents estimations with

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regression discontinuity and difference in difference framework and analyzes the validity of the identification and the results. Section 5 presents the difference in difference framework and Section 6 concludes.

2.2 Data and the institutional framework

2.2.1 Data

The analysis is based on an individual level administrative panel database from Hungary.[4] The data covers half of the 5 - 74 year-old population in 2003, who were randomly selected and followed-up until 2011. The database consists of linked data sets of the pension, tax and health care authorities and contains detailed individual level information on employment and earnings history, use of the health care system, pension and other social benefits. The monthly database also contains information about the type and amount of different disability benefits.

In the analysis, I apply the following adjustment on the wage [5] data in the administrative database. Monthly earnings are not observed directly, employers report employment records in spells, with the starting date, closing date and earnings for the whole period. There is information on minimum 1 spell per year, however, employers usually report every changes, severance pay etc. in different spells. The monthly wages are calculated by the owner of the data, the Databank of the Centre for Economic and Regional Studies, taking the number of days in a month into consideration.[6]As the majority of the employment agreements fix the monthly wage regardless of the number working days, this method introduces an artificial seasonality into the data, I adjust monthly wages by the number of days of that given month. Specifically, the monthly wages are divided by the number of calendar days of that given month, and multiplied by the average number of days in that

[4]The owner of the database is the Databank of the Centre for Economic and Regional Studies in Hungary. The raw administrative data were cleaned and processed by the Databank.

[5]Earnings and wage is used as synonyms here. Both refers to the amount for a given period, instead of the wage rate

[6]If the actual number of days are not known, the Databank calculates the average daily wage by dividing the total payment with the total days in the spell and calculates monthly wages by multiplying daily amount with the number of calendar days of that month.

month (30.5 in leap years and 30.42 in other years). The analysis is restricted to the 20-60 years old population.

2.2.2 Disability benefit system in Hungary

Preceding the 2008 reform, the Hungary disability benefit system was relatively generous. The roots of this generosity can be traced back to the post-transition period of Hungary in the 90's, when a huge labor demand shock hitted the economy, decreasing the employment rate from 71% to 55% within a few years. The social system absorbed many people by allowing them into different inactive statuses, first of all early pension and disability schemes Scharle (2011)). As a result, around 12% of the working age population received some kind of disability benefit, well above the 5,6% of the OECD average Bíró and Elek (2019). The share of disability beneficiaries reached its peak in 2003 and started to decline gradually as a result of some attempts of tightening both the rules and the practice of evaluation committees, and as the labor market shock died out.

Besides to its general leniency, the Hungarian disability benefit system was rather complicated at the time of our analysis, between 2003 and 2011. Many types of disability benefits existed at the same time, and disabled individuals were eligible to different benefits according to the degree and type of disability, age of becoming disabled and number of years in work. The main disability benefit was the disability pension (DP hereafter). Individuals with a significant work history and at least 50% of health impairment (or previously 60% decrease in working capacity) were eligible to the disability pension. Disability pension was divided into 3 categories, based on the level of health impairment. DP category I-II refers to disability pensioners above 79% health impairment. DP category III refers to disability pensioners with 50%-79% health impairment.

The regular social allowance (RSA hereafter) was a low-value benefit designed to individuals with moderate disability, with at least 40% of health impairment (previously, 50% decrease in working capacity.) The degree of the health impairment is assessed by the rehabilitation authority (National Rehabilitation and Social Office until December 2016.) The remaining disability benefits include for example, the accidental disability pensions, transitory allowance for moderately disabled close to the pension age, the disability allowance for persons who acquired health impairment before age 25, blind person's allowance. It is important to note that the disability benefit system was reformed completely in 2012. The RSA and the disability pensions and other benefits were abolished and replaced by two new benefits, the rehabilitation and the disability allowance.

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Although the relatively low degree of health impairment implies that RSA recipients have not lost their entire working capacity, according to the eligibility criteria of RSA, they were not able to work in their pre-disability job, and any other jobs according to their level of education without rehabilitation or further education. The most common health problems among RSA recipients are musculosceletal diseases that encumber physical work.

The RSA, similarly to disability pension was a contributory benefit, but the required number of years in work and of paying social security contribution was half of the number of years necessary for obtaining eligibility to disability pension.[7] Meanwhile, the amount of the RSA was very low compared to the disability pension: about 38% of the statutory minimum wage.[8] As a comparison, the amount of disability pension was linked to previous earnings and also to the number of worked years (similarly to other pensions) and is amounted 80% of the minimum wage on average. Table 2.1 displays descriptive statistics of RSA recipients, in comparison with category III. (50%-79% health impairment) disability pension, and all disabled beneficiaries at December 2009. The data suggest that RSA recipients are in relatively unfavorable position even among other disabled beneficiaries. The RSA recipients constitute around 30% of the total disability beneficiary population, are less educated and more concentrated in smaller towns and villages than disability pensioners and other disabled beneficiaries. The share of women is relatively high, around 60%, suggesting that secondary earners prefer this benefit as a form of inactivity that yields some income.

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[7] The necessary number of years in work depends on age.

[8] In 2008, 26400 HUF.

Table 2.1: Descriptive statistics - RSA recipients and other disability beneficiaries

	RSA	DP (III.category)	All disability benefits
Share of men (%)	39.9		47.5
Mean age (years)	49.8	53.0	51.1
Number (thousand)	79.7	176.7	331.1
Type of settlement			
Village (%)	44.9	35.7	38.6
Town (%)	34.3	32.9	33.2
Capital and major towns (%)	20.8	31.5	28.2
Pre-disability job			
Manager, professional, technician (%)	11	28	23
Office, commerce and services Agriculture (%)	22	19	20
Physical and elementary occupations (%)	70	60	56

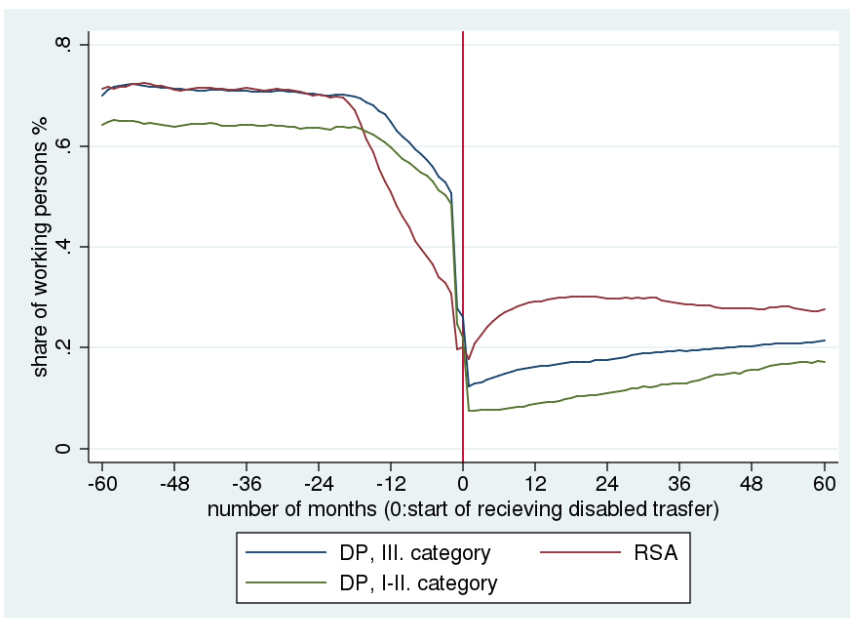
DP category III refers to disability pensioners with 50%-79% health impairment. The table contains disability beneficiaries between 20-60 years in 2008. Occupation categories refer to the Hungarian standard classification of occupations, HCSO-08/FEOR-08. The number of persons displays observations in the database that includes about half of the disabled population.

2.2.3 Employment and earnings of disabled beneficiaries

Disabled beneficiaries are allowed to work during the time of receiving the benefit, but the eligibility rules impose restrictions on earnings, or in some case on working time. These restrictions vary across different types of benefit, but the basic principle is the same: if earnings exceed a certain ceiling in average of 4-6 months, the beneficiary loses her eligibility to the transfer. The benefits of severely disabled individuals (for example disability, pension category I. and II.) were not subject to any earnings restriction. Of course a benefit recipient may always decide to exit the benefit and taking a job with a wage level above the limit.

Figure 2.1 displays employment rate of disabled beneficiaries of different benefits, by the time of becoming disabled. The vertical line denotes the date of entering disability scheme, the first month when a person becomes eligible to the disability benefit. This chart contains 20-60 years old people who became disabled during this period. Persons who were born disabled or became disabled at a young age and started to receive disability transfer before their adult age are not included. It is important to note that after the date of becoming disabled, this chart also contains individuals who have already left the benefit. The employment rate starts decreasing 2 years before becoming disabled and naturally falls to very low levels. After this drop, the employment rate starts recovering in case of all disability benefits, but not surprisingly, never approaches its pre-disability level and remains relatively low. Compared to moderate and severe disability pensioners, RSA recipients are the most likely to return to work relatively quickly. Their employment rate is higher than that of other disabled groups and it exceeds 35%, though the difference is decreasing over time. The higher employment rate is not surprising, as the health impairment of RSA recipients is lower than that of disability pensioners and the amount of the benefit is also lower on average.

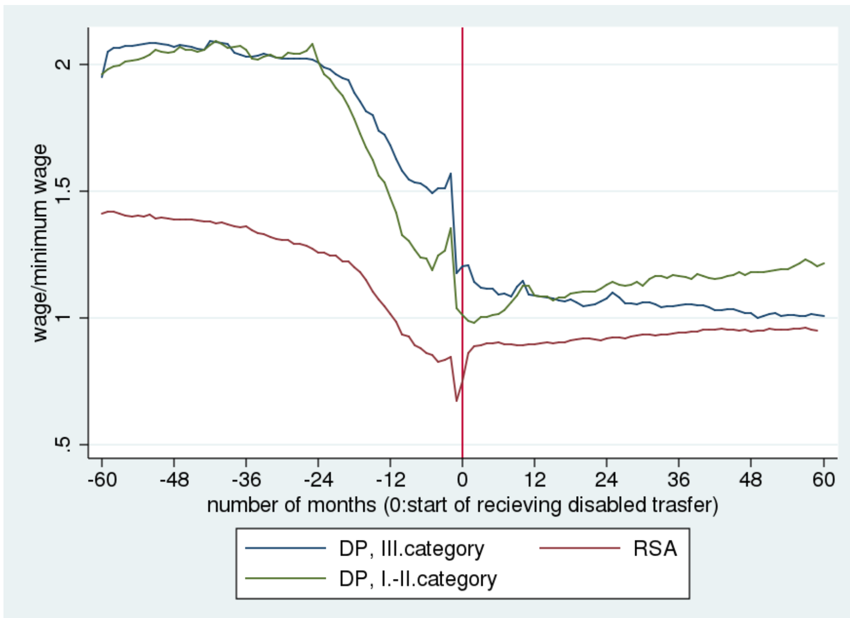
Figure 2.1: Evolution of the employment rate of entrants into different disability benefits around the entrance



The figure shows the employment rate relative to the entrance. The figure displays entrants who entered after 1 January 2007, because for disability pensioners, the rules of reporting earning activity changed from that date. DP I-II category refers to disability pensioners with health impairment above 79%. DP category III refers to disability pensioners with 50%-79% health impairment

Figure 2.2 displays the pre- and post- disability earnings of RSA and disability pension entrants compared to the minimum wage. For the period before becoming disabled, this chart contains people only if they worked both before and after entering the disability benefit.

Figure 2.2: Evolution of the average relative wage to the minimum wage of entrants into different disability benefits around the entrance



The figure shows the relative wage to minimum wage relative to the entrance. DP category I-II refers to disability pensioners above 79% health impairment. DP category III refers to disability pensioners with 50%-79% health impairment.

The figure suggests that RSA is mainly the benefit of low-wage earners: the average pre-disability wage is less than 150 % of the minimum wage, compared to the about 200% of disability pensioners' wage. Note that the average wage of healthy people exceeds 250 % of the minimum wage. Similarly to employment rate, earnings start to decrease well before going to disability, probably reflecting to deterioration of health. In case of the disability pensions, pre-reform decrease in wages is interrupted by an increase due to severance pay, unused off-days. No similar hike can be observed in case or RSA entrants, probably because the magnitude of severance pays, payed free days etc. is much lower in case of these jobs.

Low pre-disability wage indicates that although the amount of the RSA is very low, it may exert an impact on the behavior of RSA recipients.

2.2.4 Policy change

Although a gradual decline started in 2003, still high reliance of disability benefits prompted the government to introduce some important changes in 2008. A new health status classification was introduced: under the new system, the health status is expressed in degree of health impairment instead of degree of decrease in working capacity. However, the new and old categories can be perfectly matched to each other and health status corresponding to benefit eligibility remained the same. The rehabilitation allowance was introduced in 2008 with similar health impairment and amounts as disability pension for those who were qualified for rehabilitation services.

This paper focuses on one element of the reform that altered earnings restriction accompanied to RSA. The aim of this change was to curb reliance on RSA and induce recipients to leave the benefit as soon as their working capacity allows to work for even on a low earnings level. As the eligibility criteria (degree and type of health impairment, age of becoming disabled, contributory or not) of the other affected benefits differ from those of RSA, they do not change the conclusions of the results.

The policy change for RSA is the following. Until January 2008, the earnings limit was linked to the previous earnings of the applicants. A person with at least 40% of health impairment [9] was allowed to apply for RSA, if her earnings did not exceed 80% of the previous earnings in the average of the 4 months preceding the application. Similarly, after a successful application, an RSA recipient lost her benefit if her earnings exceeded 80% of her pre-disability earnings in average of 4 consecutive months. The pre-disability earnings here refers to the earnings that the person could earn in absence of the disability. The calculation of pre-disability earnings, which is based on the rules of calculation of disability pensions, is complicated, takes into account earnings of several years before going to disability and previous earnings are adjusted by the increase in the total economy average net in earnings.[10]

[9]Before 1 January, 2008, the health status was expressed in loss of working capacity. 40% of health impairment is equivalent with 50% of working capacity.

[10]The Ministerial Decree 8/1983 (VI.27.) declares that RSA recipients can be engaged in earning activity

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Effective from January 1 of 2008, a new earnings limit came into effect for RSA recipients.[11] The policy change abandoned the conditionality on previous earnings and introduced a unified earnings limit at a very low level, 80% of the statutory minimum wage for full-time work. This implied that RSA recipients were allowed to take only part-time work in a low paid job that can hardly be considered as a substantial gainful activity.

The magnitude of the policy change can be assessed in light of the pre-disability wages. The average wage of RSA entrants, who entered within one year after or before the policy change, was 126% of the minimum wage 2 years before the entrance and exceeded the minimum wage at about 60% of the entrants. The average within this latter group 2 years before the entrance - who are most directly affected - was 169% of the minimum wage.

The policy change is summarized in Table 2.2. The policy change also affected the grace period: new-entrants lost their benefit if their earnings exceeded the new limit in average of 6 consecutive months, instead of the previous 4 months.

The decision about the new wage restriction was made at the end of 2007. The first internal proposal was written in November 2007 and it was accepted on 23th of December. Hence it was unexpected and motivated by the need for adjusting the regulation to the reform of disability pension. The policy was introduced in January 2008.

According to the government decree, the new earnings limit was to be introduced in two steps. In the first wave, the new rules applied only to new-entrants, who submitted their application after 1 January 2008. Old-entrants, who submitted their application before 1 January 2008 would be exempt from the regulation until 1 January 2010. Consequently, in the 2008-2009 period different earnings restrictions applied to new-entrants and old-entrants. However, the exemption period for old-entrants was extended twice. First, the date of introduction was protracted from 1 January 2010 to 1 January 2011 in the very last moment, on 28th of December 2009 and it was postponed again at the end of 2010, again in the very last moment, to January 2012.[12] Consequently until 2012, the regulation was not introduced for the old-entrants at all.

A large part of our analysis falls in the period of the financial crises, starting in end-

according to the same rules as disability pensioners. The rules of calculations of disability pensions are legislated in Act LXXX of 1997 on the Eligibility for Social Security Benefits.

[11] 387/2007. (XII. 23.) Government Decree.

[12] 309/2009. (XII. 28.) Government Decree and 358/2010. (XII. 30.) Government Decree.

Table 2.2: Change in RSA eligibility earnings limit

	Eligibility rule of	
Date of enter	applying to RSA	keeping the RSA
Before Jan 1 2008	80% of previous earnings in average of 4 cons. months	80% of previous earnings in average of 4 cons.months
After Jan 1 2008	80% of min wage in average of 4 cons. months	80% of min wage in average of 6 cons. months

2008 and causing significant drop in economic activity in 2009. Therefore the analysis puts an emphasis on controlling for macroeconomic swings in the causal inference.

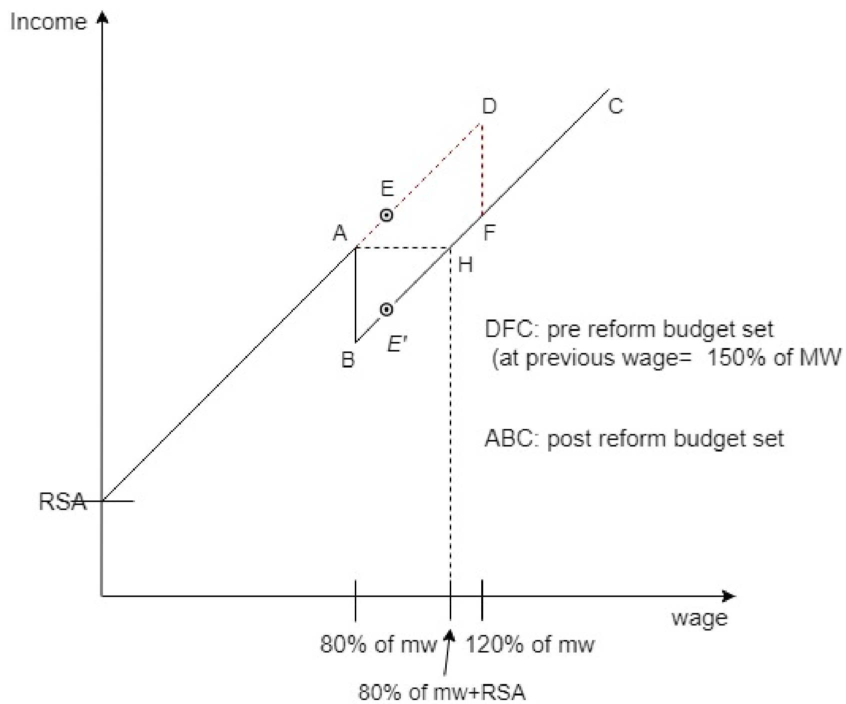
2.3 Theoretical framework

Disability benefit earnings limit is often blamed for its potential negative labor supply effects, and often recommended to be replaced by a gradual offset of the benefit (Kostøl and Mogstad (2014), Center (2015)). The main argument is that the discontinuous drop in the budget set when wage increases above the threshold gives an incentive for the beneficiaries to keep their earnings below the ceiling. However, more generous earning rules might increase the costs of the benefit program by inducing more applications, decreasing the incentive for exit, and the labor supply effects are not clear-cut a priori as it could even reduce the labor supply of disabled beneficiaries trough the income effect. In the following, I show how the change in the wage restriction affects the labor supply decisions of RSA recipients in a simple static labor supply model.

Figure 2.3 shows how the budget set changes due to the reform. The new earnings limit alters the budget set for all potential beneficiaries whose choice of working time would yield earnings higher than 80% of the minimum wage. The X axis shows earnings, as a % of the statutory minimum wage, and the Y axis displays the total income, including the benefit.

The line along the DFC points shows the pre-reform budget set of a person whose pre-disability wage was 150% of the minimum wage. Before the reform, she was allowed to work and keep her RSA if her earnings remained below 120% of the minimum wage. Thus, her pre-reform wage threshold is 120% of the minimum wage. The line along the ABC points displays the budget set after the reform, as the new earnings limit is uniformly 80% of the statutory minimum wage, regardless of the previous wage. Consider an RSA recipient, whose pre-reform labor supply choice is displayed by the point E. Without

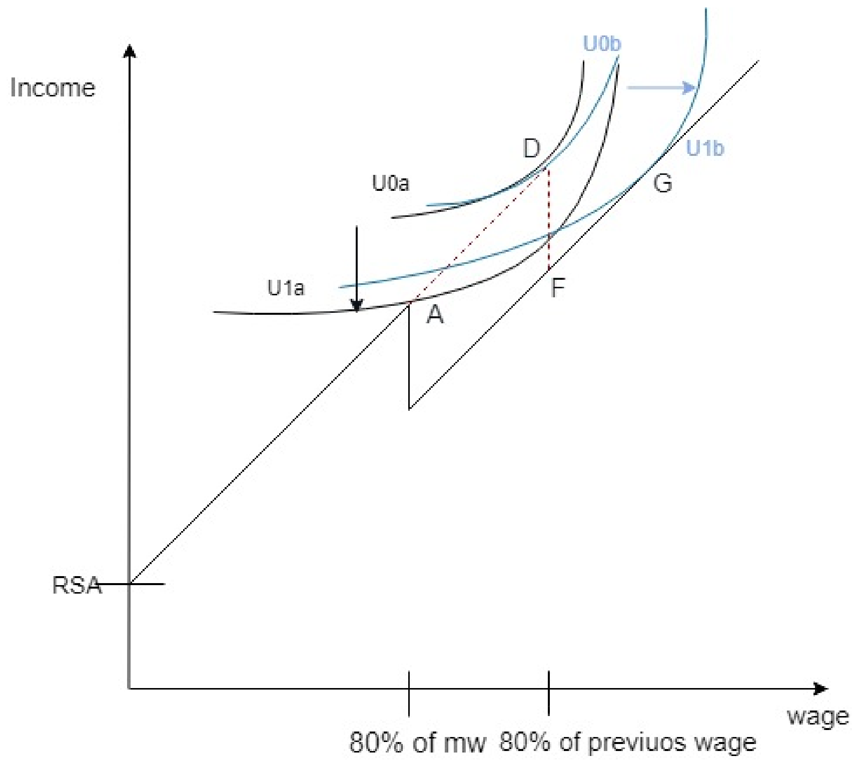
Figure 2.3: Budget set before and after the policy change



modifying her amount of work, her income would fall to point E' after the reform. Under the new rules she is simply better off with choosing a lower amount of work at the new limit (A) as she can keep the transfer, and can attain a higher income with less work. Consequently, if labor supply can be adjusted freely, she will not choose anything between the points B and H (the new threshold, and the new threshold plus the RSA), this region is clearly dominated. Instead, she will choose a lower amount of work to remain eligible for the transfer (A) or take more work (beyond point H) in order to compensate for the lack of the benefit. The choice basically depends on the leisure-consumption preferences and the distance between the new earnings limit and the chosen level of earnings under the pre-reform rules.

The effect of the earnings limit on the labor supply choices of RSA recipients is enlightened by Figure 2.4. Lets consider a person, whose labor supply choice would be at point D under the pre-reform earnings limit, that is, she earns 80% of her previous wage, that is larger than 80% of the minimum wage, consequently in addition to her earnings, she is still eligible to the benefit. Under the new earnings limit, with the same amount of work she would lose the benefit. It results in a a decrease in non-labor income compared to the

Figure 2.4: Labor supply choice before and after the policy change



pre-reform rules that would imply a higher labor supply due to the income effect according to the standard labor supply model (e.g. see Killingsworth (1983)). However, she doesn't have to sacrifice the benefit if she cuts her labor supply such that her income decreases to the 80% of the minimum wage, that is, she has to take only a low paid part-time job. This effect that predicts a bunching in the wage distribution of disabled beneficiaries just below the earnings limit, is called the substitution effect in Autor and Duggan (2007). As Deuchert and Eugster (2019) points out, this is not the classical, Hicksian substitution effect triggered by the change in the wage rate. But the mechanism is similar in the sense that discontinuous jumps in the budget set change the relative price of leisure above the earnings limit. The $U0a$ and $U0b$ indifference curves show the role of the preferences. When the disutility of work is high, that is, the indifference curve is steep ($U0a$), the person will rather choose work at point A under the new earnings limit, but if the disutility of work is lower ($U0b$), an individual probably will choose her labor supply at point B. However, individuals may not choose their working time freely as part-time work is not accepted at many jobs and firms. In this case, an individual might choose between accepting the lower income, quit the labor market or increase the amount of work. Higher labor supply might

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not be an option either, for example, because of the health impairment. To sum up, the consequences of the reform and the earnings limit on employment and earnings of disabled beneficiaries are not clear a priori.

Distribution of wages

Discontinuous, discrete changes in the level of the choice set constitute notch points, creating incentive for bunching (Kleven and Waseem (2013)). The abrupt drop in the budget set of the RSA benefit predicts a bunching in the wage distribution below the earnings limit. Consequently, the wage distribution is expected to change after the policy reform. Specifically, I expect that a bunching below the unified earnings limit of 80% of the minimum wage develops after the policy change. The following figures confirm this hypothesis. Figure 2.5 a) shows the distribution of monthly adjusted wages of new-entrants between January and December 2009 (only after entering RSA), the red vertical line denotes the new earnings limit, 80% of the minimum wage. In line with the prediction of the above theoretical framework, a bunching appears below the new earnings limit in the wage distribution of new-entrants in 2009. In contrast, old-entrants' wage distribution (see Figure 2.5) b) is less skewed, and the peak of the distribution is well above the 80% of the minimum wage. It is close to the statutory minimum wage.

These charts indicate that the earnings limit has an effect on realized earnings and the choice of work of RSA entrants and earnings park at the threshold. Using wage distribution of disability benefit recipients, Ruh and Staubli (2019) estimates the elasticity of earnings with respect the implicit net-of-tax rate. However, in the Hungarian case, estimation of structural elasticities from the bunching would not be an easy task. First, before the reform, RSA also contained an earnings limit, though it was not unified to a single amount but was linked to the previous earnings. However, the pre-reform distribution can be hardly used as a counterfactual distribution. Second, while the excess mass is in line with theoretical predictions, it seems that a sizable mass takes place above the threshold, in the dominated region (the between 80% and 118% of the minimum wage). There are at least two factors behind this. First, the chart displays monthly wages and the limit regulates wages in average of the last 6 months. Second, the compliance to the earning rules is not full: the histogram of 6-month average wages of actual RSA recipients (Figure 2.6) also have many individuals above the limit, however, I do not know the roots of the partial compliance. Based on these considerations, earnings distribution charts serve only as an illustration and I assess the effect of the new earnings limit by estimating whether it

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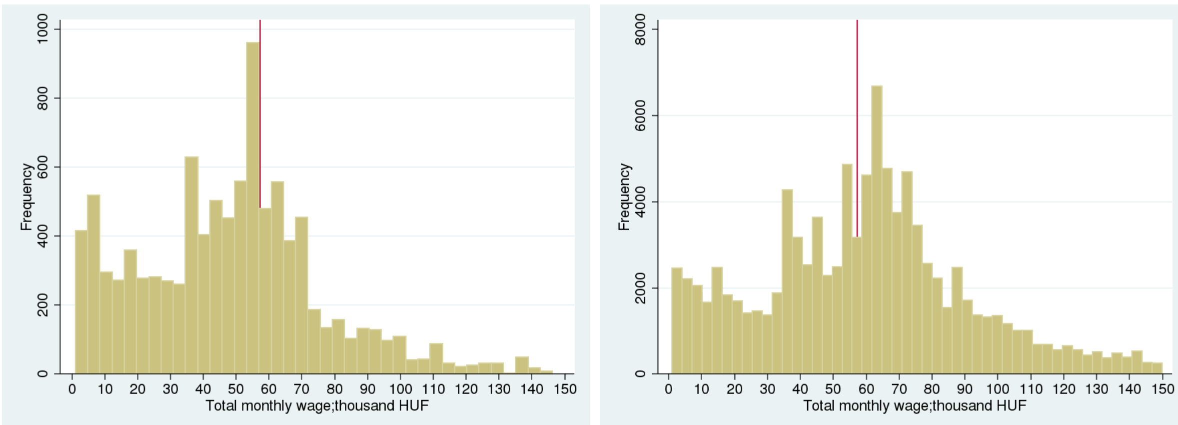
Figure 2.5: Wage distribution of new-entrants' and old-entrants' monthly earnings, January-December 2009



(a) New-entrants (b) Old-entrants

The figures contains monthly earnings of RSA entrants if monthly earnings exceed 1000 HUF, pooled between January -December 2009. Subfigure (a) ahows indivudials who entered RSA between 1 January 2008 and 31 December 2009, figure (b) displays those who entered between 1 January 2003 and 31 December 2007. The red vertical line denotes 80% of the monthly minimum wage

influences decision on exit from the transfer, on work and the earnings by comparing new and old-entrants labor market outcomes.

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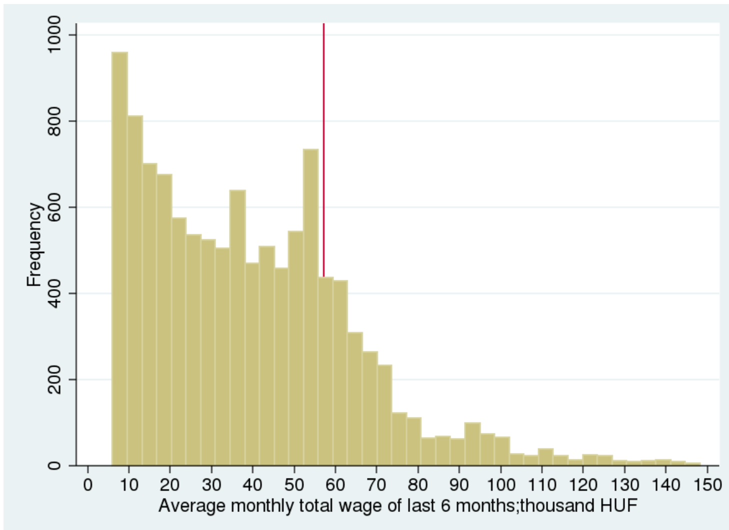
Figure 2.6: Wage distribution 6-month average wage of new-entrants monthly wages, January-December 2009



The figures contains earnings in average of the latest 6 months of individuals who entered RSA between 1 January 2008 and 31 December 2009.

2.4 Empirical strategy

The empirical strategy exploits the first date of the policy change, 1 January 2008 to analyze the employment and wage reactions to the change in earnings limit. As the date of entry determines whether an RSA recipient is subject to the new earnings limit, the possibility arises to analyze the potential labor supply and wage effects of the regulation by comparing labor market outcomes of new-entrants and old-entrants.

2.4.1 Expected effects

As working hours are not observed in the database, intensive margin labor supply reactions are not observed directly. However, we can conclude about the labor supply reactions from earnings and extensive margin reactions. The empirical analysis is based on 4 outcome variables: employment rate, RSA beneficiary rate (fraction of persons who still receive the RSA transfer with a given period after entering RSA), wage expressed relative to the statutory minimum wage and probability of receiving a wage above 80% of the full-time minimum wage, if working. The term *wage* includes all labor income recorded at the social security, that is wages, bonuses and other one-off labor income, so is interpreted as earnings. It is important to note that the analysis is based on individuals who entered RSA, regardless of whether they still receive the benefit or not at the date of evaluation. This is because the decision to stay in or exit RSA and labor choice after exit is also part of the reaction and to be analyzed.

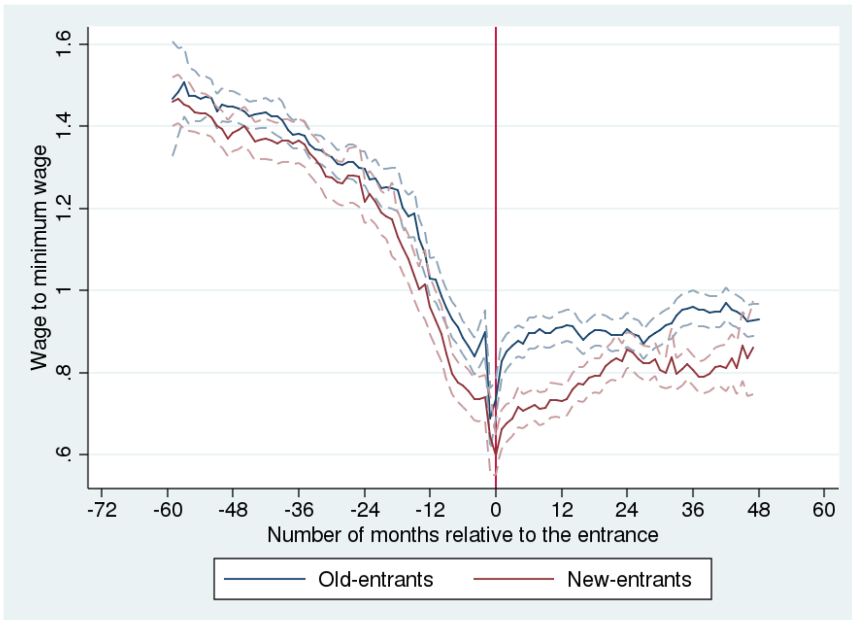
If the substitution effect dominates, new-entrants will choose working hours such that they remain eligible for the RSA. In this case, new-entrants would have lower wage on average, hence we could see a discontinuous decrease in wages at the cutoff date. If arbitrary decrease in labor supply is not possible, for example, part-time work is not allowed in a job, someone who would choose her work with a wage level just below the new limit under the old rules, might decide not to enter the labor market at all under the new rules. If this effect is important, we could see a lower employment rate among new-entrants than among old-entrants.

On the contrary, if the income effect is the dominant effect, RSA entrants will have higher labor supply under the new rules than under the old rules. This should be reflected in lower beneficiary rate and higher wages of new-entrants. In this case, RSA recipients, whose labor supply would be above the new earnings limit, would choose to abandon the RSA and take a job with a wage exceeding the new earnings limit. In this case we could observe new-entrants exiting RSA more frequently than old-entrants. Consequently, we should see a discontinuous decrease in the beneficiary rate at the cutoff entrance date.

To sum up, if the the regulation is successful in decreasing deadweight losses of the benefit and the tighter earnings limit reduces reliance on the transfer, we can expect a discontinuous decrease in the beneficiary rate and an increase in wages. However, if the new regulation restraints labor supply, we shall observe a discontinuous decrease in wages and perhaps even in employment rate at the cutoff, and no decrease in the beneficiary rate.

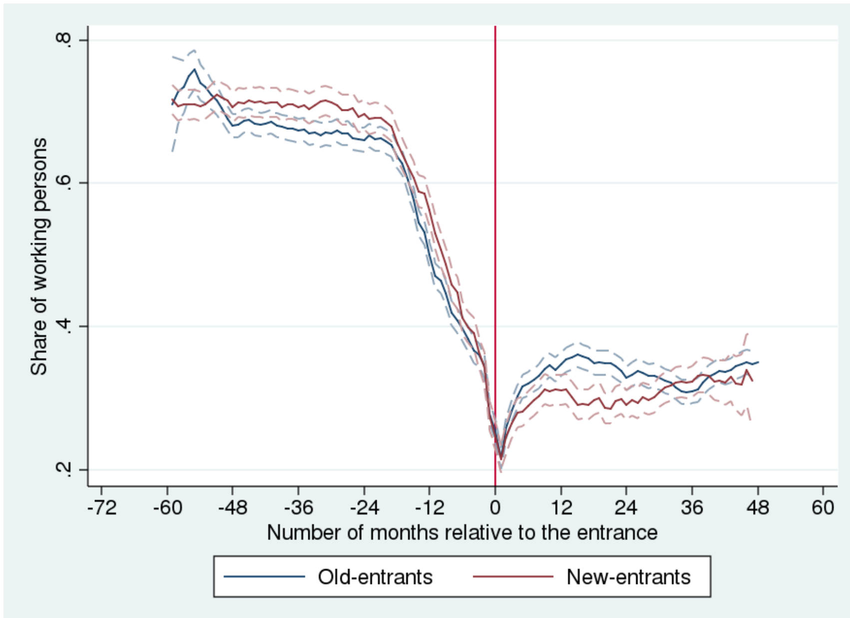
The following charts compares new-entrants and old-entrants wage and employment outcomes. The charts include individuals who entered RSA within one year before and after the policy change. Specifically, group of old-entrants include persons who entered RSA in 2007, new-entrant consists of individuals with entrance in 2008. Figure 2.7 and 2.8 display the average of relative wage to the minimum wage and employment rate for new-entrants and old-entrants relative to the entrance. The charts suggest that new-entrants and old-entrants exhibit similar dynamics before entering into RSA, even new-entrants have on average higher employment rate than the new-entrants before the entrance. The outcomes seem to diverge after the entrance in case of both employment probability and wages, indicating that becoming an RSA recipient, reduces labor supply of new-entrants to a higher extent.

Figure 2.7: Relative wage to the minimum wage of old-entrants and new-entrants around the entrance



The figure contains means of relative wage to the minimum wage of old-entrants and new-entrants, who entered RSA within 12 months before and after the policy change, respectively, relative to the month of entrance.

Figure 2.8: Employment rate of old-entrants and new-entrants around the entrance



The figure contains means of relative wage to the minimum wage of old-entrants and new-entrants, who entered RSA within 12 months before and after the policy change, respectively, relative to the month of entrance.

There are two basic directions to compare old-entrants' and old-entrants' outcomes: regression discontinuity (RD) and a difference-in-difference (DiD) framework. In the RD framework, the assignment variable is the calendar date (month) of entry into the RSA, and the cut-off date is the introduction of the reform, January 2008. The DiD framework compares old-entrants' and new-entrants' outcomes before and after the entrance. In the following, I present estimations based on these two strategies, comparing the assumptions behind the two methods.

2.4.2 The response to the reform: an RD framework

The RD approach exploits the sharp change in earnings restrictions for those who gained eligibility after January 1 2008.

The outcomes are evaluated at a fix time window relative to date of becoming beneficiary, that is, the time spent in disability is the fixed for all observations. This implies that, the outcomes are evaluated at different dates, the date of evaluation is increasing along the X axis.

$$Y_{it} = \begin{cases} Y_{it}(1), & \text{if } entry\_date_i >= c\_date \\ Y_{it}(0), & \text{if } entry\_date_i < c\_date \end{cases}$$

Where $Y_{it}(1) =$ is the outcome for a randomly chosen population unit if treatment is imposed exogenously
$Y_{it}(0) =$ is the outcome for a randomly chosen population unit if excluded from treatment exogenously

entry_date is the variable that divides the population into treated and control groups (running variable), in our case the date of entry, and *c_date* is the cutoff date, January 2008.

and $t = entry\_date_i + X$ ans X is a fixed time window, 12, 18 and 24 months.

The RD is estimated on the following outcome variables: employment rate, RSA beneficiary rate and wages (expressed relative to the statutory minimum wage, or probability of working below the 80% of the minimum wage), and the total income (the amount of the benefit and the wage). A person is regarded to be at work in a given month if it receives any labor income in that months above 1000 HUF.

One potential pitfall of evaluating the outcomes at different dates is the potential effect of observed or unobserved factors that are correlated in time. Time variant factors, for example, the general labor market environment might influence the outcome variable of the treated and control groups differently, which need to be controlled for. This is especially important in the period of the financial crises in 2008-2010 that can be characterized by large swings in output and also in employment. Hausman and Rapson (2017) points out, unobservables correlated with the running variable may have discontinuous impacts on the potential outcome. For that reason, macroeconomic variables are controlled for in the baseline model. As a robustness check, I also carried out estimations where the outcome is evaluated at a fixed date, December 2009. (A similar approach is used for example, by Kostøl and Mogstad (2014)).

In any case, the question arises whether the running variable really captures the cut-off date. The law determines whether an RSA recipient is subject to the new rules or not according to the date of submission of the application. The variable *entry_date* shows not

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the date of submission, but the date of gaining eligibility to RSA. However, according to the law, eligibility starts at the date of the health impairment, but the earliest possible date is the date of submission. Presumably vast majority of people submit their application to disability benefit after becoming disabled, so the eligibility date is a good approximation of the date of submission. The date of becoming eligible does not necessarily coincide with the starting date of receiving the transfer. The assessment process might take 0-3 months, and the benefit is given retroactively. Consequently, using the eligibility date as a running variable is plausible.

Validity of the RD design

As discussed in Section 2.2, the legislation about the change in the earnings limit was accepted in end-December of 2007 and the proposal was prepared in November. As a result, the policy change was unexpected and potential RSA recipients could not manipulate the entry date by bringing forward their application. Indeed, no bunching can be observed before the end of 2007 in the number of entrants (see Figure 2.9). This is in contrast with the number of entrants to disability pension, where a large upsurge in inflows can be observed before the new regulation came into force. The RSA recipients, who entered in the first months of 2008 are probably expected the old regulation.

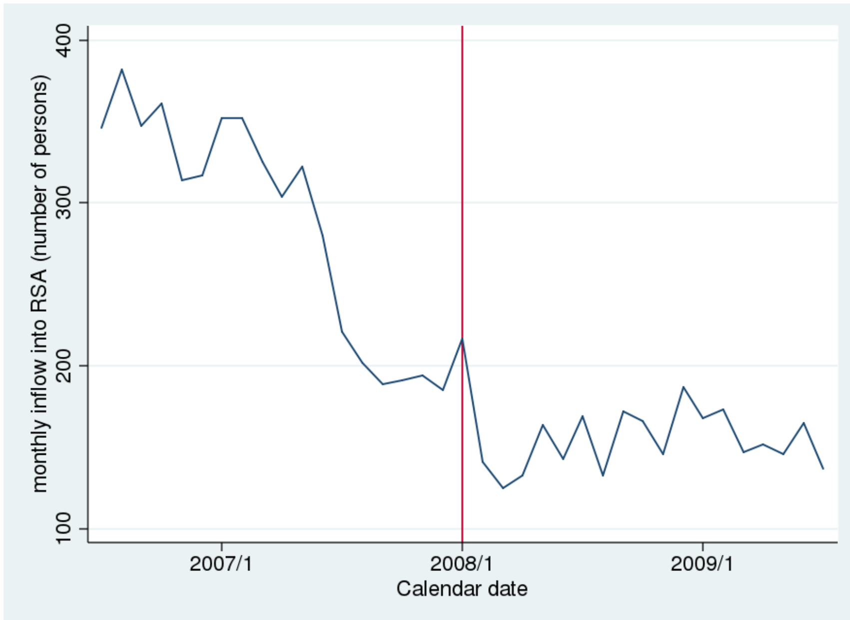
However, old-entrants and new-entrants might differ in many observed and unobserved characteristics, as (1) the assessment process might have become more rigorous and (2) the pool of applicants also might have changed. The following considerations and data on observed characteristics suggest that old and new-entrants are comparable and might constitute valid treatment and control groups.

1. The assessment process itself has changed, but according to aggregate data about assessments of all disability applications, the ratio of accepted/rejected applications have not changed considerably (was around 55% in 2008 and 2007) although this data contains all disability applications, not specifically applications for RSA.)[13]

2. Applying for RSA was a rational strategy after the new regulation came into effect even for those, who planned to work above the new earnings limit as for a couple of months they were eligible to RSA regardless of their earnings. As RSA recipients

[13]Source: Yearly Reports of National Rehabilitation and Social Office.

Figure 2.9: Monthly inflow into RSA by calendar time



The figure shows monthly number of entrants into RSA.

consists of people with low education level and low pre-disability earnings, the amount of benefit can not be regarded as negligible.

3. Table 2.3 shows covariate balance of of new-entrant and old-entrant RSA recipients, who entered within 12 months before and after the policy change. The comparison reveals that the two groups are pretty similar regarding most of the pre-disability characteristics. Although new-entrants are slightly younger, the t-test suggests no significant difference in the best job before gaining eligibility to RSA, settlement type and regions. new-entrants might differ in their pre-disability wage, as the eligibility requirement of applying for RSA has changed: persons, whose wage was below 80% of the minimum wage in the 4 preceding months can apply after the reform, while it was 80% of the previous wage in until 2008. However, average wage to minimum wage 12 months before becoming RSA recipient in average of new-entrants and old-entrants do not differ significantly. The employment probability 12 months before entrance is even significantly higher for new-entrants than for old-entrants. Comparison on new-entrants with III category DP recipients (last three columns in Table 2.3 shows that the two RSA groups differ significantly from DP recipients.

Table 2.3: Covariate balance of RSA new-entrants and old-entrants and DP entrants (%)

	Mean		T-test		Mean	T-test	
	New entr.	**Old-entr**	t	p¿t	**DP entr.**	(with new-entr) t	p¿t
Gender							
Male	0.407	0.381	1.87	0.062*	0.555	-12.26	0.000***
Type of settlement							
Major city	0.159	0.177	-1.7	0.090*	0.219	-6.03	0.000***
Town	0.340	0.343	-0.21	0.835	0.315	2.18	0.029**
Village	0.437	0.419	1.19	0.233	0.352	7.18	0.000***
Age							
35-44 years	0.181	0.212	-2.65	0.008***	0.120	7.52	0.000***
45-55 years	0.748	0.715	2.55	0.011**	0.834	-9.21	0.000***
Best job before disab							
Managers	0.046	0.043	0.49	0.624	0.112	-8.45	0.000***
Professionals	0.019	0.019	0.02	0.983	0.064	-7.53	0.000***
Technicians	0.085	0.089	-0.44	0.662	0.139	-6.17	0.000***
Office and customer serv.	0.046	0.050	-0.51	0.613	0.048	-0.31	0.757
Commercial and services	0.169	0.150	1.73	0.084	0.119	5.95	0.000***
Agriculture	0.038	0.037	0.09	0.927	0.029	1.98	0.048**
Industry and constructions	0.279	0.268	0.8	0.421	0.224	5.09	0.000***
Machine operators,drivers	0.112	0.123	-1.13	0.258	0.114	-0.3	0.762
Elementary occ	0.206	0.221	-1.24	0.214	0.151	5.89	0.000***
Region in 2003							
Central Transdanubia	0.100	0.098	0.23	0.814	0.121	-2.64	0.008**
Western Transdanubia	0.057	0.062	-0.73	0.463	0.123	-8.35	0.000***
Southern Transdanubia	0.152	0.150	0.24	0.811	0.115	4.66	0.000***
Northern Hungary	0.125	0.152	-2.56	0.010**	0.128	-0.29	0.772
Northern Great Plain	0.219	0.198	1.75	0.080*	0.134	9.82	0.000***
Southern Great Plain	0.193	0.191	0.14	0.891	0.164	3.21	0.001***
Prob. work 12 m before	0.563	0.500	4.27	0.000***	0.668	-9.16	0.000***
Wage to mw 12 m before	0.948	0.987	-0.96	0.339	1.683	-10.24	0.000***
Number of observations	1896	3116			15737		

New-entrants: entered RSA between Jan 1 2008-Dec 31 2008. Old-entrants: entered RSA between Jan 1 2007-Dec 31 2007. DP entrants: entered DP between Jan 1 2007-Dec 31 2008. DP refers to disability pensioners category III, with 50%-79% health impairment. The table contains disability beneficiaries between 20-60 years. Occupation categories refer to the Hungarian standard classification of occupations, HCSO-08/FEOR-08.

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However, although pre-disability wage in *average* of the pool of new-entrants and old-entrants and employment probability of new-entrants is significantly higher, the pre-disability outcomes exhibit different picture in an RD setup. The following charts show the average pre-disability wage/minimum wage and employment rate of RSA recipients by date of entrance respectively, 12 months before gaining eligibility to RSA. Figure 2.10 a) displays the probability of working 12 months before becoming disabled as an RSA recipient. The X axis denotes the date of entrance into RSA and the Y axis denotes the outcome variable of interest. The dots represent raw means of the outcome variable of each monthly date of entrance and a fitted polynomial of order 2. Figures 2.10 b) and c) describe pre-disability wage of RSA entrants. The former shows the probability of receiving a monthly wage above the minimum wage, conditional of working, 12 months before becoming disabled. Figure 2.10 c) shows the wage/minimum wage ratio 12 months before becoming disabled.

Table 2.4 displays nonparametric RD estimations for 12 months before the entrance in wage to minimum wage, probability of the wage being above the minimum wage and the probability of working using the method of Calonico et al. (2014b), applying triangular kernel. One common bandwidth is selected on both sides of the cutoff by minimizing the MSE of the treatment effect. The table contains the treatment effect (denoted by τ) of conventional and the bias-corrected RD estimation of the treatment effect, the latter is displayed also with the conventional and with robust standard errors. The regression discontinuity estimations for the outcomes 12 months before the entrance suggest that the probability of working and receiving a wage above the minimum wage, if working is lower for new-entrants.

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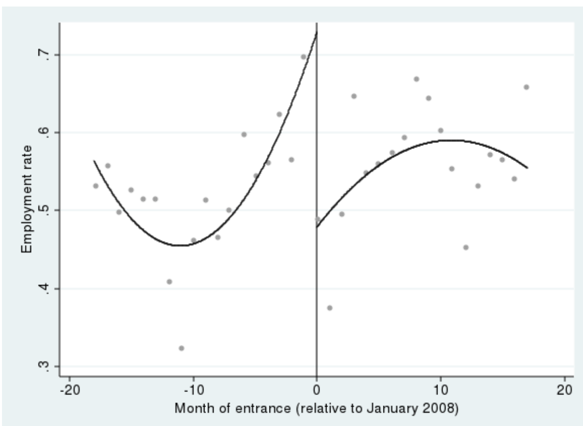
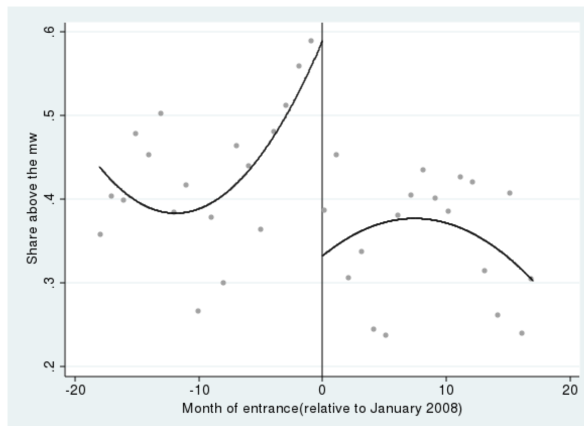
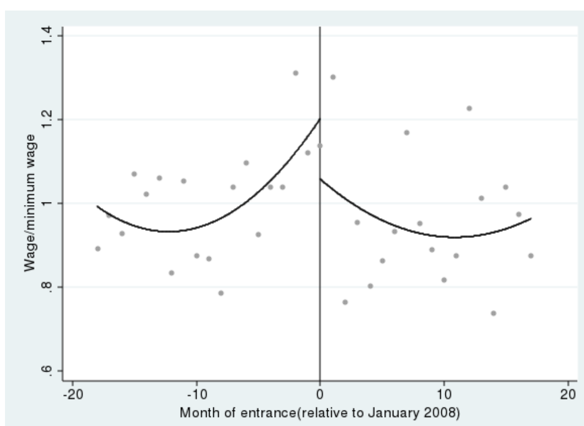
Figure 2.10: Employment and earnings 12 months before the entrance



(a) employment rate



(b) wage above %mw



(c) wage to mw

The figures contain unconditional means of the outcome variable and a fitted polynomial of order 2 of individuals who entered RSA by the month of entrance into RSA, from 18 months before to 18 months after January 2018.

Table 2.4: RDrobust: discontinuity 12 months before the entrance in wage to minimum wage, probability of the wage being above the minimum wage and the probability of working

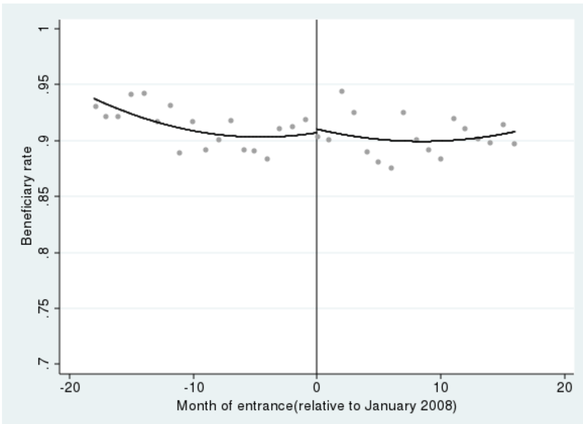
	(1)	(2)	(3)
Dep.var	wage/minw	wage above the min wage	work
Conventional	-0.219***	-0.156	-0.231***
	(0.0404)	(0.130)	(0.0549)
Bias-corrected	-0.234***	-0.191	-0.259***
	(0.0404)	(0.130)	(0.0549)
Robust	-0.234***	-0.191	-0.259***
	(0.0456)	(0.155)	(0.0596)
Observations	28,107	14,730	14,333
Covariates	YES	YES	YES
Conventional SE	0.0404	0.130	0.0549
Robust SE	0.0456	0.155	0.0596
BW Loc. Poly. (h)	7.627	12.93	7.717
Eff. obs left	1461	1627	845
Eff. obs right	1225	1158	653

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

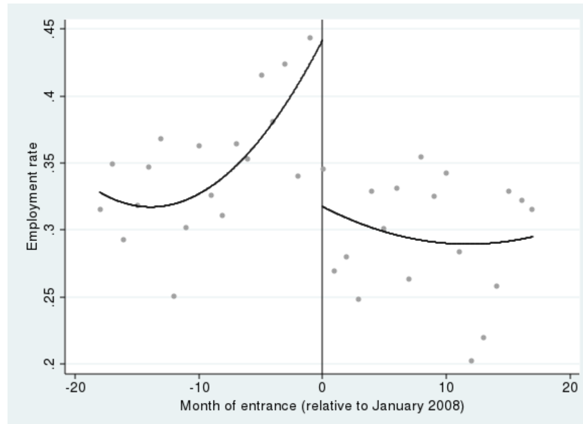
The RD charts for pre-disability wage and employment reveals that the discontinuity in the the pre-disability wages and employment that it is mainly due to the increasing trend *within* the group of old-entrants. However, this reason behind this increasing trend is no clear-cut, the labor market environment (total economy wages and employment) can not provide an explanation.

The question arises whether discontinuity in pre-disability employment rate and wage to minimum wage threatens the validity of the RD design. I address this concern by two methods. First, and I control the pre-disability employment status and wages in RD estimations of discontinuity in outcomes *after* entering into RSA. Second, subsection 2.4.4 complements the RD estimations with a DiD framework, where new-entrants' and old-entrants' outcomes are explicitly compared before and after entering into RSA, and the trends *within* the two groups do not show up in the estimation.

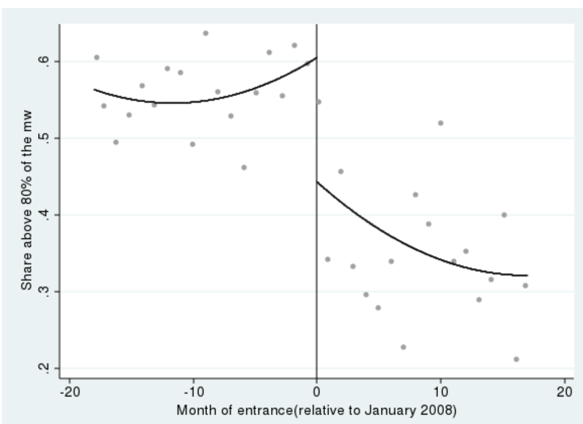
Figure 2.11: Extensive and intensive margin reactions 12 months after the entrance



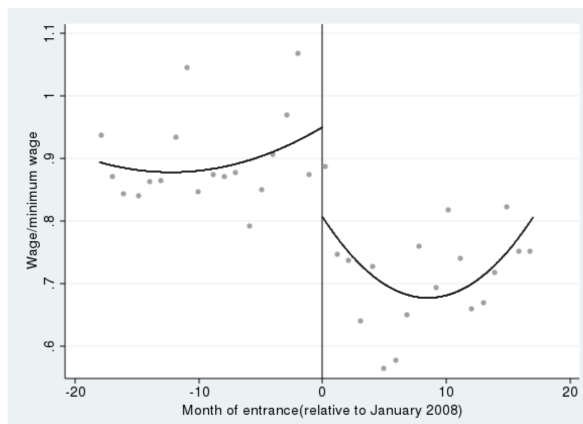
(a) beneficiary rate



(b) employment rate



(c) wage above 80%mw



(d) wage to mw

The figures contain unconditional means of the outcome variable and a fitted polynomial of order 2 of individuals who entered RSA by the month of entrance into RSA, from 18 months before to 18 months after January 2018.

2.4.3 RD estimation results

This section presents RD charts and nonparametric estimations. The first question is whether new-entrants exit RSA in higher proportion due to stricter earnings limit, that is, they choose abandoning the transfer and take a better paid job with a wage above the threshold. Figures 2.11 (a) and 2.12 (a) show the probability of still receiving RSA 12 and 24 months after entrance respectively. The dots capture unconditional means by the date of entrance. The figures suggest that vast majority of persons who entered the RSA keep the transfer persistently, and no discontinuity can be seen at the date of the policy change.

Figures 2.11 (b) and Figure 2.12 (b) display the probability of working 12 and 24 months after becoming disabled as an RSA recipient respectively, by the date of entrance. The figures suggest that employment rate of new-entrants is lower on average on both horizons, however, employment rate exhibits high volatility. Figure 2.11 (c) and 2.12 (c) show the share of RSA entrant earners with wage above the new earnings limit, 80% of the statutory minimum wage, 12 and 24 months after the entrance. Figure 2.11 (d) and 2.12 (d) display wages in another way: they show mean of the wages relative to the minimum by date of entrance. Note that these charts contain all persons who entered RSA at a given date, regardless that they still receive the benefit or already left it at the date of evaluation. The RD charts of wage per minimum wage and the share of wages above 80% suggest that new-entrants have significantly lower wages than old-entrants.

The following tables summarize results of the sharp RD estimations. I present estimations in which the outcomes are evaluated 12, 18 and 24 months after the entrance. As a robustness check, I also present estimations for a fixed date, December 2009. The following covariates are added as controls: age, gender, the pre-disability wage or pre-disability probability of working. The pre-disability wage shows the wage/minimum wage ratio 12 months before becoming eligible to RSA, and it added as a control for discontinuity estimations of wage outcomes and the RSA beneficiary rate. In the RD estimation of probability of working on different horizons after entering the disability, I apply the pre-disability working status as a control, which is the probability of working 12 months before the entrance.

In order to control for the effect of changes in the macroeconomic environment in the fixed window estimations, I add two monthly macro variables from the macro statistics. The *ln total economy employment* shows the logarithm of total economy employment from the LFS statistics, seasonally adjusted and *total economy w/minimum wage* shows the logarithm of average gross wages compared to the minimum wage. Table 2.5 - 2.8 contain nonparametric RD estimations using the method of Calonico et al. (2014b), applying triangular kernel. One common bandwidth is selected on both sides of the cutoff by minimizing the MSE of the treatment effect. The table contains the treatment effect (denoted by τ) of conventional and the bias-corrected RD estimation of the treatment effect, the latter is displayed also with the conventional and with robust standard errors. Relative τ shows the bias corrected treatment effect of the last three observations of the outcome variable below the cutoff, that is, the average of the outcome variable of RSA entrants between

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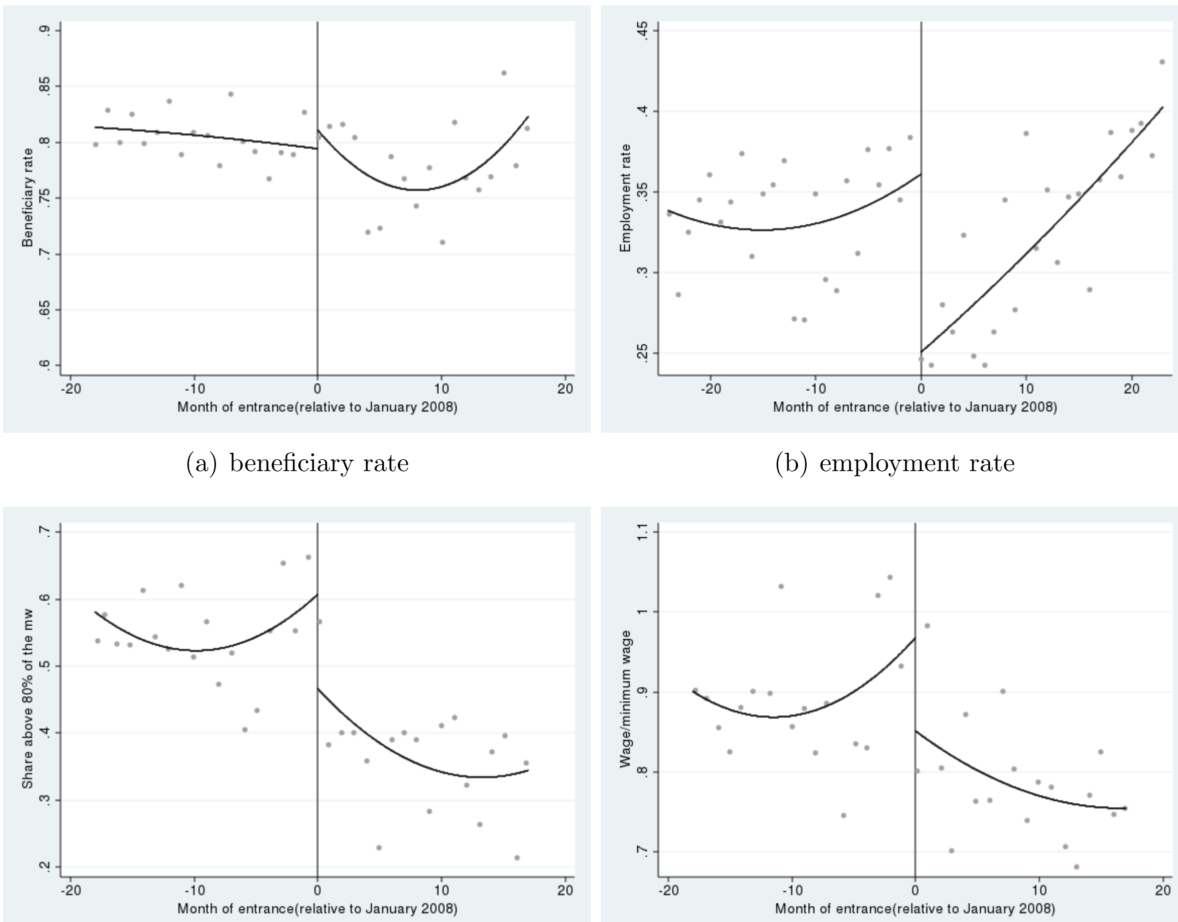
Figure 2.12: Extensive and intensive margin reactions 24 months after the entrance



(a) beneficiary rate

(b) employment rate

(c) wage above 80%mw

(d) wage to mw

The figures contain unconditional means of the outcome variable and a fitted polynomial of order 2 of individuals who entered RSA by the month of entrance into RSA, from 18 months before to 18 months after January 2018.

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October-December 2007. [14]

Table 2.5: RDrobust: discontinuity in probability that the wage exceeds 80% of the minimum wage 12, 18, 24 months after entrance and in December 2009

Dep.var	(1) wage above 80% of the mw 12m	(2) wage above 80% of the mw 18m	(3) wage above 80% of the mw 24m	(4) wage above 80% of the mw Dec 2009
τ Conventional	-0.226***	-0.186***	-0.318***	-0.182***
	(0.0595)	(0.0661)	(0.0992)	(0.0644)
τ Bias-corrected	-0.230***	-0.198***	-0.365***	-0.203***
	(0.0595)	(0.0661)	(0.0992)	(0.0644)
τ Robust	-0.230***	-0.198**	-0.365***	-0.203***
	(0.0712)	(0.0772)	(0.119)	(0.0745)
Relative τ	-0.39	-0.34	-0.58	-0.34
Observations	5,250	5,110	4,909	6,011
Covariates	YES	YES	YES	YES
Macro controls	YES	YES	YES	NO
Conventional SE	0.0595	0.0661	0.0992	0.0644
Robust SE	0.0712	0.0772	0.119	0.0745
BW Loc. Poly. (h)	15.78	12.92	6.301	13.84
Eff. obs left	927	673	300	741
Eff. obs right	506	414	180	447

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age, wage 12 months before entrance. Macro control: total economy wage to minimum wage. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

The most robust result is that the probability that the wage is above 80% of the minimum wage, if someone works, is significantly lower for new-entrants on all horizons (Table 2.5. The discontinuity is significant in all specifications (parametric and nonparametric estimations 12,18 and 24 months after the entrance and at a fixed date, December 2009). The estimated probability that the received wage exceeds the 80% of the minimum wage is lower for new-entrants by 0.19-0.36 percentage points depending on the horizon which

[14] In the Appendix, Tables B.1 - Table B.6 show the simple parametric estimations, using linear model, applying two bandwidth: 6 and 12 months.

Table 2.6: RDrobust: discontinuity in wage to minimum wage 12, 18, 24 months after entrance and in December 2009

Dep.var	(1) wage/minw 12m	(2) wage/minw 18m	(3) wage/minw 24m	(4) wage/minw Dec 2009
τ Conventional	-0.280***	-0.165*	-0.167	-0.157**
	(0.0763)	(0.0868)	(0.107)	(0.0781)
τ Bias-corrected	-0.287***	-0.172**	-0.206*	-0.179**
	(0.0763)	(0.0868)	(0.107)	(0.0781)
τ Robust	-0.287***	-0.172	-0.206*	-0.179*
	(0.0910)	(0.105)	(0.124)	(0.0928)
Relative τ	-0.30	-0.18	-0.21	-0.18
Observations	5,407	5,244	5,034	6,067
Covariates	YES	YES	YES	YES
Macro controls	YES	YES	YES	NO
Conventional SE	0.0763	0.0868	0.107	0.0781
Robust SE	0.0910	0.105	0.124	0.0928
BW Loc. Poly. (h)	10.87	9.723	9.609	13.40
Eff. obs left	587	506	492	744
Eff. obs right	367	320	302	453

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age, wage 12 months before entrance. Macro control: total economy wage to minimum wage. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

is consistent with a 32-58% decrease in relative terms. The wage/minimum wage ratio is also lower for new-entrants on all horizons. After 12 months of entrance, the difference is sizable: wage/minimum wage ratio is lower by almost 30 % (Table 2.6). Taking into consideration that before the reform, the average pre-disability was in average 120-130% of the minimum wage, that is, in average, the wage ceiling was reduced by around 20 %, the estimated effect on wages can be regarded as significant. The estimated parameter is also negative, but not significant at 5% level 24 months after the entrance and in the fixed-date, December 2009 estimation. Note that the group of newcomers include all entrants, regardless whether they still receive the benefit or not at the time of the evaluation, so lower wage of newcomers is not self-evident. If many entrants left the RSA in the first year and took a highly paid job, we could observe that newcomers have higher wage on average. However, there is no sign of discontinuity in beneficiary rate in any of the specifications, suggesting that the lower wage ceiling has not influenced the choice of exit from the RSA (Table 2.8).

Table 2.7: RDrobust: discontinuity in probability of working 12, 18, 24 months after entrance and in December 2009

	(1)	(2)	(3)	(4)
Dep.var	work 12m	work 18m	work 24m	work Dec 2009
τ Conventional	-0.089***	-0.041	-0.117***	-0.046
	(0.033)	(0.056)	(0.034)	(0.031)
τ Bias-corrected	-0.092***	-0.046	-0.125***	-0.043
	(0.033)	(0.056)	(0.034)	(0.031)
τ Robust	-0.092**	-0.046	-0.125***	-0.043
	(0.038)	(0.065)	(0.041)	(0.037)
Relative τ	-0.22	-0.12	-0.33	-0.12
Observations	26,559	25,519	24,458	27,451
Covariates	YES	YES	YES	YES
Macro controls	YES	YES	YES	NO
Conventional SE	0.0332	0.0560	0.0341	0.0312
Robust SE	0.0381	0.0651	0.0409	0.0375
BW Loc. Poly. (h)	10.81	4.432	9.584	11.94
Eff. obs left	2412	758	2087	2758
Eff. obs right	1709	779	1557	1891

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age, in work 12 months before entrance. Macro control: total economy employment. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

The treatment effect for the probability of working is significantly negative on a longer horizon, 24 months after the entrance, but it is significant only at 10% level on the 12 months horizon and not significant 18 months after the entrance and in December 2009. All in all, the results suggest the presence of the substitution effect: despite the low value of the RSA, many RSA recipient choose staying below the threshold rather than leaving the benefit and take a better paid job under the stricter wage restrictions, resulting in discontinuously lower wages of new-entrants. The income effect would imply higher exit rate from the transfer and higher wage of new-entrants, however, the results do not reveal any positive labor supply effect due to income effect.

Table 2.8: RDrobust: discontinuity in beneficiary rate 12, 18, 24 months after entrance and in December 2009

	(1)	(2)	(3)	(4)
Dep. var	beneficiary rate 12m	beneficiary rate 18m	beneficiary rate 24m	beneficiary rate Dec 2009
τ Conventional	0.002	-0.019	0.026	-0.015
	(0.024)	(0.032)	(0.041)	(0.043)
τ Bias-corrected	0.001	-0.012	0.041	-0.008
	(0.024)	(0.032)	(0.041)	(0.043)
τ Robust	0.001	-0.012	0.041	-0.008
	(0.029)	(0.037)	(0.048)	(0.051)
Relative τ	-0.00	-0.01	0.05	-0.01
Observations	13,905	13,362	12,800	14,459
Covariates	YES	YES	YES	YES
Macro controls	YES	YES	YES	NO
Conventional SE	0.0241	0.0320	0.0406	0.0430
Robust SE	0.0287	0.0368	0.0484	0.0512
BW Loc. Poly. (h)	12.98	11.67	9.049	7.948
Eff. obs left	1627	1473	1204	884
Eff. obs right	1158	1079	887	662

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age, wage 12 months before entrance. Macro control: total economy wage to minimum wage. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

Total income

Lower wages, similar or lower employment rate and similar beneficiary rate of new-entrants compared to old-entrants indicate that total income (the benefit plus earnings) is probably lower for the new-entrants (see Figures 2.13 a)-c). The estimation on total income confirm this assumption on the 12 and 24 months horizon, however, the 18 months and the fixed date (December 2009) specifications show no discontinuity, so the results are not robust to the chosen horizon. The volatility in wages and in employment rate by entrance date adds up in the total income, and as the number of observations is relatively low, the treatment

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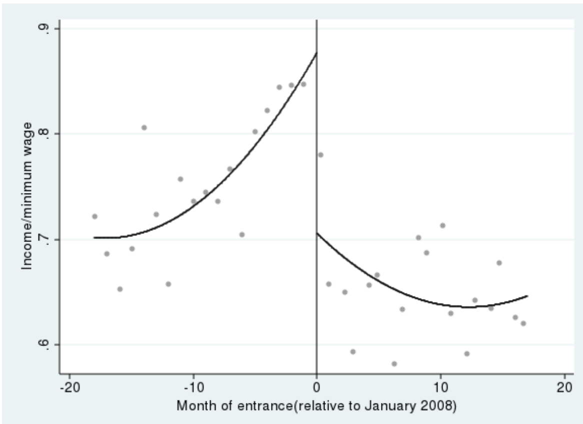
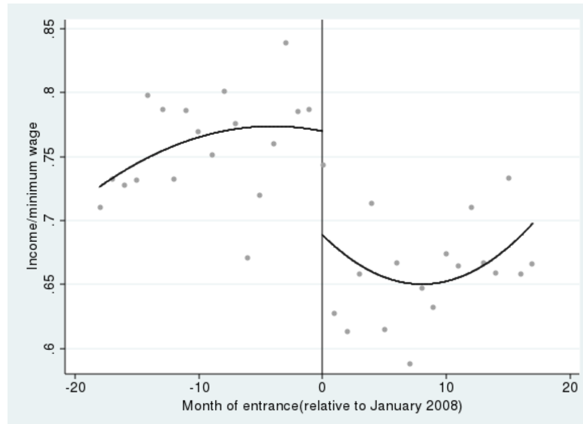
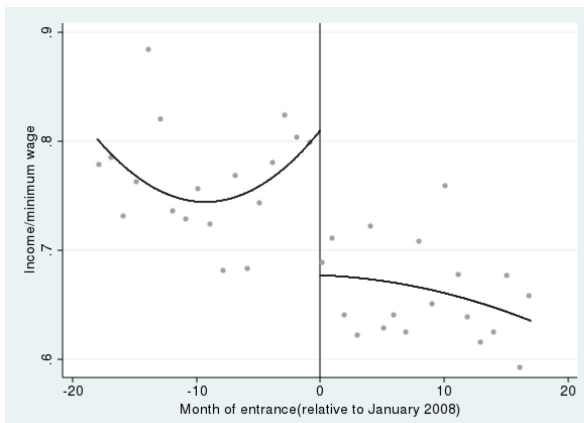
Figure 2.13: Total income (benefit+wage), 12, 18 and 24 months after entering disability



(a) 12 months



(b) 18 months



(c) 24 months

The figures contain unconditional means of the outcome variable and a fitted polynomial of order 2 of individuals who entered RSA by the month of entrance into RSA, from 18 months before to 18 months after January 2018.

effect can not be estimated precisely.

Table 2.9: RDrobust: total income 12, 18, 24 months after entrance and in December 2009

Dep.var	(1) 12m_after	(2) 18m_after	(3) 24m_after	(4) in Dec 2009
Conventional	-0.208***	-0.0676	-0.240***	-0.0867
	(0.0633)	(0.0699)	(0.0832)	(0.0558)
Bias-corrected	-0.214***	-0.0674	-0.265***	-0.0737
	(0.0633)	(0.0699)	(0.0832)	(0.0558)
Robust	-0.214***	-0.0674	-0.265***	-0.0737
	(0.0760)	(0.0829)	(0.0976)	(0.0662)
Relative τ	-0.277	-0.0831	-0.322	-.090
Observations	13,905	13,362	12,800	14,459
Covariates	YES	YES	YES	YES
Macro controls	YES	YES	YES	NO
Conventional SE	0.0633	0.0699	0.0832	0.0558
Robust SE	0.0760	0.0829	0.0976	0.0662
BW Loc. Poly. (h)	12.82	7.370	5.518	13.57
Eff. obs left	1627	884	598	1798
Eff. obs right	1158	662	481	1251

The sample consists of RSA entrants between 20-60 years. Nonparametric estimation, applying triangular kernel. Covariates: gender, age, wage 12 months before entrance. Macro control: total economy wage to minimum wage. One common bandwidth is selected on both sides of the cutoff minimizing the MSE of the treatment effect.Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

2.4.4 The response to the reform: a DiD framework

The discontinuity found in the pre-disability wage and employment might raise concerns about the validity of the RD design as it suggests that new-entrants close to the threshold are different, thus the estimated effect might reflect sorting instead of response to the policy change. In addition to controlling for n pre-disability wages and employment in the RD estimations, the sorting problem is addressed by estimating the labor supply effects in a difference-in-difference framework, as follows.

The treatment group consists of new-entrants, who gained eligibility to RSA between 1 January 2008 an 31 December 2008. The control group includes old-entrance with date of entrance between 1 January, 2007 and 31 December, 2007. The outcomes are estimated

12 months before and after the entrance. The macroeconomic environment is controlled for in two ways adding quarter dummies to the estimation and adding a macroeconomic variable.

The following outcome variables are estimated: being employed (work indicator), wage relative to the minimum wage, and total income. The outcomes of new-entrants and old-entrants are evaluated 12 months before and 12, or 24 months after the entrance.

Similarly to the baseline RD approach, the employment status and wage of the RSA recipients are evaluated at different calendar months, in a time period of the financial crises, when the macroeconomic environment is volatile. In order to control for the changes in the macroeconomic environment, I run two estimations. In the first, quarter dummies are added to the regression, and in the second, I added the total economy wage/minimum wage as a control variable, that changes from time to time.

The estimated model:

$$Y_{it} = \beta_1 Newentrant_i + \beta_2 After_t + \delta Newentrant_i * After_t + \beta_3 X_{it} + T_t + \epsilon_{it}$$

where i denotes persons and the t the calendar time. Y_{it} stands for the wage to minimum wage, being employed, or total income. $Newentrant_i$ is a dummy variable that equals 1 if the entrance date is after 1 January 2008, and $After_t$ is a dummy variable that equals 1 if the person is observed after entering to RSA, that is if $t >= entry\_date_i$. T_t is 1) and indicator variable of the actual quarter Q_t or 2) Total economy wage/minimum wage or employment. X includes age and gender.

The treatment and the control groups are compared 12 months before and 12 or 24 months after the entrance. The outcomes are $t = entry\_date_i + / - 12 months$ or $entry\_date_i + 24 months$ and $entry\_date_i - 12 monhts$ The sample contains individuals where

$1\ January\ 2007 <= entry\_date <= 31\ December\ 2008$

The analysis for the RSA recipient rate contains only the quarter dummy and the treatment indicator, as the RSA beneficiary rate is uniformly zero for both new-entrants and old-entrants before the crisis.

Table 2.10: Effect of the reform on the RSA beneficiary rate, 12 and 24 months after the regulation

	(1)	(2)
	12 m	24 m
VARIABLES	RSA rate	RSA rate
New-entrant	-0.006	-0.024
	(0.016)	(0.022)
Age	-0.005***	-0.006***
	(0.001)	(0.001)
Male dummy	-0.030***	-0.051***
	(0.009)	(0.012)
Constant	1.176***	1.154***
	(0.026)	(0.040)
Observations	4,977	4,928
R-squared	0.020	0.020
covariates	YES	YES
macro contr	Qdum	Qdum

The sample consists of RSA entrants between 20-60 years. OLS estimation. Covariates: gender, age. Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

The results point to the same direction as the result of the RD estimations. The analysis of the RSA beneficiary rate confirms that exit from the RSA rate has not changed as an effect of the regulation (see Table 2.10).

The results for the DiD analysis are summarized in Table 2.11 2.12 and 2.13. The DiD estimations indicate both external and internal margin reactions to the new regulation: both the employment rate and the wage over the minimum wage proved to be lower for newcomers as a result of the reform, taking into account the pre-disability differences, both 12 and 24 months after entering into RSA. The same holds for the total income. The magnitude of the estimated policy impact varies depending on the method of controlling for the macroeconomic variable. While the direction of the DiD estimations is the same, the magnitude also differs from the RD results. Specifically, the the wage to minimum wage is lower (-0.125--0.155 on the 12 months horizon in DiD and -0.28 in the RD). However, the estimated policy effect the on the employment rate is larger. (On the 12 months horizon, the DiD estimations show -0.19--0.29, while the employment effect is -0.09 the RD). The main factor behind the differences is most probably the estimated trend within the two groups in case of the RD. In addition, the RD estimation employs a triangular kernel that gives a higher weight to cases near the cut-off and the window is also estimated, instead of applying an arbitrary 12 months window of the DiD.

Table 2.11: DiD: effect of the reform on the employment rate, 12 and 24 months after the regulation

VARIABLES	(1) 12 m workw	(2) 12 m workw	(3) 24 m workw	(4) 24 m workw
After	0.017	-0.235***	-0.008	-0.372***
	(0.026)	(0.024)	(0.026)	(0.055)
Treated	0.209***	0.040**	0.210***	0.040**
	(0.027)	(0.016)	(0.027)	(0.016)
After_treated	-0.292***	-0.196***	-0.248***	-0.133***
	(0.038)	(0.030)	(0.038)	(0.020)
Age	-0.004***	-0.004***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Male	-0.014	-0.016	-0.013	-0.015
	(0.011)	(0.011)	(0.010)	(0.010)
Macro employment (ln)		-3.339***		-3.430***
		(0.801)		(0.866)
Constant	0.576***	28.282***	0.602***	29.066***
	(0.036)	(6.620)	(0.036)	(7.164)
Observations	9,987	9,987	9,938	9,938
R-squared	0.057	0.044	0.066	0.053
covariates	YES	YES	YES	YES
macro contr	Qdum	econ emp	Qdum	emp econ

The sample consists of RSA entrants between 20-60 years. OLS estimation. Covariates: gender, age. Robust standard errors are clustered by persons in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

2.5 Conclusion

This paper aims to add to the debate whether disability benefit wage restrictions behave as a cash-cliff by analyzing a policy change which decreased the earnings limit accompanied

Table 2.12: DiD: effect of the reform on wage to minimum wage, 12 and 24 months after the regulation

	(1)	(2)	(3)	(4)
	12 m	12 m	24 m	24 m
VARIABLES	w to mw	w to mw	w to mw	w to mw
After	0.044	-0.095***	0.083	-0.098***
	(0.063)	(0.031)	(0.065)	(0.030)
Treated	-0.053	-0.054	-0.052	-0.052
	(0.051)	(0.044)	(0.051)	(0.044)
After*treated	-0.155**	-0.125**	-0.178**	-0.042
	(0.076)	(0.050)	(0.080)	(0.049)
Age	0.005***	0.005***	0.004**	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
Male	0.111***	0.106***	0.107***	0.102***
	(0.034)	(0.034)	(0.036)	(0.035)
Macro w_to_mw		0.075		0.066
		(0.086)		(0.091)
Constant	0.626***	0.505*	0.663***	0.564*
	(0.101)	(0.278)	(0.105)	(0.293)
Observations	4,382	4,382	4,297	4,297
R-squared	0.023	0.014	0.017	0.009
Covariates	YES	YES	YES	YES
Macro contr	Qdum	econ emp	Qdum	emp econ

The sample consists of RSA entrants between 20-60 years. OLS estimation. Covariates: gender, age. Robust standard errors are clustered by persons in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

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Table 2.13: DiD: effect of the reform on total income, 12 and 24 months after the regulation

VARIABLES	(1) 12 m inc_to_mw	(2) 12 m inc_to_mw	(3) 24 m inc_to_mw	(4) 24 m inc_to_mw
after	0.289***	0.118***	0.257***	0.099
	(0.038)	(0.038)	(0.036)	(0.087)
treated	-0.029	-0.057*	-0.029	-0.050
	(0.035)	(0.031)	(0.035)	(0.032)
after_treated	-0.148***	-0.104**	-0.089*	-0.039
	(0.051)	(0.043)	(0.047)	(0.029)
Age	0.002	0.002*	0.002*	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Male	0.042**	0.041**	0.051***	0.050***
	(0.019)	(0.019)	(0.019)	(0.019)
ln_empecon_f		-1.697		-0.856
		(1.256)		(1.373)
Constant	0.459***	14.529	0.453***	7.570
	(0.057)	(10.389)	(0.057)	(11.366)
Observations	9,987	9,987	9,938	9,938
R-squared	0.017	0.011	0.017	0.011
covariates	YES	YES	YES	YES
macro contr	Qdum	econ emp	Qdum	emp econ

The sample consists of RSA entrants between 20-60 years. OLS estimation. Covariates: gender, age. Robust standard errors are clustered by persons in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

to the disability benefit of moderately disabled individuals in Hungary in 2008. Although disability earnings limits are often blamed for their embedded negative work incentives, their labor supply effect is not straightforward even in priori, and the empirical evidence is mixed.

Beneficiaries lose their eligibility to the benefit if their earnings exceed the earnings limit, resulting in a discontinuous drop in total income. The aim of this threshold is to constrain deadweight losses and fiscal costs of the program by withdrawing benefit eligibility from those who have regained majority of their working capacity. However, the threat of losing the benefit may induce recipients to take a job with a wage under the limit instead of using their full earning capacity. In a simple static labor supply framework I show that the effect is not clear a priori. The RD and DiD estimation results suggest that disabled persons do not fully use their earning capacity under the low earnings limit, rather they constrain their labor supply and choose their amount of work to remain eligible to the benefit, perhaps because leaving the RSA increases the risk of remaining without income. The results suggest the presence of the substitution effect: despite the low value of the RSA and the low level of the new earnings limit, many RSA recipient choose staying below the threshold rather than leaving the benefit and take a better paid job under the stricter wage restrictions, resulting in discontinuously lower wages of new-entrants. Although the magnitude of the estimated parameters varies across specifications, the direction is the same and the results indicate that a low earnings limit might prevent disabled beneficiaries from fully using their remaining working capacity even if the level of the benefit is very low. Although it can not be ruled out that the inflow to RSA has reduced due to the reform, similar beneficiary rate of new-entrants suggests that the stricter employment rules have not yielded sizable cost saving to the government, but left moderately disabled persons with lower wage income.

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Chapter 3

Economic growth and real exchange rate misalignments in the European Union

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3.1 Introduction

We start from the statistical observation that there is a very close spatial (cross-county) association between relative real incomes, comparative price levels and price structures within the EU (e.g., Podkaminer (2010) and Berka et al. (2012).[1] Higher (lower) levels of real incomes tend to be accompanied by higher (lower) general price levels, as well as higher (lower) relative prices of services to goods. We shall refer to the comparative general price level – the ratio of the purchasing power parity (PPP) of GDP to the nominal exchange rate – as the overall real exchange rate (RER). The ratio of the comparative price level of services to goods, in turn, is considered as an indication of the internal RER.

As attested by subsequent rounds of the Penn World Tables (PWT), the positive correlation between real incomes and price levels is a global phenomenon (Feenstra et al.

[1]The term „comparative" refers to the fact that spatial price levels/structures can be interpreted only in comparison to a reference country or a group of countries, e.g., the average of the EU.

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(2015)), but it holds much more closely within the EU. This relationship, however, does not generally hold at each point in time, or in the short-to-medium run for individual countries. Our study aims to investigate the implications of such "disconnects" between levels (structures) of relative prices and relative real incomes. We shall refer to these disconnects as *misalignments* of the overall/internal RER from relative real incomes. Our primary interest lies in the relationship between misalignments and economic growth.

The concept of misalignment presumes that there is a "non-misaligned" (benchmark or "neutral") level/structure of prices corresponding to the actual state of economic development of a particular country. The basic notion underlying our study is that within a group of countries consisting of members at considerably different levels of economic development, but closely integrated by trade, capital and labor flows – such is the EU – the overall pattern reflecting the relationship between relative prices and incomes for the group as a whole offers guidance for judging RER-misalignments in individual members of the group. This practically means that in this study the regression line (more precisely: regressions based on alternative specifications) expressing the relationship between prices and incomes for the EU as a whole is (are) taken as the benchmark(s) for the empirical interpretation of misalignments in member-states. Positive/negative deviations from the benchmark are interpreted as indications of over/undervaluation with respect to the specified benchmark.

We first quantify indicators of misalignment, and continue by investigating the relationship between misalignment and growth in per capita GDP. Similarly to other works on the topic (e.g., Aguirre and Calderon (2005); Gala (2008); Rodrik (2008); Habib et al. (2017)), we complement standard growth equations with indicators of misalignment. While following the two-step procedure of earlier studies, our article intends to contribute to the literature on the relationship between RER-misalignments and economic growth in several respects.

First, and most importantly, the literature on this topic has mainly addressed the experiences of developing countries, or a very broad set of countries; just a few studies dealt specifically with the EU. Our work, in turn, focuses on the experiences of the present member-states of the EU, consisting of countries at medium and high levels of income. Their economies are deeply integrated and most are very open, implying that the RER has an important economic role.

Second, studies related to our topic generally rely on the overall RER (the comparative price level of GDP) for quantifying misalignments. We draw on the internal RER (the relative price of services to goods) as well, since indicators of misalignment based on internal relative prices may capture the effect of domestic price distortions – not necessarily reflected by indicators of external RER-misalignment. The internal relative price of services to goods, in contrast to the relative price of GDP is not directly influenced by the changes in nominal exchange rate. Hence, it can be especially relevant among countries of the Eurozone. A further reason for addressing the relative price of services to goods is that it can be considered as a proxy for the relative price of non-tradables to tradables, which is essential in supply-side explanations of the association between the RER and the level of economic development. Moreover, demand-side explanations of this association also stress the role of the relative price of services to goods.

Third, we address several aspects of country level heterogeneity in our sample. In particular, we intend to clarify, whether the level of development, approximated by belonging to the Central and East-European (CEEU) member-states, or maintaining a fixed exchange rate regime makes a difference in the relationship between misalignment and growth. We also investigate asymmetries (over- vs undervaluation) and nonlinearities in the growth-misalignment relationship.

Fourth, we amend earlier endeavours to identify the channels through which RER misalignments may hurt or assist economic growth. Besides investments, already addressed in previous studies (e.g., Razmi et al. (2012)), we investigate the relationship between misalignments and alternative indicators of external trade performance. Since the majority of EU-countries are very open, the "competitiveness-channel" is an important link between misalignments and economic growth.

Fifth, beyond results based on estimations of RER-misalignments, we also consider estimates relying on "wage-misalignments" , as interpreted by discrepancies between labour costs and productivity.

As compared to the results of the related literature, covering a larger sample of countries, in our sample including the EU27, the long term coefficient between the GDP price level and relative indicators of development, as well as the explanatory power of economic development in the price level of GDP and internal relative prices can be regarded as high. The relationship between relative GDP variables and relative internal prices is comparably strong, with the slope being less steep.

Our results indicate that the contemporaneous real exchange rate misalignment is associated with economic growth: a 10% over/undervaluation is accompanied by 0.1-0.6 percentage point lower/higher rate of growth across different specifications. The magnitude is similar for or two RER indicators: the price level of GDP and the internal relative price. This effect is substantial, considering the fact that the mean annual growth rate of per capita GDP was 2.3% in the EU27 over the period covered by our analysis. However, the statistical significance of the results is sensitive to the specification and the composition of the sample. A robust finding of the study is that the relationship between growth and misalignment, both in the GDP price level and in internal relative prices, is attributable mostly to countries operating under fixed exchange rate regimes, i.e., to Eurozone countries and CEEU countries with pegged exchange rates. Regarding the price level of GDP, we find that the positive relationship between undervaluation and growth diminishes with the degree of undervaluation. We find that an increase in misalignment – that is, moving towards overvaluation - has negative effect on both export market shares and the ratio of private gross fixed capital formation to GDP, indicating that both the competitiveness and the investment channel have an important role in connecting the effects of RER-misalignments with economic growth. We find that both relative price of GDP and the internal relative price plays a role in the propagation mechanism.

An important finding is that in majority of the specifications, the internal relative price exhibits similar effect as the relative price of GDP. This result points to the robustness of our results to alternative indicators. As internal relative price reflects structural differences in prices and only indirectly influenced by the nominal exchange rate, our results indicate that RER changes might play an important role also without nominal exchange rate fluctuations.

The rest of the paper is structured as follows. In the next section we define the key concepts of the study, review the related literature and present stylized facts related to our analyses. In section 3 we estimate alternative measures of RER-misalignment. Section 4 presents the results of our estimations regarding the relationship between economic growth and RER-misalignments. Section 5 addresses issues related to misalignments of wages. In Section 6 we draw conclusions and indicate further lines of research.

3.2 Key concepts, background and stylized facts

3.2.1 Concepts

Three statistical concepts, matching three economic concepts, are central for our further analyses. The first is the cross-country (or spatial) comparative price level index of GDP, which we regard as an indicator of the overall real exchange rate (RER) level. The second is the spatial volume index of GDP per capita (or per labor input) – generally considered to be the indicator of the level of real income (or labor productivity). The third is the ratio of the spatial price level index of services to goods; we consider it as an indicator of the internal RER. In our empirical analyses we rely on the Eurostat PPP-database (containing PPPs calculated from the expenditure side of GDP) for quantifying these indicators.

(i) A cross-country price level index can be interpreted analogously to a price index measuring the change in price levels over time. The difference is that an ordinary price index, such as the CPI, reflects the change in prices between two points in time, while a spatial price index expresses the difference in price levels between countries at a point in time. A price level (PL) index is always measured relative to a reference country, or a group of countries (our choice is the latter: the average of the EU15). It is defined as the ratio of a purchasing power parity (PPP) to the nominal exchange rate (E) with respect to the reference group, i.e., $PL = PPP/E$. [2]

It should be stressed that PPPs (and, by implication, price level indices) for different expenditure categories of GDP are likely to differ for individual countries, implying that there is no such thing as "the" PPP of a currency. Therefore, it is essential to indicate: for which particular category a PPP (PL index) applies. Our analyses involve three mayor expenditure categories: the GDP, total goods and total services, whose respective price level indices in country i relative to the EU15 are denoted by $PLgdp^i$, PLg^i *and* PLs^i. r

Our overall price level index is based on the PPP for the GDP:

$PLgdp^i = PPPgdp^i/E$, where $PPPgdp^i = Pgdp^i/Pgdp^{EU15}$.

$PLgdp^i$ shows how much higher/lower the general price level of country i is relative to the EU15-average. In the following we refer to $PLgdp$ as the overall real exchange rate (RER). Note that in analyses of exchange rate developments, usually the inverse of our indicator (the ratio of the nominal exchange rate index to a relative price or cost index) is considered to reflect changes in RERs. According to our definition, an increase in the RER indicates appreciation, while a decrease indicates depreciation.

[2] The PPP reflects the purchasing power of the domestic currency relative to a reference region. Our empirical work relies on the PPP database of the Eurostat, which expresses the purchasing power of currencies as compared to an artificial currency unit, called purchasing power standard (PPS). The PPS is defined so that 1 PPS has the same purchasing power as 1 euro with respect to an average of EU member-states. In other words, the PPS shows the cost of a basket in country i, which costs 1 euro in the average of (a group of) EU countries. Since the time series for certain items, in particular, goods and services, expressed in PPS-EU28 are relatively short, our analyses rely on data measured in PPS-EU15.

(ii) Spatial volume indices are obtained by dividing the nominal value index of a particular category (expressed in euro) by the PL of the respective category. The volume level index we rely on is that of per capita GDP ($VLCgdp^i$) relative to the EU15. This indicator reflects the relative level of development (or relative real income) of a country, and it is also referred to as "real" per capita GDP in international comparisons. If GDP per labor input (persons employed or hours worked) is considered, an indicator of the relative level of labor productivity is obtained.

(iii) We define the *internal relative price* of two aggregates (components of GDP) as the ratio of their price level indices. For the purposes of our study, the most important internal relative price is that of *services to goods*, defined as $RPsg^i = PLs/PLg^i$. We consider this ratio as a measure of the *internal real exchange rate*. Similarly to the overall RER, its increase (decrease) involves the appreciation (depreciation) of the RER. It can be considered either as a proxy of the relative price of non-tradables to tradables, or as an indicator on its own right[3].

3.2.2 Background and a selective review of the related literature

Our article builds upon, and contributes to, a rich and prolific strand of research in international economics, namely, the literature on the relationship between economic growth and real exchange rate (RER) misalignments. Within this strand, our work is related to the line of research that interprets misalignments as deviations from the estimated price level of GDP consistent with the level of economic development. This approach involves three steps: (i) identifying the benchmark (or "neutral") RER, relative to which misalignment is interpreted; (ii) estimating the sign and size of misalignments; (iii) estimating the association between economic growth and indicator(s) of misalignment, controlling for other variables potentially affecting growth. In the following we review the conceptual background of, and the literature related to, these steps.

[3] It should be stressed that the internal relative price indicator is also interpreted to a reference group: it shows how the price level of services is related to the price level of goods in the home country, as compared to the EU15.

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The interpretation of the “neutral” RER: the PPP adjusted for the “Penn-effect”

Our point of reference for interpreting RER-misalignments is the purchasing power parity (PPP), adjusted for cross-country differences in relative levels of development. In its original form, the absolute version of the PPP theory of exchange rates claims that the equilibrium RER (ERER) corresponds to the PPP.[4] In the following, we avoid the notion of ERER, and focus at the background of adjusting the PPP for the level of development.

The idea that a positive relationship exists between levels of (changes in) RERs and levels of (changes in) economic development has a long tradition, but the association between the two has first been statistically demonstrated, accompanied by a model-based explanation, in seminal article Balassa (1964) on the reappraisal of the PPP theory. Samuelson (1964), independently from Balassa, also criticised the PPP-theory, relying on a similar model, and eventually the close positive association between national price and per capita GDP (income) levels came to be known as the “Balassa-Samuelson *effect*”. Samuelson (1994), however, considered it important to clearly distinguish the observed statistical regularity, which he coined the “*Penn-effect*” [5], from one of its possible explanations, i.e., the Balassa-Samuelson (BS) *model*.[6]

There are several layers of understanding/explaining the Penn-effect; here we refer only to two of these.[7] One relates to the following question: the relative price of which particular GDP-aggregate is chiefly responsible for the observed effect? In this respect, there has been a broad consensus among economists and economic statisticians: mainly the relative price level of services increases in line with the level of economic development (for earlier works

[4] Cassel (1922). The PPP-theory implies that the equilibrium level of PL (PPP/E) is 1.

[5] Samuelson referred to the results of international comparisons performed in the framework of the ICP project in which the University of Pennsylvania had a major role. The Penn World Table (PWT) constitutes a major statistical source for worldwide comparisons of real GDP and its components. The data indicate a close positive association between the level of real incomes and relative price levels of GDP.

[6] The term “Balassa-Samuelson model” was suggested by Asea and Corden (1994). For reviews on alternative tests of the model, see e.g. Égert et al. (2006) and Tica and Družić (2006).

[7] It should be noted that while the Penn-effect works among countries at considerably different levels of economic development, it does not appear to be significant within the most and the least developed group of countries; see Rogoff (1996) and Hassan (2016) on this point.

see e.g., Harrod (1933); Clark (1940); Fourastié (1950); Kuznets (1971).

The second question concerns explanations of the observed effect. The most well-known is the BS model, which, building on rather restrictive assumptions, focuses on differences in productivity between tradables (approximated by goods) and nontradables (approximated by services), and attributes the differences in overall price levels to the higher productivity of producing goods relative services in more advanced economies. The discussion on the relevance of the "productivity channel" has continued ever since its exposition.[8] An alternative explanation was offered by Bhagwati (1984), who built his model on differences in factor endowments of the two sectors.

There is, however, a long tradition of explanations from the demand side as well (in particular Fourastié (1950), but there were several later attempts in this vein (e.g., Bergstrand (1991); Podkaminer (2011)). Bergstrand's model was based on the assertion that services are "luxury goods" while tradable commodities are "necessities" . Therefore, as national income grows, the demand for services increases more than that for goods, which results in an appreciation of the RER. His results supported the hypothesis that, beside the supply-side, there is a demand-side channel responsible for the observed regularity. With respect to the catching-up process within the EU, Égert (2010) also provided evidence for the importance of the demand-side channel.

In the further part of the study we do not deal with alternative explanations; we simply consider the Penn-effect as a statistically firmly based stylized fact, which, as documented in Section 3.2.3, certainly holds for the EU27 in the period in our focus.

Estimating RER-misalignments and their effect on economic growth

Several studies discussed the implications of exchange rate misalignments, in particular, the negative effects of overvaluations on economic growth in developing countries.[9] There were some earlier attempts to combine the relationship between price levels and levels

[8]A thorough review of the related literature is provided by Devereux (2014). For a recent contribution, challenging the notion that higher productivity growth is accompanied by RER-appreciation, see Gubler and Sax (2019)

[9]See e.g., Cavallo et al. (1990), Dollar (1992), Razin and Collins (1997)), Benaroya and Janci (1999), Acemoglu and Angrist (2001), Fajnzylber et al. (2005)

of economic development with differences in growth performances Dollar (1992)). However, the notion that deviations of RERs from levels implied by the "Penn effect" may be interpreted as RER-misalignments, capable to explain differences in growth rates, became popular and gained broader professional interest only in the late 2000s (Gala (2008), Eichengreen (2008), Podkaminer (2010), Rodrik (2008)).[10] Recent studies (e.g., Habib et al. (2017)), similarly to previous ones, found evidence that misalignments are negatively related to economic growth, but they also found, similarly to Rodrik (2008), that these results hold mainly for less developed countries and do not apply for countries at higher levels of economic development.

For the eurozone countries, Fischer (2007) and Andersson et al. (2009) For the CEEU countries, Cuestas et al. (2019) estimate the effect of the RER misalignment on growth in a two-step method for the 1995-2012 period, using quarterly data. However, they use real effective exchange rate indexes, that is, rely on within country variation in estimating misalignment and do not use cross-country differences in relative price levels. They also find that the overvaluation is harmful for growth, however, undervaluation has had only a limited impact on economic activity.

The results, naturally, depend on the way of calculating RER-misalignments. Balassa (1964) used a simple linear functional form, but later studies used a log-log form (Rogoff (1996), or Rodrik (2008)), or a quadratic form (Dollar (1992) or Easterly (2001)), while Bhalla (2012) estimated an "S-shaped" exponential model. The results are also sensitive to the chosen econometric method. Some authors estimated the misalignment using cross-sectional data for each year (e.g., Johnson et al. (2007)), while others applied advanced panel techniques (Prasad et al. (2007); Rodrik (2008); MacDonald and Vieira (2010)).

Several authors argued that that the benchmark ("neutral") RER is not only the function of the level of development; they suggested the inclusion of other variables in the equation for the estimation RER-misalignment. For example, Aguirre and Calderon (2005) controlled for differences in the terms of trade index, labour productivity and government spending in their RER equation. Depending on the included control variables, the estimation technique, the underlying assumptions and simplifications, many different concepts

[10]It should be noted that while several endeavours had been made to explain the underperformance of particular developed economies by RER-overvaluations (see in particular Kaldor (1966) and Kaldor (1971) on the UK and Corden (1984) on the "Dutch disease" , these interpretations did not refer to misalignments of RERs from levels implied by the level of development.

have been established for interpreting RER-misalignments (Isard (2007); Berg and Miao (2010)).

We summarized the results of some of the related studies in Table 3.1 The table shows the method applied, the sample chosen and the findings of the authors with respect to the estimated RER, as well as the estimated effect of misalignment. The works included in the table aim to clarify and compare (i) the estimated long-term relationship between different concepts of the RER and economic fundamentals, most importantly, the level of economic development; (ii) the effect of misalignment of the real exchange rate from its development-consistent value on growth, or both. The third column of the Table 3.1 confirms that there is a large variety of methods applied for estimating misalignment.

The effect of misaligned real exchange rates is usually measured by adding in some form the estimated misalignment to a growth regression, in addition to the usual variables affecting economic growth. Most approaches add the contemporary value of the misalignment. The majority of studies find that overvalued real exchange rates hamper growth contemporaneously, but there are exceptions. For example, Easterly (2001) found that if extreme values are excluded from the sample, overvaluation does not have detrimental effects. Béreau et al. (2012) do not support this finding, but call attention to non-linearities: larger misalignments have disproportionally larger effect. Most papers find that the direction of the deviation from the estimated benchmark-RER is symmetric in the sense that overvaluation is harmful and undervaluation is beneficial for growth.[11] This is the finding of Berg and Miao (2010) as well, but they also point out an identification problem: the same factors that contribute to growth, may also contribute to RER-changes and their misalignments.

The foregoing review, along with Table 3.1, shows the variety of methods for estimating the level of the RER consistent with the level of development, as well as the differences among findings of studies concerning the relationship between RER misalignment and economic growth, based on different samples and time periods. In the following we focus on the EU.

[11] Similarly to Berg and Miao (2010), we use the term "symmetric effect" of misalignments in the above sense, though we are aware that "symmetry" is sometimes considered to imply that both under- and overvaluations are harmful for growth. This, however, would involve an asymmetry in the sense that misalignments with a negative and a positive sign would both have a negative effect on growth.

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Table 3.1: A selective overview of estimates of RERs consistent with the level of development and the relationship between RER-misalignment and economic growth

	The level of the RER consistent with the level of development			Effect of misalignment	
Author	Sample	Method	Results	Method	Results
Kravis –Lipsey (1983)	34 developed and developing countries	Cross sectional regressions	High elasticity (0,6-0,9) for price level, somewhat lower (0,5-0,6) for internal relative price	-	
Fischer (2007)	Euro area	Panel, fixed effect, single equation	Elasticity of 0.5-0.6 for a one percent shock to relative productivity on relative price levels	-	-
Galstyan –Lane (2009)	1980-2004, OECD countries	Panel DOLS, country and time fixed effects, single equation	High elasticity, 0.75-1.1, gov. consumption increases, gov. investment decreases RER	-	-
Anderson et al. (2009)	Euro area countries	VECM	High elasticity, close to 1 in most countries		
Aguirre – Calderon (2005)	1965-1993; 60 developed and developing countries	Panel DOLS, country and time fixed effects, single eq.	High elasticity	Panel system GMM	Undervaluation accelerates, overvaluation decelerates growth
Rodrik (2008)	1950-2004, 188 developed and developing countries	Panel, time effect	Elasticity of 0.24	panel, 5 year averages, time and co fixed effect	Undervaluation accelerates growth but only in developing countries
MacDonald – Vierra (2010)	1980-2004, 90 developed and developing countries	Panel, fixed and random effect	Elasticity of 0.31; insignificant with controls	Panel, GMM	Undervaluation accelerates, overvaluation decelerates growth, effect is stronger for developing and emerging countries
Bereau et al. (2012)	1980-2007, advanced and developing countries (cca 25)	Panel fixed effect, pooled mean group estimator	Variables are cointregrated, all the three variables are significant	Nonlinear panel	Undervaluation accelerates, overvaluation decelerates growth, effect increases with the size
Bhalla (2012)	130 countries, 1950-2011	Multiple	Elasticity of 0.3-0.4	Multiple	Undervaluation accelerates, overvaluation decelerates growth, result is robust to specification and the method
Mbaye (2012)	72 countries, 1970-2008	Multiple	Low elasticity, 0.16	Multiple	Undervaluation accelerates, overvaluation decelerates growth through the TFP channel
Razmi et al. (2012)	153 countries, 1960-2004	Multiple	Elasticity of 0.24	Multiple	Undervaluation accelerates, overvaluation decelerates growth through the investment channel
Habib et al. (2016)	150 countries, 1970-2010	Panel	Elasticity of 0.24-0.27	Panel, based on IV	Undervaluation accelerates, overvaluation decelerates growth in developing countries, the effect is stronger with pegged ER
Berg – Miao (2010)	181 countries 1950-2004	Multiple	Elasticity of 0.23	Multiple	Undervaluation accelerates, overvaluation decelerates growth, but identification problems

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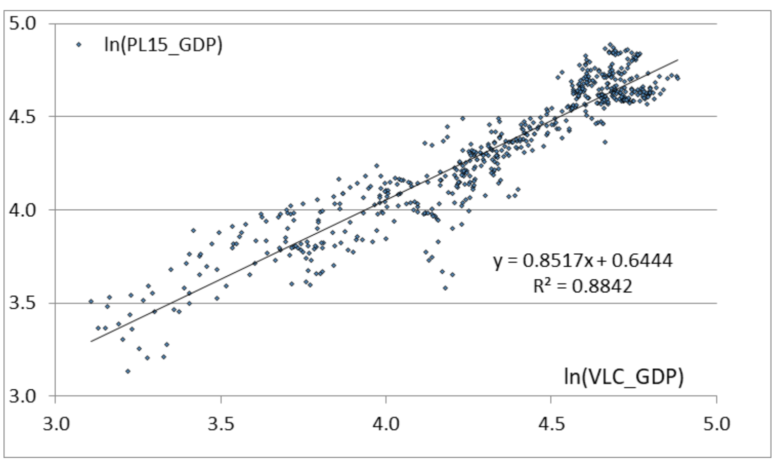
3.2.3 Stylized facts

In this section we demonstrate the close positive association within the EU between the price level of GDP (the overall RER) and the internal relative price of services to goods (the internal RER) on the one hand, and relative per capita GDP (the level of income), on the other. We also show that the first relationship (the Penn-effect) holds much more closely within the EU than worldwide. Finally, we document that changes in GDP price levels relative to the EU15 average (our indicator of the overall RER) are closely associated with changes in the GDP deflator-based real effective exchange rate (REER) index against 42 industrial countries. This finding suggests that our indicator of the overall RER represents relative price movements compared to a much broader set of countries than those belonging to the EU.

Figure 3.1 shows the association between the price level of GDP and per capita GDP in 27 EU-member states[12] relative to the EU15, based on the pooled cross section of the observations for the period 1995-2016.

Figure 3.1: The relationship between the price level of GDP and per capita GDP (measured at PPP) within the EU (pooled cross-section data, 1995-2016; EU15=100)



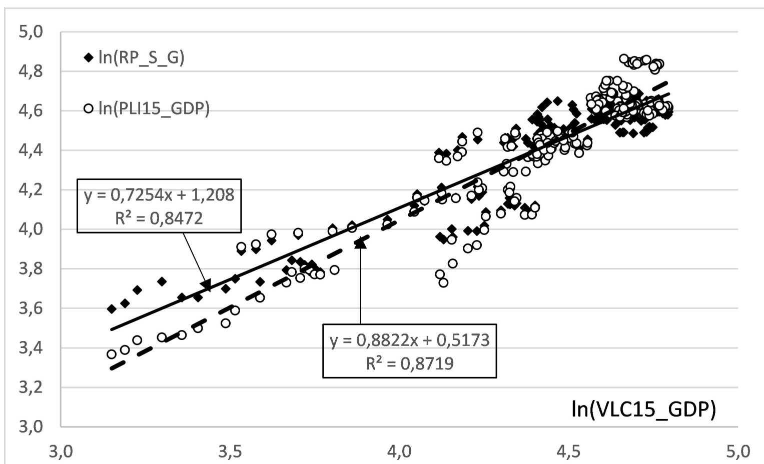
Notations: $PL15_GDP$: the price level of GDP; VLC_GDP: per capita GDP measured at PPP (both relative to the EU15). Source: Eurostat, PPP-database

Figure 3.1– reflecting the Penn-effect – shows that the association between the two vari-

[12]Luxembourg, an extreme outlier, is not included in our sample.

ables is indeed rather close ($R^2 = 0.88$), and the coefficient of per capita GDP (significant at 1%) shows that, on average, a one percent higher (lower) real income is accompanied by a 0.85 percent higher (lower) GDP price level. If we regress the GDP price level on GDP per worker (an indicator of labour productivity) for the same sample, we get a slightly higher elasticity, close to 0.9 (the R^2 is almost the same: 0.86), indicating that the close relationship between the GDP price level and the level of development does not depend on whether the latter is represented by real income or productivity.

Figure 3.2: The relationship between the price level of GDP, the internal relative price of services to goods (vertical axis) and per capita GDP (measured at PPP) within the EU (pooled cross-section, 1999-2016; EU15=100)



Notation: *RP_S_G*: the (internal) relative price of services to goods. For other notations see Figure 3.1.Source: see Figure 3.1 and own calculations based on Eurostat.

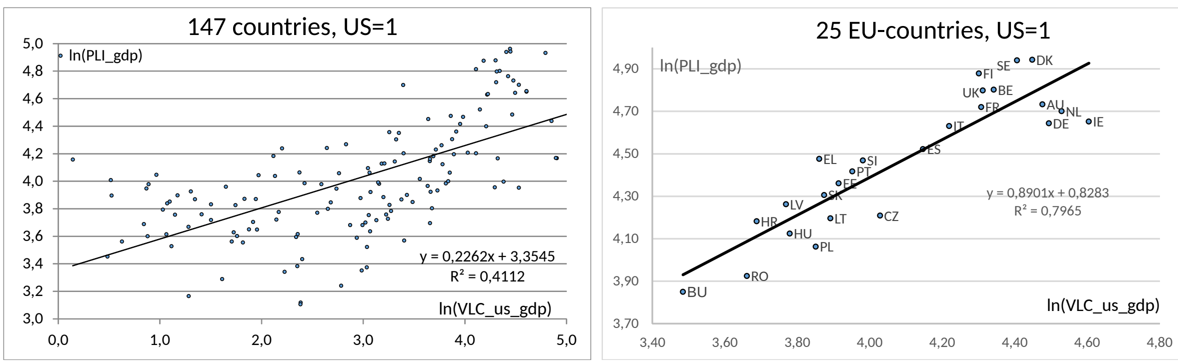
Figure 3.2, beside the GDP price level, includes pooled cross-section observations on the relative price of services to goods (the internal RER) as well, for the years 1999 - 2016, the period for which data regarding both overall and internal RERs are available for our full sample of 27 EU-countries. The elasticity of the internal RER to the level of income is somewhat lower (0.73) than that of the overall RER (0.88), but both RER-indicators are very closely related to real income.[13] We consider the points on the regression lines,

[13]This is similar to the much earlier results of Kravis and Lipsey (1983). Berka and Devereux (2013) also documented the close association of relative price and income levels within the EU for the period 1995-2009. They quantified the aggregate internal RER as the relative price of nontradables to tradables, based on a selection of items at the lowest level of aggregation. Their results are similar to ours, suggesting

similarly to Figure 3.2 as alternative expression of RERs consistent with the level of income. Deviations from the development-consistent levels serve as references for interpreting and measuring alternative indicators of RER-misalignments: downward (upward) alterations are, respectively, interpreted as under (over-) valuations of the RER.[14]

Next, drawing on the Penn World Table (PWT) 9.0[15], we show the relationship between the price level of GDP and per capita real GDP for a large sample of countries with population size above 1 million, and contrast the results with those for the EU Figure 3.3.

Figure 3.3: The relationship between the price level of GDP and per capita real GDP in 146 countries (upper chart) and in 25 EU countries (lower chart) relative to the US in 2014



Source: own calculations based on PWT.9.0 (2017)

The levels are expressed relative to the US, and the data relate to 2014, the last year covered by PWT.9.0. In the broad sample for 2014, consisting of almost 150 countries (upper pane), the elasticity of the GDP price level with respect to relative income is 0.23 (significant at 1%), with a R^2 of 0.41. This result, confirming the existence of the Penn effect, is quite similar to other findings in the literature, based on a large sample of countries, covering longer periods, generally relying on panel data, but ending before

that at the aggregate level there is a rather close correspondence between the relative price of nontradables to tradables on the one hand, and services to goods, on the other.

[14]The actual regressions estimated in Section 3 differ from the ones illustrated in Figure 3.2, as our estimates contain year dummies and we apply the DOLS method by adding short term dynamic terms to the regression.

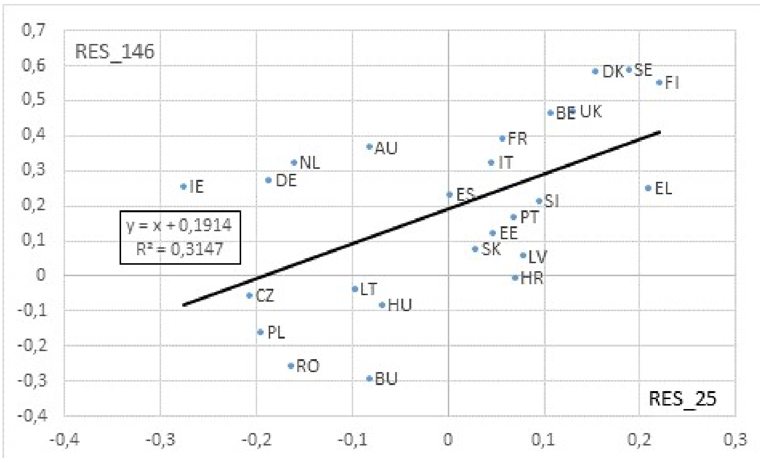
[15]Penn World Table database, see also Feenstra et al. (2015)

2014 (the corresponding results of several other papers are summarised in Table 3.1). As shown by the lower pane, the pattern reflecting the relationship between price levels and relative incomes among the 25 EU-countries included in our sample, based on the PWT[16], matches the world-wide pattern, but the elasticity of the price level (0.89) and the R^2 (0.80) is significantly higher within the EU than among countries included in the broad sample. This indicates that the Penn-effect "works" much more forcefully among EU member-states, closely integrated by trade, capital and labour flows than what we observe worldwide. It also suggests that measuring RER-misalignments by deviations from PPPs adjusted for the Penn-effect may be more relevant among EU member-states than for the large sample of countries.

The differences in the residuals of the regressions illustrated in the upper and lower pane of Figure 3.3 are shown in Figure 3.4. The comparison of the residuals (which, by definition, imply zero misalignment for the EU in within EU-comparisons) indicate that the EU25 as a whole is by 20 percent overvalued as compared to the broad international sample. The differences are particularly striking regarding the most developed EU-countries. While, in 2014 the real exchange rate of four developed economies (Austria, Germany, Ireland and the Netherlands) are found to have been undervalued in the European context, the same countries' real exchange rates are estimated to be grossly overvalued, when the large sample of countries is considered as a reference. The differences between the two types of estimations of misalignment for advanced EU-countries is extremely large (40-55 percentage points). These massive differences are likely to explain why previous studies, relying on samples consisting of both underdeveloped and highly developed economies, concluded that RER misalignments have insignificant effect on economic growth in advanced economies. According to our results, based on the sample of the EU27 (Section 4), there is no evidence of a significant difference in the growth effect of misalignments between less and more affluent countries.

[16] Since the population of Cyprus and Malta is below 1 million, they are not included in our sample.

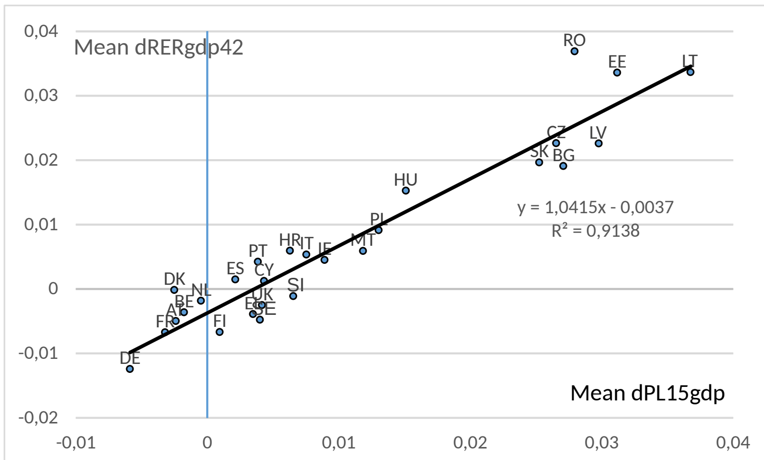
Figure 3.4: The relationship between the residuals for EU-countries of the regressions based on the broad sample and the sample consisting of EU-25



Notations: RES_25 and RES_146, respectively, denote the residuals of the regressions illustrated in the lower and upper pane of Figure 3.3 for the 25 EU-countries.

Finally, we draw attention to the fact that changes in our measure of the overall RER, that is, the price level of GDP relative to the EU15 average, are closely correlated with changes in GDP-deflator based real effective exchange rate (REER) indices measured against the average of a broader set of 42 countries, representing the bulk of competitors. Figure 3.5 suggests that, for the EU as a whole, changes in RERs in our interpretation represent changes in REERs in a broader interpretation as well.

Figure 3.5: Mean changes in the price level of GDP (horizontal axis) vs. mean changes in the real effective exchange rate (REER) index based on GDP deflators: 1995-2016



Source: own calculations based on PWT.9.0 (2017)

3.3 Interpreting and measuring real exchange rate misalignment

In the present section we calculate alternative measures of RER-misalignment. As discussed in Section 2, we rely on two concepts of the RER: the price level of GDP and the internal relative price of services to goods. With respect to the level of development, we apply real income (GDP per capita) and real productivity (GDP at PPP per persons employed) as an indicator. We interpret RER-misalignment as the deviation of an actual RER from the level consistent with the relative real income/productivity of a country.

Our approach basically follows the method based on PPP adjusted for the relative level of development, but similarly to e.g., Aguirre and Calderon (2005), Galstyan and Lane (2009) and others, we also consider other fundamental control variables that relates our method to the BEER approach.[17] We use single equation panel cointegration regressions to estimate the long term relationship between the level of development and real exchange rate indicators. We estimate the relationship using panel data for the period 1995-2016 for

[17] On the „behavioural equilibrium exchange rate" (BEER) Clark and MacDonald (1999)

27 EU countries.[18]

The literature is ambivalent with respect to using country fixed effects in the panel estimation, as the choice between adding or omitting fixed effects can be characterized by a trade-off. On one hand, by applying fixed country constants, one practically loses the cross-country variation of RERs, and the long term relationship is identified only from within variation. The fixed effects actually imply that the misalignment is zero in all countries in the average of the period, but this is a very strong assumption, taking into account that our sample covers only 22 years. On the other hand, without fixed country effects, the estimated misalignment might also contain long term country-specific factors that arise e.g. from compositional or methodological differences (or related to other unobserved characteristics) rather than from mispricing. Given that the zero misalignment assumption seems to be quite restrictive and not realistic in our short sample, while between-country variation explains the bulk of the total variation in our RER and development-level variables, our baseline model, similarly to e.g. Rodrik (2008), does not include country specific constants. However, as a robustness check, we also present fixed effect estimations.

The long term relationships are calculated with the Dynamic OLS (DOLS) method, as this method accounts for the serial correlation and heteroscedasticity of the residual by adding the leads and lags of the differenced independent variable to the regression.[19] All coefficients are presented with robust standard errors. The DOLS specification with fixed time effects is the following:

$$\log\left(RER_{ti}\right) = \alpha_t + \beta \log\left(GDP_{ti}^{REL}\right) + \Gamma X_{ti} + \sum_{j=-1}^{1} \delta_j \Delta\left(X_{t+j,i}\right)$$

$$+ \sum_{j=-1}^{1} \theta_j \Delta \log\left(GDP_{t+j,i}^{REL}\right) + \varepsilon_{it} \tag{3.1}$$

RER_{ti} stands for two different measures of the real exchange rate of country i in year

[18] For reasons discussed earlier, Luxembourg is not included in our sample.

[19] The sample period is short and the number of a cross-sections is large so the power of unit root and cointegration tests is low and sensitive to the number of lags, but the majority of the tests confirmed cointegration between the variables in the long term equation.

t, namely: (i) the relative price level of GDP measured at current PPP $PLgdp_{ti}$; (ii) the internal relative price of services to goods ($RPsg_{ti}$); all relative prices are compared to the average of the EU15. X_{ti}

stands for the control variables.

GDP_{ti}^{REL} , in turn, denotes two different measures of the level of economic development of country i in year t, relative to the to the EU15 average: (i) per capita GDP at current PPP ($VLCgdp_{ti}$); (ii) GDP per persons employed, at current PPP ($VLWgdp_{ti}$) .

Misalignment is measured as the deviation of the actual RER from its *long term* predicted value by the above regression.

$$Misal_{ti} = \log\left(RER_{ti}\right) - \log\widehat{\left(RER_{ti}\right)} \quad (2)$$

Where:

$$\log\left(\widehat{RER_{ti}}\right) = \widehat{\alpha_t} + \hat{\beta}\log\left(GDP_{ti}^{REL}\right) + \hat{\Gamma}X_{ti} \quad (3)$$

$\log\widehat{\left(RER_{ti}\right)}$ is the natural logarithm of the level of the RER which is consistent with the level of development. We shall refer this level as a “neutral” RER.

Note that in the DOLS specification, the differenced terms are not accounted for with respect to the long term relationship.[20]

Based on the literature, we added the following controls in the equation of the long term relationship: the impact of the terms of trade on domestic income, government consumption, net external debt, openness. However, even if these variables are significant determinants of the real exchange rate in the long term, it is not evident whether these factors alter the development–consistent, neutral real exchange rate. In the following, we present estimations of misalignments both with and without control variables.

Overall, the control variables do not add much to the model in terms of explanatory power. The level of relative economic development, alternatively measured, seems to be the major determinant of variations in alternatively defined RERs (Table 3.2). However, the misalignment estimated with the regression extended with controls differs from the simple misalignment significantly in the case of a few countries.

Table 3.3 shows the basic summary descriptive statistics for the four measures of RER-

[20] The role of leading and lagged dynamic terms is to give an asymptotically efficient estimation for the long term parameter by eliminating the feedback in the cointegrating system.

Table 3.2: The long term relationship between the price level of GDP or the internal relative price of services to goods indicators and the level of economic development

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent var.		log_gdp				log_rp_s_g		
		controls		controls		controls		controls
log_vlc15_gdp	0.854***	0.800***			0.656***	0.654***		
	(0.016)	(0.016)			(0.015)	(0.019)		
log_vlw15_gdp			0.906***	0.841***			0.715***	0.715***
			(0.021)	(0.02)			(0.023)	(0.028)
nxdebt_gdp		-0.011**		-0.008**		-0.014***		-0.010**
		(0.004)		(0.003)		(0.005)		(0.005)
lntot_eff		-1.882		0.477		-1.842		0.100
		(1.603)		(1.697)		(1.275)		(1.552)
open		-0.257***		-0.255***		-0.317***		-0.330***
		(0.025)		(0.027)		(0.032)		(0.034)
gov_gdp		0.016***		0.0192***		0.002		0.006***
		(0.002)		(0.002)		(0.002)		(0.002)
Constant	0.612***	0.606***	0.380***	0.373***	1.588***	1.669***	1.310***	1.307***
	(0.075)	(0.069)	(0.091)	(0.0985)	(0.075)	(0.082)	(0.107)	(0.122)
Observations	591	535	591	535	535	496	535	496
R-squared	0.891	0.916	0.860	0.891	0.850	0.893	0.821	0.879
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Clustered standard errors in parentheses*** *** p<0.01, ** p<0.05, * p<0.1.
Notations:
log_vlc15_gdp: the log of relative per capita GDP measured at PPP, EU15=100
log_vlw15_gpd :log of relative per worker GDP measured at PPP, EU15=100
log_pl_gdp: log of price level of GDP, measured at current PPP, EU15=100
log_r_p_sg: log of relative price of services to goods, EU15=100
gov_gdp : government consumption GDP, open: openness (import + export)/GDP
nx_debt : net external debt/GDP
lntot_eff: the effect of changes in the terms of trade on the change in real gross domestic income

Table 3.3: Summary statistics of different measures of RER misalignment

Variable	Obs	Mean	Std.dev	Min	Max
mis_rp_vlc	536	-0.023	0.109	-0.321	0.282
mis_rp_vlw	536	-0.017	0.109	-0.372	0.329
mis_pl_vlc	589	-0.004	0.113	-0.606	0.254
mis_pl_vlw	589	-0.002	0.127	-0.464	0.354
mis_rp_vlc_w/ controls	508	-0.023	0.109	-0.333	0.256
mis_rp_vlw_w/ controls	508	-0.016	0.111	-0.374	0.329
mis_pl_vlc_cont w/ controls	550	-0.009	0.115	-0.566	0.290
mis_pl_vlw_cont w/ controls	550	-0.009	0.129	-0.464	0.349

Notations:
mis_rp_vlc and mis_rp_vlw stands for the estimated misalignment in internal relative price, the benchmark variable is the relative per capita and per employed person GDP respectively. The average of misalignments is close, but not equal, to zero, as the dynamic terms do not count into the neutral RER,hence the misalignments are not equal with the residuals of the regressions (see footnote 20).

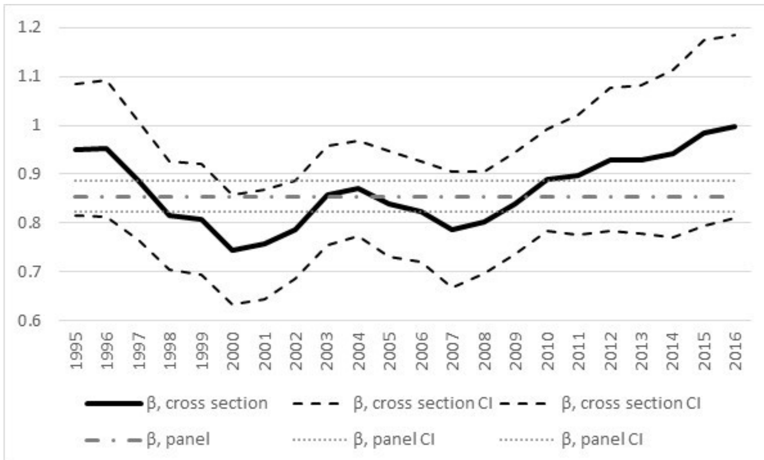
misalignment used in our growth regressions. As it can be seen, estimated misalignments vary in a relatively wide range, and the standard deviation is sizable, 11-13% .

To sum up, as compared to the results of the related literature, covering a larger sample of countries, in our sample including the EU27, the long term coefficient between the GDP price level and relative indicators of development, as well as the explanatory power of economic development in the price level of GDP and internal relative prices can be regarded as high. Per capita income or labour productivity explains the bulk of the variation in relative price developments.

The relationship between relative GDP variables and relative internal prices is comparably strong, with the slope being less steep. However, for some countries, the misalignment implied by the internal relative price differs significantly from the one estimated using the GDP price level.

As a robustness check, we present results from the cross-country estimations estimated year by year to present the evolution of the estimated parameter of GDP per capita. For this comparison, we present the simplest panel estimations with fixed time effect, and no control variables. As Figure 3.6 shows, the estimated long term coefficient of relative development (measured by per capita GDP) from the panel estimation lies in the confidence interval of the cross-country estimations in the entire period. This stability enables us to apply the same model for the whole sample period

Figure 3.6: The coefficient of GDP per capita on the relative price level in yearly cross-country regressions and panel regressions



Notations: β denotes the estimated long term parameter of relative price level (log_pl_gdp) on per capita GDP (log_vlc15_gdp); CI: confidence interval. Source: own calculations based on Eurostat

3.4 The relationship between RER-misalignments and economic growth

3.4.1 Our approach

In this section we investigate the relationship between RER-misalignments and growth. The novelty of our approach is that we systematically compare the growth effect of misalignments based on measures relying on both the relative price level of GDP and the internal relative price of services to goods and apply different estimation techniques as a robustness check. Furthermore, we address the heterogeneity in the growth effects of misalignment with respect to the exchange rate regime, the sign and size of the misalignment, as well as the level of development.

Our basic specification is the following[21]:

[21] This specification is similar to Rodrik (2008), however, he adds country fixed effect instead of lagged dependent variable to the equation.

$$d\log\left(Y_{ti}\right) = \eta_t + \rho d\log\left(Y_{t-1}\right) + \zeta\log\left(GDP_{T0,i}^{REL}\right) + \Phi Z_{ti} + \gamma Misal_{ti} + \varepsilon_{it} \quad (4)$$

$d\log\left(Y_{ti}\right)$ economic growth of country i in year t. Basically we use annual growth rate of GDP per capita at constant (2010) prices (QC_gdp_{ti} .

$\log\left(GDP_{T0,i}^{REL}\right)$

is the value of the per employed GDP relative to EU15, measured at current PPP in the first year of 5 year blocks: 1995, 2000, 2005,2010,2015. This variable captures the effect beta convergence.

Z_{ti} stands for the following control variables. *Free*: Heritage Foundation economic freedom index; *Infl*: HICP, annual rate of change; *Gov_def*: deficit of consolidated government as a % of GDP; *Inv_gdp*: fixed capital formation, as a % of GDP. The other control variables used in the literature proved to be insignificant, and as the data coverage was not full for these variables, we decided to drop them from the estimation (years of education, life expectancy, terms of trade).

$Misal_{ti}$ represents RER-misalignment measured in four different ways. The specific indicators differ along two dimensions, as we use two different RER indicators and two different concepts for the level of development. Accordingly, we calculate misalignment of the (i) price level of GDP and that of the (ii) internal relative price, which, in turn, are interpreted as the deviation of an actual RER from the level consistent with relative development of a country. As a baseline, we present results of estimation with misalignments interpreted as deviations from levels consistent with productivity (GDP per worker). Results with per capita income based misalignments are presented in the Appendix (*Table C.5-Table C.12*). The misalignment shows up with its sign in the regression, what is consistent with the assumption that overvaluation has the opposite effect as undervaluation. We will analyze asymmetry with respect to the sign of the misalignment later.

Our baseline results rest on estimated misalignments in which the long term relationship is calculated without control variables, that is, relying only on the relationship between the RER and the respective indicator of relative development. The reason is that the models with control-adjusted misalignments have lower explanatory power; these indicators proved to be insignificant in most of the cases, suggesting that simple misalignments are more closely related to growth than control-adjusted misalignments.

Adding the contemporaneous misalignment as an explanatory variable raises the danger of endogeneity. Indeed, the real exchange rate is an endogenous variable, the direction of causality from/towards growth is not straightforward and the same shock might influence both variables. For example, if a negative GDP shock reduces growth, and if prices and the exchange rate react with a lag, this will move misalignment upwards (toward overvaluation) and might bias the coefficient in the negative direction. We address the endogeneity problem by mainly two specifications. In the first, we add lagged misalignment instead of its contemporaneous value. An important feature of the specification with lagged misalignment is that the potential bias arising from *contemporaneous* shocks affecting growth and misalignment at the same time is ruled out, and the indirect effect through lagged growth is captured by the lagged dependent variable.

Similarly to e.g., Rodrik (2008) and Aguirre and Calderon (2005), we also estimate a system GMM model in spirit of Blundell and Bond (1998), where the misalignment is explicitly treated as an endogenous variable. Here the instruments can be regarded as fully exogenous.[22]

As in the case of our first step estimations, a dilemma arises with respect to using fixed country effects in the growth regression. As Angrist and Pischke (2009) show, in shorter samples, time invariant country specific factors (to be modelled by country fixed effects) on the one hand, and highly persistent, but not time invariant developments (to be modelled by lagged dependent variables) on the other, are hard to distinguish, so the fixed effect and lagged dependent variable can be regarded as boundaries of the true parameter. Adding both fixed effect and lagged dependent variable raises a new problem of dynamic panels: inconsistent estimation arising from correlation between the lagged dependent variable and the error term (Blundell and Bond (1998)). This can be cured by instrumenting the lagged dependent variable in a system or difference GMM estimation. [23]

Based on the above considerations and to ensure robustness and address the problem of endogeneity, we present the following models. (1) lagged dependent variable with contemporaneous misalignment, (2) fixed effect specification with contemporaneous misalignment, (3) system GMM with lagged dependent variable, (4) lagged misalignment with lagged de-

[22] In addition to the lagged dependent variable, the specification also includes the second lag of the dependent variable and the Arellano–Bond test statistic for the AR(2) in the first differences is not rejected in any specification.

[23] If the data generating process is the lagged dependent variable, but modelled with fixed effect, the model might overestimate the effect of misalignment, and the estimated parameter is biased downward if a fixed effect model is incorrectly estimated by the lagged dependent variable.

pendent variable and (5) lagged misalignment with country fixed effect. Specifications (6), (7), (8) are estimated with misalignments based on country fixed effect specifications. Results of specifications (5), (6), (7), (8) are presented in the Appendix (*Table C.1-Table C.4*).

We apply year fixed effects in every specification. The standard errors are clustered by country in order to control for autocorrelation of the residuals.

3.4.2 Results

Baseline results

Table 3.4 shows the results of our baseline growth regressions based on the *level* of the contemporaneous misalignment for the EU27. The parameter is negative in all specifications, indicating, in line with the common finding in the literature, that an under/overvalued real exchange rate – relative to its development-consistent, "neutral" level – is positively/negatively associated with contemporaneous growth. However, the parameter of misalignment is insignificant in some of the specifications, i.e., the results are not fully robust to the specification for the sample as a whole. Misalignments based on the GDP price level and the internal relative price behave similarly.

In line with our convergence estimations, the initial level of development – the relative GDP per capita in the first year of 5-year blocks (*log_vlc15_gdp_i5*) – is highly significant in all specifications; the value of the parameter is higher in case of per capita items. This result is robust to the variable applied for measuring the "initial" level of development: both beta convergence and the other variables are similar when using the relative per capita GDP of the first year of the sample (1995 or 2009) or that of the previous year.[24]

[24] The effect of the inflation, government deficit and investment/GDP is similar in the fixed effect specifications, that is, when only the within variation is used for identification. However, economic freedom usually loses significance in fixed effect models, as the within variation is much less important at this variable.

Table 3.4: Growth regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
L.dlog_qc_gdp	0.424***		0.232***	0.429***	0.407***		0.220***	0.404***
	-0.042		-0.074	-0.041	-0.049		-0.079	-0.045
misal	-0.022***	-0.063**	-0.035**		-0.020**	-0.072*	-0.025	
	-0.007	-0.029	-0.016		-0.008	-0.04	-0.021	
L.misal				-0.009				-0.012**
				-0.006				-0.006
log_vlc15_gdp_i5	-0.019***	-0.053***	-0.031***	-0.019***	-0.018***	-0.062***	-0.025***	-0.025***
	-0.003	-0.013	-0.008	-0.003	-0.003	-0.013	-0.008	-0.003
inv_gdp	0.015	0.219**	0.212***	0.03	0.053*	0.282***	0.242***	0.042
	-0.031	-0.088	-0.067	-0.031	-0.03	-0.087	-0.064	-0.026
infl	-0.007***	-0.007**	-0.057	-0.007***	-0.023	-0.051	-0.1	-0.051
	-0.002	-0.003	-0.038	-0.002	-0.032	-0.05	-0.066	-0.044
gov_def	-0.122***	-0.207***	-0.436***	-0.105***	-0.084**	-0.150*	-0.430***	-0.087**
	-0.035	-0.059	-0.141	-0.036	-0.036	-0.081	-0.137	-0.037
free	0.043*	-0.01	-0.016	0.037	0.036	-0.042	-0.06	0.040*
	-0.021	-0.079	-0.075	-0.022	-0.023	-0.085	-0.067	-0.021
Constant	0.084***	0.220***	0.132***	0.080***	0.077***	0.268***	0.131***	0.107***
	-0.014	-0.062	-0.048	-0.015	-0.014	-0.074	-0.045	-0.015
Observations	538	564	511	538	508	522	494	495
R-squared	0.681	0.602		0.675	0.696	0.637		0.727

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume

Heterogeneity in the effect of the misalignment: the exchange rate regime, non-linearity and CEEU-countries

Fixed vs. floating exchange rate regime countries

The question arises whether the relationship between misalignments and growth depends on the exchange rate (ER) regime. This question is tested by adding the interaction term of the misalignment with the dummy variable that equals when the exchange rate is fixed vis-à-vis the euro. The classification of fixed and fixed exchange rate cases is in Appendix C.16. Our estimation shows that the negative effect of misalignment on growth is attributable mainly to countries with fixed ERs, moreover, as Table 3.5 shows, the growth effect of misalignment in some specifications is significantly positive when the ER is not fixed.[25] This result is robust to estimation method: for the GDP price level all specifications confirm the negative effect of misalignment in countries with fixed ERs. For the

[25] We also investigated whether the exchange rate regime influences the long-term real exchange rate, but the dummy for fixed exchange rate proved to be insignificant in all specifications for the long-term relationship.

internal relative price, the parameter of misalignment is also negative in all specifications, though not significant when misalignment is estimated with country fixed effect. Habib et al (2016) also find that the growth effect of misalignment is stronger if the ER is pegged.

Next, we investigate whether differences in patterns of misalignments, namely the magnitude and persistence might account for the observed differences in the growth effect of the misalignment between alternative ER regimes. The effect of the ER regime on the average size and the persistence of the misalignment is not straightforward. On one hand, under flexible ERs, price adjustments might materialize also through nominal ER changes that can promote cross country price convergence if nominal prices are stickier than the nominal exchange rate. Under fixed ERs, in turn, in lack of nominal ER adjustment, misalignments might be more persistent and sizable. On the other hand, excessive nominal ER volatility might be a source of destabilizing shocks and may increase the volatility of the RER (Berka et al. (2012)). Moreover, fixed ERs – by decreasing transaction costs – might enhance trade and hence induce cross-country price convergence (Rose (2000)).

In our sample, the average size and the standard deviation of misalignments is even smaller in fixed ER countries (see Appendix, *Table C.* 13). The persistence of misalignments is measured similarly to Fidora et al. (2018), who measure it by the γ parameter in regression (5), indicating the responsiveness of the RER to past misalignments. A negative parameter indicates mechanisms moving the RER toward the neutral level. The higher is the absolute value of the parameter, the lower is the persistence of the misalignment. The regression is similar to the short term ECM equations, with the main difference that our regression captures long term, five year changes in the exchange rate.

$$dRER_{t/t-5,i} = \vartheta + \vartheta dGDP^{REL}_{t/t-5,i} + \varphi Mis_{t-5,i} + \varepsilon_{it} \qquad (5)$$

$dRER_{t/t-5,i}$ and $dGDP^{REL}_{t/t-5,i}$,respectively, denote the change in the RER (based on the GDP price level and internal relative price) and variables of relative development (per capita or per worker GDP) compared to its's value five years earlier, and $\varphi Mis_{t-5,i}$ denotes the corresponding misalignment lagged with five years.

The estimated persistence exhibits a mixed picture (see Table 3.6). GDP price level misalignments proved to be somewhat more persistent in fixed exchange rate countries, however, internal relative price misalignments show larger persistency for floating countries, but the difference is not particularly sizable in either case. We get similar results, if we estimate regression (5) with country fixed effect and investigate persistence for a shorter

Table 3.5: Estimates of asymmetric effects of misalignment: fixed exchange rate countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
misal	-0.001	-0.036	0.020		0.003	-0.033	0.014	
	(0.008)	(0.023)	(0.015)		(0.011)	(0.030)	(0.025)	
fixer	-0.003*	-0.009*	-0.008*		-0.004**	-0.010**	-0.009*	
	(0.002)	(0.005)	(0.005)		(0.002)	(0.005)	(0.005)	
misal*fixer	-0.047***	-0.088***	-0.095***		-0.050**	-0.089***	-0.083**	
	(0.016)	(0.024)	(0.028)		(0.020)	(0.020)	(0.036)	
L.misal				0.013*				0.005
				(0.007)				(0.011)
L.fixer				-0.002				-0.002
				(0.002)				(0.002)
L.misal*l.fixer				-0.054***				-0.040**
				(0.015)				(0.018)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	508	522	494	495
R-squared	0.689	0.625		0.686	0.704	0.652		0.732

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume

Table 3.6: Persistence of misalignment for fixed and floating exchange rate countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
misalignment	mis_pl_vlc		mis_pl_vlw		mis_rp_vlc		mis_rp_vlw	
d.RER (t/t-5)	S5.log_pl15_gdp		S5.log_pl15_gdp		S5.log_rp_s_g		S5.log_rp_s_g	
	floating	fix	floating	fix	floating	fix	floating	fix
L5.misal	-0.362***	-0.243***	-0.275***	-0.212***	-0.146***	-0.220***	-0.131***	-0.159***
	(0.053)	(0.038)	(0.053)	(0.030)	(0.044)	(0.034)	(0.041)	(0.031)
log_vlc15_gdp(t/t-5)	0.561***	0.486***			0.272***	0.190***		
	(0.083)	(0.033)			(0.058)	(0.029)		
log_vlw15_gdp(t/t-5)			0.610***	0.592***			0.253***	0.298***
			(0.084)	(0.044)			(0.059)	(0.039)
Constant	0.023*	0.010***	0.012	0.008*	-0.008	0.004	-0.004	0.003
	(0.012)	(0.004)	(0.013)	(0.004)	(0.009)	(0.003)	(0.009)	(0.004)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	154	300	154	300	108	293	108	293
R-squared	0.334	0.440	0.331	0.395	0.266	0.288	0.218	0.250

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

time span, three or four years.

Nonlinearity: the sign and size heterogeneity in the effect of RER misalignment

Many papers find that overvaluation hinders, while undervaluation enhances growth. Our baseline specification – where misalignment is represented with its sign – also implies that not only the distance, but also the sign of the deviation from the "neutral" level matters, that is, overvaluation effects growth in an opposite way as undervaluation.[26] However, one might question whether the magnitude of the effect depends on the sign of the misalignment. One can assume that the effect of a change in the RER might be different if the RER is overvalued from the effect of a change in case of initial undervaluation. If prices and wages can be characterized by asymmetric downward rigidity, the adverse effect of overvaluation might be stronger than the favourable growth effect of the undervaluation. On the other hand, Rodrik (2008) found that for developing countries, the positive effect of an increase of undervaluation is just as powerful as the negative growth effect of overvaluation.

In addition to the sign, the size of the misalignment might also influence the growth effect of misalignment. Bereau et al (2012) find that the growth effect of the misalignment is not linear, but increases with the size. Aquierre and Calderon (2005) investigated non-linearity separately for undervaluation and overvaluation and found that the size of the misalignment indeed matters, but while large overvaluations are excessively harmful, the positive effect of undervaluation loses momentum with increasing the magnitude and becomes negative above a certain level. Rodrik (2008) found little evidence of nonlinearity in the relationship between real exchange rate misalignment and economic growth.

We tested the sign and size asymmetries, adding overvaluation, undervaluation and the squared values of overvaluation and undervaluation separately. In case of undervaluation, the squared value is multiplied by minus one. (Similar methodology was applied by Aguirre and Calderon (2005) .[27]

The added variables are the following:

$u\_misal_{it} = D_{it}$ where $D_{it} = 1$,if the currency is undervalued and zero if overvalued. Consequently, $o\_misal_{it} = (1 - D_{it})$.

$sq\_u\_misal_{it}$ is the squared value of u_misal_{it} , multiplied by -1, and $sq\_o\_misal_{it}$ is the square of o_misal_{it}.

[26] If only the absolute size of misalignments were considered, it would not be possible to differentiate between the effects of over- and undervaluations.

[27] First we tested the sign asymmetry by adding the dummy variable and the interaction term of the dummy variable to the baseline regression, however, the interaction term was not significant in any specifications.

Our results (Table 3.7) suggest that in the case of GDP price levels, moderate undervaluations are positively associated with growth, nevertheless, this diminishes with increasing magnitude, as the coefficient of the squared undervaluation is significantly positive. Similar nonlinearity was found in Aguirre and Calderon (2005). Consequently, a country cannot expect much gain from an excessively undervalued real exchange rate, and the parameter values imply that above 25-30 percent the positive effect turns negative. This result is more in line with the so called "Washington Consensus" [28] which states that large misalignments imply significant distortions and imbalances that are harmful for growth in both directions; the result is also in line with Oblath et al. (2015). However, the significant coefficient of the square term might also be the consequence of the coincidence of economic and currency crises, rather than the harmful effect of large undervaluations. Misaligned internal relative prices do not show this type of asymmetry. Both the values and the squared value of overvaluation loses significance in this specification, and the overvaluation shows diminishing negative effect. One explanation might be that while the level of misaligned internal relative prices do have significantly negative effect, the threshold between under- and overvaluation is not estimated precisely.

[28] See Edwards (1998) and Berg and Miao (2010).

Table 3.7: Testing for nonlinear effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
undervalued	0.001	-0.003	0.006		-0.002	-0.002	0.001	
	(0.005)	(0.005)	(0.007)		(0.004)	(0.005)	(0.005)	
umisal	-0.109**	-0.314***	-0.111		-0.028	-0.119	-0.027	
	(0.048)	(0.072)	(0.073)		(0.044)	(0.083)	(0.058)	
o_misal	0.000	-0.127*	0.062		-0.079	-0.159*	-0.091	
	(0.054)	(0.074)	(0.083)		(0.052)	(0.082)	(0.077)	
misal_sq_u	0.399**	1.009***	0.314		0.013	0.211	-0.012	
	(0.163)	(0.198)	(0.227)		(0.103)	(0.191)	(0.146)	
misal_sq_o	-0.060	0.123	-0.179		0.283**	0.253	0.436**	
	(0.147)	(0.169)	(0.224)		(0.128)	(0.197)	(0.175)	
L.under				-0.010*				-0.001
				(0.005)				(0.004)
L.u_misal				-0.173***				-0.040
				(0.051)				(0.032)
L.o_misal				-0.036				-0.043
				(0.042)				(0.056)
L.misal_sq_u				0.542***				0.069
				(0.161)				(0.081)
L.misal_sq_o				0.076				0.228
				(0.111)				(0.170)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	508	522	494	495
R-squared	0.687	0.636		0.684	0.699	0.641		0.730

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Dependent variable: annual growth rate of GDP per capita volume

Asymmetry with respect to CEEU countries

A common finding in the literature is that in highly developed countries growth is less affected by RER misalignment (e.g. McDonald and Vieira, 2010) or is completely unaffected (Rodrik, 2008). Rodrik (2008) argued that bad institutions and market failures have a much stronger impact on the tradable sector than on nontradables. Since in developing countries these problems are probably more serious, suboptimal amount of resources will be used in the tradable sector. RER undervaluation makes the production of tradables more profitable, thus it pushes the economy closer to the optimal level of production. He empirically tested this hypothesis and found that the effect of RER misalignment on growth proved to be larger for economies with bad institutions.

Estimations of Rodrik (2008) and McDonald and Vieira (2010) are based on a mixed sample of developed and developing countries. The EU is more homogenous in terms of GDP per capita than the above samples, however, differences in the stage of development also play a role within the EU. We investigate whether an asymmetry exists between developed EU countries and the newcomer CEEU countries. Despite the substantial convergence of CEEU countries, the group as a whole lags behind in terms of GDP per capita throughout the period (see Appendix, *Table* C.14). Beyond the lag in the level of development, CEEU countries might behave differently because of structural differences inherited from the socialist era.

The asymmetry is tested by adding the interaction term of misalignment and the dummy variable for CEEU countries to our basic regression. The results are mixed across growth and misalignment measurements and show asymmetry only for the GDP price level misalignments. As Table 3.8 shows, the cross-term is insignificant in case of misalignment in internal relative prices, and insignificant, or significantly positive in some specifications of the GDP price based misalignment, implying that the relationship with misalignments is similar or weaker than in non-CEEU-countries.

The important takeaway from this table is that within the EU, less developed countries do not react more strongly to exchange rate misalignments, that is, our results do not confirm the usual finding in the literature that misaligned real exchange rates have stronger growth effects in countries with lower GDP per capita. However, the estimated misalignments might largely differ depending on the pool of countries included in the estimation sample, even if estimated with the same method. As already discussed in Section 3, the misalignments which are estimated on the sample of EU countries differ significantly from the misalignments that are based on a broader sample of 146 developing and developed countries of the Penn World Table. Besides, one has to note that while the majority of developed EU countries (except UK and Sweden) have been operating under a fixed exchange rate regime since 1997, CEEU countries exhibit more heterogeneous picture regarding the exchange rate regime. [29]

Channels: investment and competitiveness

From a policy point of view, a key question regarding the connection between growth effect and RER misalignment is the transmission channel through which misalignment exerts its

[29] Since 1995, the following CEEU countries operated under fixed exchange rate regime: BU, EE, LT, LV; since 2007: SI, since 2009: SK. Table C.16 in the Appendix includes the classification of EU member-states by exchange rate regimes.

Table 3.8: Estimates for asymmetric effect on CEEU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
misal	-0.026**	-0.109**	-0.030		-0.024*	-0.085*	-0.019	
	(0.010)	(0.043)	(0.026)		(0.013)	(0.044)	(0.034)	
ceeu	-0.002		-0.011		-0.004		-0.014*	
	(0.004)		(0.007)		(0.004)		(0.008)	
misal*ceeu	0.005	0.075	-0.008		0.001	0.024	-0.022	
	(0.016)	(0.052)	(0.034)		(0.021)	(0.060)	(0.045)	
L.misal				-0.021***				-0.019*
				(0.007)				(0.011)
L.ceeu				0.003				-0.003
				(0.003)				(0.004)
L.misal*ceeu				0.028**				0.007
				(0.013)				(0.019)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	508	522	494	495
R-squared	0.681	0.607		0.678	0.696	0.637		0.728

Clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Dependent variable: annual growth rate of GDP per capita volume

effect on growth. There are three main channels identified by the literature. These point to a symmetric effect in the sense that undervaluation enhances and overvaluation hinders growth, i.e., the direction of the deviation from the value implied by fundamentals have a great importance.

The conventional competitiveness channel (Obstfeld and Rogoff (1996)) argues that a more undervalued RER increases the profitability of the export sector and enhances growth through conjuncture in exports, while the increase in the price of imports increases the growth via the expenditure switching mechanism.

The other main channel emphasizes the role of capital accumulation. Rodrik (2008) argues that an undervalued RER enhances investment and production in the tradable sector, but only in developing countries, where bad institutions and market failure lead to a suboptimal share of the tradable sector, which suffers more from the institutional weakness. Other papers emphasize the positive effect of RER undervaluation on overall savings and investments, implying that the beneficial impact on investment is not limited to the tradable sector (e.g. Bhalla (2012)).

A related mechanism, the total factor productivity channel (e.g. Mbaye (2013)), also considers increased profitability of the tradable sector as a starting point, but the focus is rather on compositional changes in the economy. Namely, production shifts from the low-

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productivity non-tradable sector towards the more productive tradable sector, ultimately increasing the overall productivity of the economy.

In the following, we try to identify the importance of the competitiveness and the investment channels by applying the investment to GDP ratio and the change in export market share at international markets as dependent variables instead of GDP growth. Specifically, we estimate equation (1) using an indicator of investment and that of competitiveness as the dependent variable and modify the set of control variables.

The variables are the following:

dlog_ms: the competitiveness channel is investigated by an indicator expressing market performance of exports of goods and services on export weighted imports of goods and services: 36 industrial markets 2010=100 (AMECO). The variable is represented in dlog form.

inv: the investment channel is represented by private gross capital formation as percent of GDP.

Our results (Table 3.9 and Table 3.10) suggest that both the competitiveness and the investment channels play a role in the effect of RER misalignment. The misalignment is negatively associated with both changes in export market shares and the private investment/GDP ratio; the results are similar for misalignment in the GDP price level and the internal relative price. Regarding private investment/GDP, the results are similar, though the parameter of misalignment is not significant at 5% significance level in all specifications. The index of economic freedom affects the change in market share positively in all specifications. It is worth noting that effect of the terms of trade differs for competitiveness and investment. An increase in the terms of trade worsens export performance, that is, higher relative export prices are accompanied by lower quantities. However, changes in the terms of trade have no significant effect on the investment/GDP ratio.

It is to be noted that our results do not imply that we rule out the operation of the channel involving total factor productivity. However, since it is not straightforward to empirically disentangle the increase in capital/labour ratio from that in total factor productivity, we cannot draw conclusions on the existence of this mechanism.

Table 3.9: Effect of RER misalignment level on private investment/GDP

	(1)	(2)	(3)	(1)	(2)	(3)
	Lagged dep var.	System GMM	Lagged misal lagged dep var	Lagged dep var	System GMM	Lagged misal , lagged dep var
	GDP price level			internal relative price		
L.inv_gdp	0.815***	1.110***	0.816***	0.839***	1.135***	0.840***
	(0.044)	(0.084)	(0.043)	(0.050)	(0.056)	(0.052)
misal	-0.020**	-0.026***		-0.029*	-0.048***	
	(0.007)	(0.010)		(0.015)	(0.017)	
L.misal			-0.020**			-0.032*
			(0.007)			(0.015)
log_vlc15_gdp_i5	-0.006**	-0.007***	-0.006**	-0.002	-0.004***	-0.005**
	(0.002)	(0.001)	(0.002)	(0.004)	(0.001)	(0.002)
free	0.059	0.046*	0.061	0.039	0.042*	0.051*
	(0.035)	(0.028)	(0.036)	(0.024)	(0.022)	(0.027)
tot_eff	0.038	-0.226*	0.039	0.061	-0.170	0.002
	(0.131)	(0.126)	(0.132)	(0.235)	(0.171)	(0.198)
Constant	-0.010	0.267**	-0.013	-0.043	0.201	0.021
	(0.137)	(0.135)	(0.138)	(0.248)	(0.178)	(0.204)
Observations	251	240	251	240	232	236
R-squared	0.888		0.888	0.879	1.135***	0.885

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: Private investments/GDP

Table 3.10: Effect of RER misalignment on export market share

	(1)	(2)	(3)	(1)	(2)	(3)
	Lagged dep var.	System GMM	Lagged misal lagged dep var	Lagged dep var	System GMM	Lagged misal , lagged dep var
	GDP price level			internal relative price		
L.dlog_xcomp2	0.232***	0.225***	0.236***	0.237***	0.224***	0.214***
	(0.047)	(0.080)	(0.046)	(0.056)	(0.084)	(0.051)
misal	-0.041***	-0.041**		-0.052***	-0.060***	
	(0.013)	(0.020)		(0.015)	(0.023)	
L.misal			-0.028*			-0.039***
			(0.015)			(0.012)
log_vlc15_gdp_i5	-0.028***	-0.040***	-0.028***	-0.030***	-0.033***	-0.039***
	(0.006)	(0.008)	(0.006)	(0.007)	(0.007)	(0.006)
free	0.114**	0.169**	0.109**	0.072*	0.143**	0.093**
	(0.047)	(0.085)	(0.046)	(0.036)	(0.063)	(0.039)
tot_eff	-1.339***	-1.703***	-1.354***	-1.582***	-1.573***	-1.314***
	(0.465)	(0.596)	(0.466)	(0.509)	(0.498)	(0.457)
Constant	1.397***	1.768***	1.414***	1.684***	1.628***	1.445***
	(0.459)	(0.597)	(0.460)	(0.524)	(0.501)	(0.467)
Observations	534	534	534	506	506	494
R-squared	0.263		0.257	0.285		0.272

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: export market share

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3.5 The effect of misalignments based on the relationship between wage and productivity levels: an extension

The indicators of relative price misalignments, estimated in Section 3, can rightly be considered as reflections of RER misalignments, since the relative price level of GDP and the internal relative price of services to goods are alternative expressions of the real exchange rate. As an extension to, and a robustness-check of, our findings concerning the relationship between RER misalignments and economic growth (discussed in Section 4), in the present section we analyse the misalignment – growth relationship in light of misalignments of relative wage levels from relative productivity levels. The concept of wages in our analysis corresponds to the national accounts: *compensation of employees* (gross wages and salaries plus employers' social contributions). This implies that we consider wages as gross labour costs, rather than net labour income.

The concept of relative "wage misalignment" is analogous to, but not identical with, relative price (i.e., RER-) misalignment. The relationship between the level of wages and productivity is unaffected by the RER, since the two items can be compared either as nominal magnitudes, expressed in euro (producer nominal wage vs. nominal productivity), or both may be deflated by the relative price level of GDP (producer real wage vs. real productivity). What we are interested in is (i) whether misalignments of wages and prices show a similar pattern; if so, (ii) whether the correspondence between misalignments and growth, based on wages and productivity show a similar pattern to the one based on RER and income (productivity) levels.

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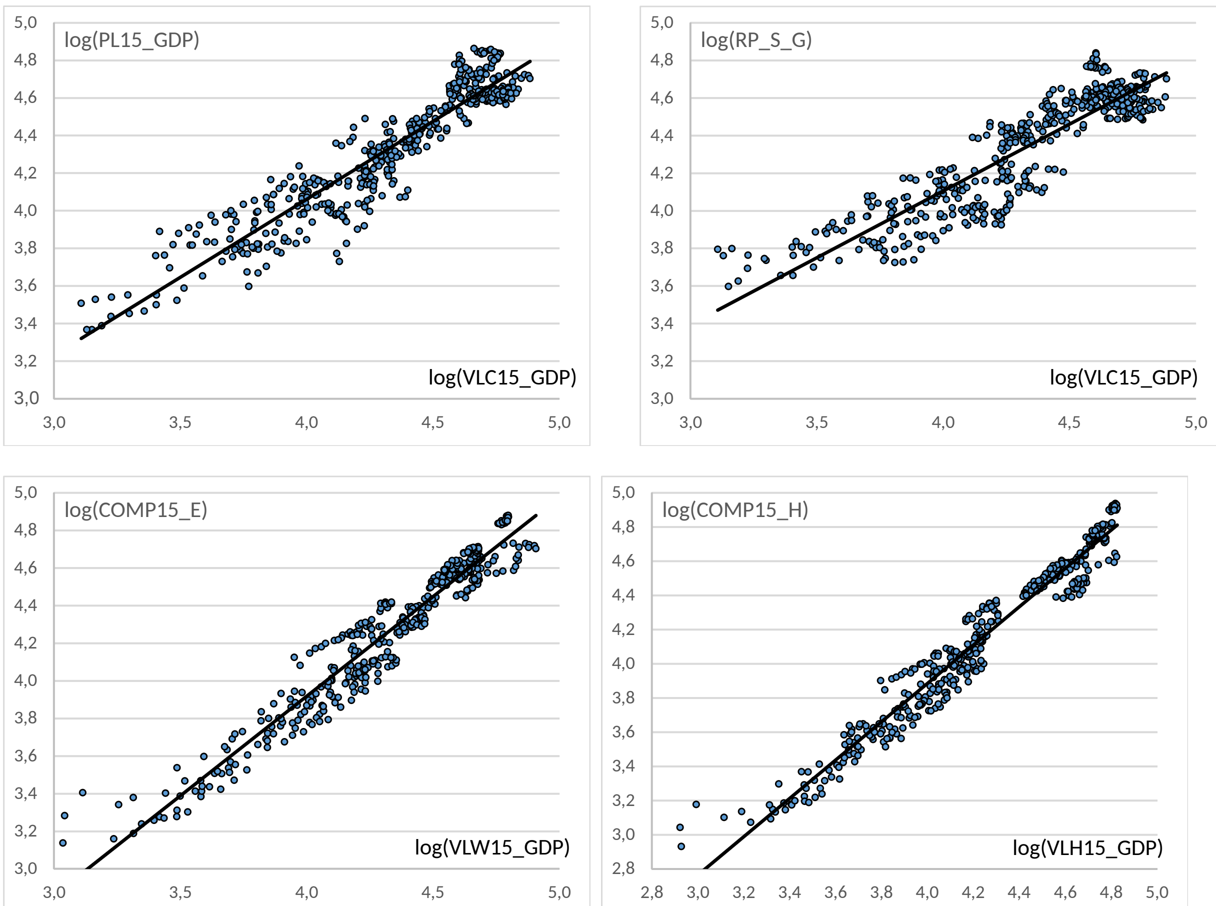
Figure 3.7: The relationship between the log of (a) the GDP relative price level (b) the internal relative price of services to goods and per capita GDP; (c) relative producer real wages and relative productivity based on the number of persons; (d) hours worked in the EU; pooled cross section data, 1999-2016



Notations: PL15_GDP: the price level of GDP, RP_S_G: the relative price of services to goods; VLC15_GDP: per capita GDP; COMP15_E: compensation per employee; VLW15_GDP: GDP per employed persons; COMP15_H: compensation per hours worked; VLH15_GDP :GDP per hours worked. All variables are based on PPS (of the GDP) and measured relative to the average of the EU15. Source:Eurostat and AMECO

The visual observation of Figure 3.7, displaying the relationships based on pooled cross-section data, clearly suggests that the association between wages and productivity [panels (c) and (d)] is somewhat closer than those based on relative prices and real incomes [panels (a) and (b)].

The relationship between productivity and wages can be interpreted on the basis of the number persons (employed for productivity and employees for wages, Figure 3.7c), or hours worked by persons employed and employees, respectively (Figure 3.7d).

The level of producer *nominal wage* per employee and per worked hours, respectively, in country i, relative to the EU average (in log):

$npw15^{b}_{i,EUR} = \left(comp_{i,EUR} - empe^{b}_{i}\right)$ - $\left(comp_{EU,EUR} - empe^{b}_{EU}\right)$

where $comp_{i,EUR}$ denotes compensation of employees expressed in euros,

$empe^{b}_{i}$ *denotes* $empe^{w}_{i}$ (the number of employees), or $empe^{h}_{i}$ (hours worked by employees) in a given year.

Producer *real wage* per employee and per hours worked, respectively, in country i relative to the EU average:

$rpw15^{b}_{PPP} = \left(comp_{\mathrm{i,\ EUR}} - empe^{b}_{i} - Pgdp_{i/EU}\right)$ - $\left(comp_{EU,EUR} - empe^{b}_{EU}\right)$

Relative per hour or per worker (real) productivity in country in country i, relative to the EU average:

$prod15^{b}_{i} = \left(nl15\_gdp_{i,EUR} - emp^{b}_{i} - Pgdp_{i/EU}\right)$ - $\left(nl15\_gdp_{EU,EUR} - emp^{b}_{EU}\right)$

where $prod15^{b}_{i} =$ $vlw15_{i/EU}$ *and* $vlh15_{i/EU}$, i.e., productivity measured by the number of persons employed and hours worked, respectively;

$nl15\_gdp_{iEUR}$ is the nominal GDP expressed in euros, and

$emp^{b}_{i} = emp^{w}_{i}$, or emp^{h}_{i} is total employment (including self-employed), or the number of hours worked, respectively.

We estimate the following DOLS equations for the producer real wage:

$$\log\left(RPW15\_b_{it}\right) = \alpha_t + \beta \log\left(PROD15\_b_{it}\right) + \sum_{j=-1}^{1} \theta_j \Delta \log\left(PROD15\_b_{t,t+j}\right) + \varepsilon_{it}$$

The LHS of the above equation is the numerator, while the RHS (excluding the dynamic terms) is the denominator of the indicator of "adjusted wage share" (i.e., adjusted for the ratio of employed persons to the number of employees, or for the hours worked by persons employed to employees).

While the wage share (often referred to as the "real" ULC) *is not*, the actual ("nominal")

ULC *is* a RER-indicator, since the latter involves a comparison between nominal wages (affected by the exchange rate) and real productivity. Comparing the evolution of the ULC over time between countries certainly makes sense, as it shows developments in an important aspect of cost-competitiveness. However, it makes little sense to compare nominal wages (in euro) to real productivity (in PPS) across countries at significantly different levels of development, since (i) it simply reproduces what we already know (price and nominal wage levels increase along with the level of development); (ii) it does not reveal anything about the level of cost-competitiveness of countries at considerably different levels of development.

Turning to the results of our estimations, the long-term relationship between PPP-based relative producer wages and relative productivity is even stronger than between RER indicators and the level of relative development, suggesting a very close relationship between wages and productivity within the EU. The coefficient is close to, but slightly above, unity in the specifications that contain only year dummies, implying that one percent higher relative productivity is accompanied by somewhat more than one percent higher relative wage level for the EU as a whole (Table 3.11). The long term parameter is lower, but the relationship is also very strong in the fixed effect specifications that identify the parameter only from within-variation.

Actually, the concept of "wage misalignment" , as quantified by the residuals of the above equation, can loosely be interpreted as a lower/higher adjusted wage share than the one that corresponds to the level of productivity. The results of the specifications with only time effects, indicating that the elasticity of wages is higher than unity and the constant is significantly negative, implies that the wage share tends to increase with the level of productivity. This partially helps in understanding why, in spite of the high explanatory power of productivity regarding wage differentials, large, even 10-20 percentage point differences can be observed in adjusted labour shares across countries.[30]

[30] An important reason for the positive relationship between cross-country wage shares and levels of productivity is the fact that the relative price of consumption to GDP is positively related to the level of productivity (see Kónya et al. (2019)). Differences in cross-country wage levels tend to reflect not only differentials in productivity, but also those in the relative price of consumption, which is closely associated with the relative price of services to goods – a major theme of our analyses presented in the previous sections of our study. The fixed effect specifications yield somewhat lower elasticities, below unity. However, in the 20 year horizon the within variation is less apparent, so fixed effect specifications cannot fully capture the long term, cross-country relationship.

Table 3.11: The long-term relationship between relative wages (in PPS) and relative productivity (in PPS) based on number of employees (1) and number of hours worked (2)

	(1)	(2)	(3)	(4)
	No country fixed effect		Country fixed effect	
Dep. var	Log rel wage(e)	Log rel wage(h)	Log rel wage(e)	Log rel wage(h)
log_vlw15_gdp	1.032***		0.864***	
	(0.016)		(0.081)	
log_vlh15_gdp		1.094***		0.859***
		(0.013)		(0.091)
Constant	-0.189***	-0.476***	0.512	0.489
	(0.073)	(0.060)	(0.341)	(0.378)
Observations	586	564	586	564
R-squared	0.950	0.965	0.894	0.874
Year FE	YES	YES	YES	YES

Clustered standard errors in parentheses *** p¡0.01, ** p¡0.05, * p¡0.1.

In the next step, we look at the relationship between wage misalignment and growth, by applying our growth equation presented in Section 4. The connection between the two is ambiguous a priori: neither the sign of the relationship, nor the direction of causality is straightforward. First, the labor share is expected to exhibit a countercyclical pattern: as wages and employment are less flexible than profits, demand shocks are reflected in changes in profits to a higher extent. That is, one can expect a negative contemporaneous correlation between wage misalignment and GDP growth in the short term.

Second, wage misalignments might have an ambiguous effect on GDP growth. On the one hand, the wage level is an important component of international cost competitiveness: if wages lag behind productivity, the resulting increase in capital revenues might translate into an improvement in price competitiveness, involving higher market shares and net exports. Alternatively, higher profits can boost private investments, but any combination of the two outcomes definitely support growth. Due to these channels, wage misalignments with an opposite sign (wages exceeding productivity) are expected to have a negative effect on growth. On the other hand, as proponents of the notion of "secular stagnation" (Summers (2015)) claim, a higher capital share is accompanied by higher inequality, involving a higher share of income of those having a lower propensity to consume. Eventually, this lowers domestic demand, and hence, growth. Another negative potential effect of inequality

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may work through human capital: a decline in the labour share leads to a reduction in human capital accumulation in credit constrained households, lowering the growth potential of the whole economy (Atkinson (2015)).

Keeping these considerations in mind, we estimate the association between wage misalignment and growth by applying the same specifications as in estimations of the link between real exchange rate misalignment and growth. The results are summarized in Table 3.12 suggesting that the association between estimated wage misalignments and economic growth is similar to the one observed in the case of RER misalignments. The coefficients are significantly negative with both measures of wage misalignment (based on per hour and per worker): "overvalued" wages are associated with lower growth and vice versa.

As wages are usually fixed in the beginning of the year, a country specific, contemporaneous unexpected decline in growth may increase wage misalignment, resulting in an upward-biased estimation. However, the coefficient of lagged wage misalignment, which does not suffer from this bias, is also significantly negative, even after controlling for lagged GDP growth; the system GMM also yields a significantly negative parameter. All in all, our results regarding the effects of wage misalignments on economic growth are broadly in line with the expected outcome implied by the impact of misalignments on competitiveness and investments.[31]

3.6 Summary and conclusions

The main goals of our study were to investigate (i) the characteristics of real economic and price convergence, (ii) the relationship between economic growth (convergence) and real exchange rate (RER) misalignments within the European Union (EU) during the period 1995-2016. Although this relationship has been analyzed by several studies with respect to the global economy (i.e., relying on samples consisting of countries at markedly different levels of development), little attention has been devoted to investigating this association among member-states of the EU.

We rely on the observation that within the EU there is a very close positive correlation

[31] The significantly negative relationship in the short term does not rule out that the long term relationship is different. For example, Charpe et al. (2019), using wavelet analysis, find a negative effect of labor share on growth in the short run, but a positive effect in the long (beyond 32 years) horizon.

Table 3.12: Growth regressions with wage misalignments (based on number of employees

	(1) Lagged dep var.	(2) Fixed effect	(3) System GMM	(4) Lagged misal, lagged dep var	(5) Lagged misal fixed effect
L.dlog_qc_gdp	0.413***		0.186***	0.421***	
	(0.042)		(0.067)	(0.042)	
misal	-0.042***	-0.144***	-0.067*		
	(0.013)	(0.033)	(0.035)		
L.misal				-0.022**	-0.042***
				(0.009)	-0.015
log_vlc15_gdp_i5	-0.016***	-0.048***	-0.020**	-0.017***	-0.027***
	(0.002)	(0.008)	(0.008)	(0.002)	(0.004)
inv_gdp	0.028	0.222***	0.232***	0.032	0.137**
	(0.036)	(0.078)	(0.066)	(0.032)	(0.053)
infl	-0.007***	-0.008***	-0.063	-0.007***	-0.007***
	(0.002)	(0.002)	(0.043)	(0.002)	(0.003)
gov_def	-0.096**	-0.159**	-0.487***	-0.094**	-0.166***
	(0.037)	(0.059)	(0.149)	(0.037)	(0.044)
free	0.014	-0.044	-0.107*	0.023	0.032
	(0.022)	(0.080)	(0.059)	(0.021)	(0.037)
Constant	0.083***	0.214***	0.145***	0.081***	0.100***
	(0.015)	(0.056)	(0.039)	(0.016)	(0.023)
Observations	535	560	509	534	559

Clustered standard errors in parentheses *** p¡0.01, ** p¡0.05, * p¡0.1.
Misalignments estimated without fixed effect

between general price levels on the one hand, and levels of economic development, on the other. While the existence of this relationship – the so-called "Penn-effect" – is a worldwide phenomenon, it holds much more strongly within the EU. This implies that economic integration through trade, capital and labor flows does not lead to the equalisation of price levels among countries at different levels of development; rather it results in an exceptionally close positive association between levels of prices and economic development.

Our interpretation and quantitative estimations of RER misalignments build upon this close association: we consider national RERs to be misaligned, if GDP price levels deviate from the level characterising the relationship between price levels and real incomes (measured by per capita or per employed GDP at PPP) for the EU as a whole. We refer to points corresponding to the common trend as expressing a "neutral" RER; national price levels above (below) the neutral one were interpreted as signs of RER-over- (under-) valuation. In this respect, we followed the approach of previous studies on the topic.

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However, as an important conceptual and empirical contribution to the literature on RER misalignments and economic growth, in addition to the relative price level of GDP, we quantified an alternative indicator for the RER: the internal relative price of services to goods, as measured from the expenditure side of GDP. This indicator is also closely correlated with the level of economic development and can be regarded as a measure of the "internal" real exchange rate (i.e., as a proxy for the relative price of non-tradables to tradables.) We estimated RER-misalignments (with, and without controlling for openness and the relative size of government expenditure) relying on this concept as well.

The core of our analyses involves estimation results regarding the relationship between economic growth and RER-misalignments within the EU. We finally applied four indicators for quantifying misalignments (two based on the relative price of GDP and two on the internal relative price), and eight different specifications.

Our results indicate that the contemporaneous extent of real exchange rate misalignment – as interpreted by the relative price of GDP – is negatively associated with economic growth: a 10% over/undervaluation is accompanied by 0.2-0.7 percentage point lower/higher rate of growth across different specifications in the EU. This effect is substantial, considering the fact that the mean annual growth rate of GDP (per capita GDP) was 2.4% (2.3%) in the EU27 over the period covered by our analysis. The relationship between growth and misalignments based on internal RERs in some cases hold even more than those based on GDP price levels, highlighting the role of relative prices in resource allocation. A robust finding of the study is that the negative association between growth and RER-misalignments is mainly attributable to countries operating under fixed exchange rate regimes, that is, to Eurozone countries and CEEU countries with pegged exchange rates or currency-board arrangements. This finding is robust to the choice of growth indicator, the measure of relative level of development and the interpretation of the RER.

Our results show that, in contrast with the common finding in the literature, the level of development does not influence the strength of the relationship between misalignments and economic growth. While GDP price level-based and internal relative price-based misalignments behave similarly on the aggregate sample, our findings are mixed regarding the symmetry with respect to the size and sign of the misalignment. Specifically, in the case of the GDP price level, overvaluation has stronger effect than undervaluation, and while larger overvaluations have an excessively negative growth effect, the positive effect of undervaluation diminishes with increasing its magnitude. The growth effect of internal relative price misalignment does not show this pattern.

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Some of our main findings are robust to the applied panel econometric method. In addition to time fixed effect specifications, we carried out system and difference GMM methods, specifying the misalignment as an endogenous variable, hence addressing the potential endogeneity bias. The GMM estimations confirm the negative relationship between misalignments in case of the GDP price level for fixed exchange rate countries. GMM specifications do not show significant asymmetry for CEEU countries and show that the positive undervaluation-growth relationship diminishes with increasing the magnitude of undervaluation.

We addressed two possible channels through which RER misalignments might influence economic growth: international competitiveness and the investment rate. The aggregate effect of misalignments is significantly negative on both export market shares and the ratio of private gross fixed capital formation to GDP, although the results for investments are less stable. This result indicates that both the competitiveness and, to some extent, the investment channel plays a role in the growth effect of RER misalignments.

As an extension, we analysed the relationship between growth and the misalignment of wages from productivity levels and found that "wage-misalignments" are also negatively associated with economic growth.

Our results capture contemporaneous and one-year lagged effects of RER misalignments, which are highly relevant for understanding growth and convergence in EU member-states in certain sub-periods of the 21 years covered by our study, but these results do not enable us to draw conclusions regarding the long-term effects of misaligned price levels and relative prices.

It is also important to stress that although our study carries important policy messages – in particular, mild real exchange rate undervaluations are positively, while overvaluations are negatively associated with growth and real economic convergence – the RER is an endogenous variable, which is not under direct policy control. However, there are several policy instruments for indirectly influencing the RER, even in countries operating under fixed exchange rates. Our results point to the importance of a growth strategy avoiding overvaluation on the one hand, and to the futility of aiming at excessive undervaluation, on the other. Rather than trying to achieve an undervalued RER, governments are advised to focus on improving the quality of institutions.

We consider the results presented in this paper as a first step in our attempt to clarify the relationship between RER-misalignments and economic growth within the EU. As a

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next step, it is important to build a theoretical model capable of reproducing the empirical results reported in our study. As a continuation of our work, we also wish to address issues left open in the present study. Two, as yet unexplained, phenomena require further analysis: (i) why does the relationship between misalignments and growth hold only for countries with fixed exchange rates; (ii) why only misalignments based on internal relative prices "work" in the case of CEEU countries? Furthermore, the general results of our study need to be amended by the analysis of individual country-experiences with respect to the evolution of the RER and economic convergence.

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Appendix A

Appendix for Chapter 1

A.1 A simple framework

This section interprets findings that the effect of the quota depends on labor supply and average wage of the firms in a simple framework as follows. Firms maximize profit:

$$\pi(N, D) = pf(N, D) - w_d D - aD - w_n N - \mathbb{1}(N + D \geq c)max(N + D)q - D, 0)T \quad \text{(A.1)}$$

where N and D denote number of employed non-disabled and disabled workers respectively,w_D and w_N are the wage of disabled and non-disabled workers respectively. a stands for the non-wage costs of employing disabled employees. Non-wage costs can be think about one-off adjustment costs, but in our framework, are expressed as a yearly equivalent, based on the expected duration of the employment. $f(N, D)$ is the production function. $\mathbb{1}()$ denotes indicator function, q is the quota (in our case, 5 %), c is the threshold employment level, T is the levy per missing employees from the quota. Hereafter I assume that the price is 1.

Let's analyze the effect of the levy through the simplest case: the problem of a firm, which does not have a disabled employee in the optimum without the quota system and stands exactly at the threshold, that is, $D^* = 0, N^* = c$, where D^*, N^* denote optimal labor choice without the quota. As the firm's labor choice was optimal, the marginal revenue product from hiring a disabled employee is lower than the marginal labor cost.

The production function of firms is the following:

$$f_i(N,D) = A_i(\delta_i D + N)^{\alpha} \tag{A.2}$$

That is, firms use non-disabled and disabled workers that are perfect substitutes, A is the TFP and relative productivity of disabled workers is δ. As disability means changed working capacity, we can assume that $\delta <= 1$. Note that other production functions might also be used, what is important that the marginal revenue product of a disabled employee at the threshold can expressed with the productivity discount to the marginal product of a non-disabled employee:

$$f_D^{'} = \delta f_N^{'} \tag{A.3}$$

Profit change from hiring one additional disabled employee at the no quota optimum:

$$\Delta\pi = w_D + a - \delta f_N^{'} < 0 \tag{A.4}$$

The formula shows that in no-quota optimum, marginal revenue product from hiring a disabled employee is lower, than the labor cost, hence generates a profit loss.

When the quota system is introduced, the firm has to hire one disabled employee to meet the quota requirement, that is $N^*q = 1$. The firm will choose hiring a disabled employee instead of paying the levy, if the profit loss from hiring a disabled is lower than the levy. (For the sake of simplicity, let's take the case of new hiring instead of substitution, and disregard the option of bunching below the threshold.)

For analyzing the role of supply and average wages of the firm in reaction of firms to the quota, lets assume that the wage of potential disabled employee the firm faces, w_D might differ from the non-disabled wage at the firm, w_N but they are linked, specifically: $w_D = w_N d$

The term d is for capturing disabled supply shortage. The idea is that if a firm can not hire a disabled form example at the minimum wage and it is reflected in as a wage premium. So in case of supply shortage d can be high: $w_D = w_N d >= w_N \delta$.

If the firm can enforce the productivity differential in the wage, or even impose wage discrimination, $d <= \delta$. But in case of supply shortage, it can be even higher than unity. w_N is allowed vary across firms.

The firm will choose fulfilling the quota instead of paying the levy, if

$$\Delta\pi = w_N d + a - \delta f_N^{'} < T$$

The formula shows that higher average wage of the firm (w_N), d¿1, as a reflection of the supply shortage, and adjustment cost (a) all decrease the probability, that a firm will hire a disabled. In contrast, higher δ (lower productivity differential of disabled employees) increases the marginal product, hence increases the chance of employing a disabled employee.

Figure A.2 and A.1 displays the effect of the quota graphically. The x axis shows the marginal labor cost of hiring a disables , the y axis displays the marginal product of the disabled employee.

Before the levy hike, all firms are at their optimum, consequently, all firms are under the 45% line Figure A.1. Introduction of the levy shifts the indifference line downwards (Figure A.2). Firms between the new and the old-line will respond by hiring a disabled worker to the quota. The figure reveals that in the Hungarian case, the minimum wage cost of employing a disabled (w_{min}) is lower than the levy. This implies, that if a firm hires a disabled at this wage level without adjustment costs, the profit loss is lower than paying the levy even if δ is zero, hence the marginal product is zero. A firm does not hire a disabled under the quota, if high average wage of the firm, or adjustment costs, or supply problems (high d) increase the actual labor cost of employing a disabled above the levy to such an extent that can not be counterweighted by the marginal product of the disabled employee. As a result, the firm will stay below the new line (firm A).

The above framework is consistent with the finding that the impact of the quota is stronger at lower average wage level at the firm and higher disabled labor supply. In addition, sheds some light about the contradiction that firms pay a levy instead of hiring a low wage disabled employee even she or he does not contribute to the value added. In case of labor supply shortage, firms might not find disabled employees at this low wage

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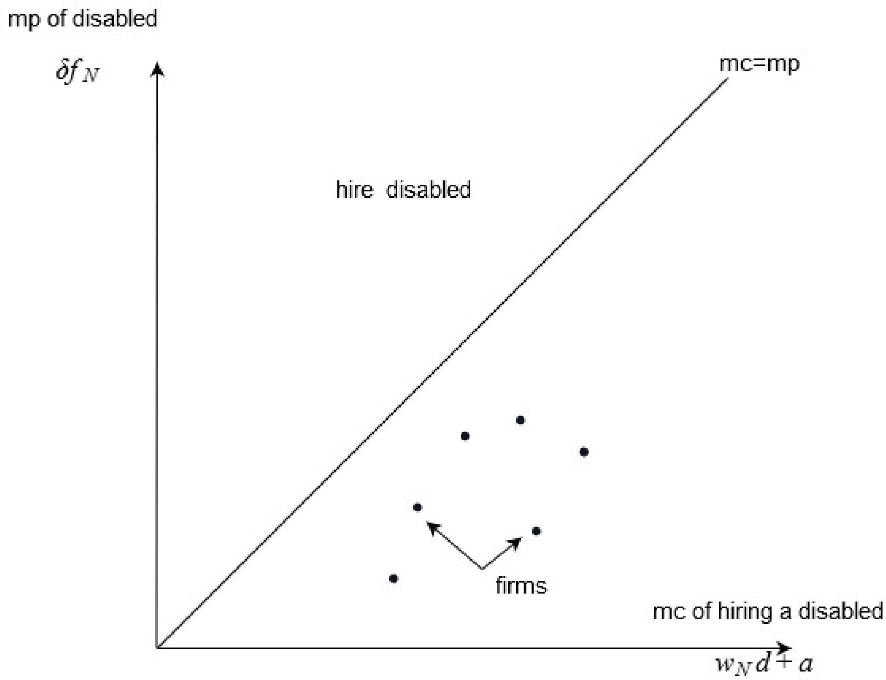
Figure A.1: Firms' decision about disabled hiring: no quota case

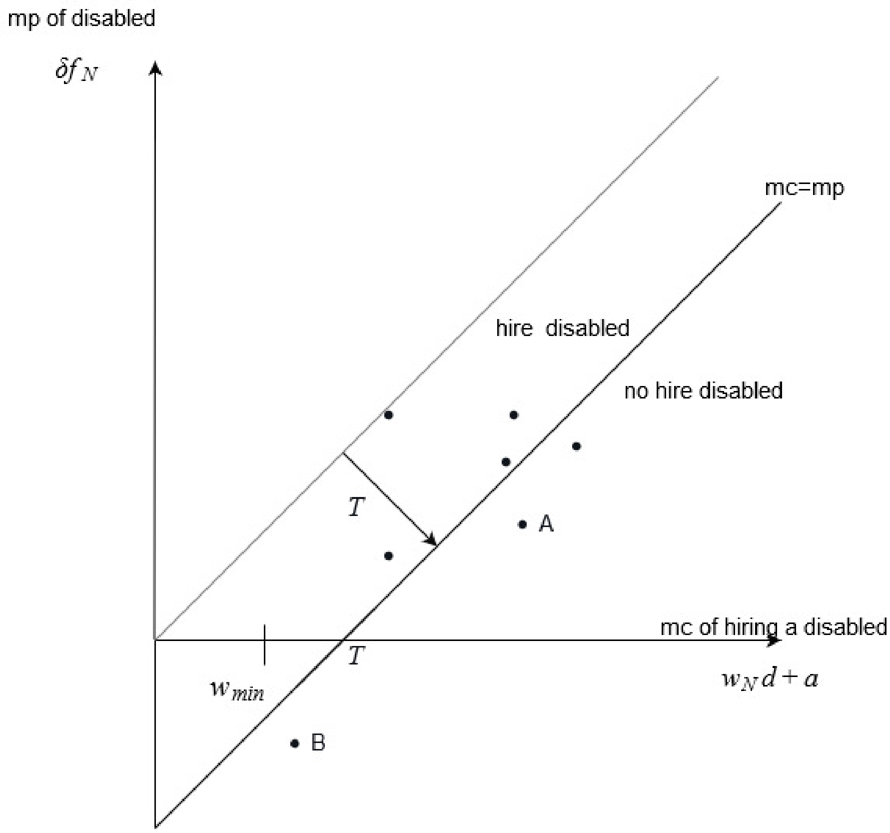


level, or high adjustment costs might turn disabled hiring too costly. Another possibility is discrimination,i.e. the firm does not hire a disabled employee despite the financial incentive, that can be represented by a negative δ (firm B).

A.2 Details of the quota rules

In average headcount, part-time employees and employees that work only in a part of the year are treated differently. Part-time employees are considered as a full person (not as a full-time equivalent), but they are counted only if their working time due to their contract is minimum 15 hours per week (about 60 hours per month).If the person is employed only for a half month, she will be counted if the number of her actual working hours exceeds 30 hours. However, employees that are employed only in a part of the year, are counted proportionally with the ratio of their time of employed status in the year.For example, an employee that was employed for 6 months at a company, is counted as 0,5 employee in average headcount, regardless that she is a part-time or full-time worker. A half-time (4 hours a day) employee employed in the whole year is considered as one person in the average headcount.The average headcount of a firm that applies 20 full-time employees and

Figure A.2: Firms's decision about disabled hiring: introduction of the quota



2 part-time employees throughout the year is 22, while the average headcount of a firm with 20 full-time employees and two employees that quit the firm mid-year is 21.

Other changes in the quota regulation in 2011 and 2012:

- From January 2011, employee leasing companies, that were exempt the regulation until 2010, are also required to pay the rehabilitation contribution. It implies that this policy change might have also contributed to the increase in aggregate disabled employment in 2011. Beyond its direct effect (45 out of the 519 employee leaser companies were between 15 and 25 employees this the regulation also might have influenced the behavior of smaller firms in general. The exemption until 2011 allowed smaller firms to exempt the regulation by working with leased workers instead of employees with employment contract, that count for the average headcount. However, the regulation probably increased the price of leased employees and decreased the relative advantage of leasing employees. (About the potential effect of this policy change, see Data section)

Table A.1: Data imputation in variable number of disabled employees at firms. Original and filled with imputed zeros.

	Variable	Obs	Mean	Std. Dev.	Min	Max
disabled employees	original	5404	0.80	2.07	0	29
disabled employees	with imputations	21710	0.20	1.09	0	29

Source:own calculation based on the NAV database

- Since 2012, employers might get allowance from employer social contribution for two years, if they employ disabled employees.[1] The allowance is 27 percent of the gross wage, but maximum 27 percent of double of the minimum wage. The regulation implies that the relative labor cost of employing disabled employment has decreased further. However, in 2012, only 6400 rehabilitation cards were demanded.

A.3 Data imputations

The firm tax database contains a variable of number of disabled employees. However for majority of firms which have data for number of total employees, this information is missing. Based on the assumption that firms who employ disabled and reduce their levy obligation do not leave this part empty, I replaced missing data with zeros. As the share of imputed data are very high, the imputation need to be addressed.

I have data on the total levy revenues for every year and for the share of revenues paid by business organizations (that are in the tax database) for 2015 and 2016. Moreover, for 2015, firm size breakdown of the rehabilitation contribution revenues paid by firms is available. Using the 2015 composition of revenues for 2013 data, the levy is paid after 47.9 thousand employees, while the calculations from tax database data show that 49.1 thousand persons are missing from the quota, the deviation is less than 2%. Regarding the firms below 50 employees, the number of missing disabled employees estimated from revenues are 6.33 thousand, while the tax database shows 6.56 thousand, the difference is 3.5%. The two data are not comparable one-by-one because potential differences caused by

[1]Persons with changed working capacity are eligible for the rehabilitation card, that qualifies employers to the allowance in case of employing card owners.

rounding, but the low magnitude of the deviation suggests that the imputation probably does not threaten the validity of results.

A.4 Parametric RD results

The treatment rule is the following:

$$D = \begin{cases} 1, & \text{if } emp_{it} >= c \\ 0, & \text{if } emp_{it} < c \end{cases} \tag{A.5}$$

(A.6)

Where D is the treatment indicator, in our case, the firm that is subject of the quota-levy regulation.

The following equation is estimated: specification:

$$disabled_i = \beta_0 + \beta_1 \widetilde{emp_i} + \delta D_i + \gamma D \widetilde{emp_i} + u_i$$

where $disabled_i$:number of disabled employees,emp_i:total number of employees, $\widetilde{emp_i} = emp_i - c$

The model is estimated in the neighborhood of the cutoff value: $emp_{it} \in [c-h, c+h]$, in baseline specification: $h = 5$, $c = 20, 25$. [2]

[2]Second order polynomial and and cross term of the of the treatment dummy with the the running variable to capture potential heterogeneous treatment effect proved to be insignificant perhaps thanks to the relatively narrow band

Table A.2: Parametric RDD on disabled employment 2008-2012, c=20

VARIABLES	(1) disemp	(2) disemp	(3) disemp	(4) disemp	(5) disemp
YEARS	2008	2009	2010	2011	2012
D	0.0264	0.109***	0.294***	0.255***	0.0170
	(0.0281)	(0.0307)	(0.0324)	(0.0307)	(0.0252)
$\widetilde{emp}$	0.0128***	0.0161***	0.0172***	0.0157***	0.00974**
	(0.00477)	(0.00513)	(0.00495)	(0.00479)	(0.00423)
$D\widetilde{emp}$	0.0178**	0.000170	-0.00325	0.00128	0.0376***
	(0.00847)	(0.00931)	(0.00971)	(0.00921)	(0.00765)
Constant	0.106***	0.136***	0.135***	0.131***	0.0935***
	(0.0166)	(0.0177)	(0.0170)	(0.0164)	(0.0149)
Observations	8,506	8,154	8,381	8,368	7,947
R-squared	0.022	0.030	0.086	0.080	0.043

$D = 1$ if $emp_t > 20$ sample: $15 <= emp_t <= 25$ and $emp_{it} \neq 20$
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A.3: Parametric RDD on disabled employment 2008-2012, c=25

VARIABLES	(1) disemp	(2) disemp
YEARS	2011	2012
D	0.0187	0.298***
	(0.0638)	(0.0526)
$\widetilde{emp}$	0.0494***	0.0206**
	(0.0117)	(0.00908)
$D\widetilde{emp}$	-0.0272	-0.0170
	(0.0190)	(0.0156)
Constant	0.545***	0.263***
	(0.0422)	(0.0320)
Observations	4,204	4,503
R-squared	0.024	0.059

$D = 1$ if $emp_t >= 25$ sample: $20 <= emp_t <= 30$ and $emp_{it} \neq 25$
Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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A.5 Descriptive statistics

Table A.4: Descriptive statistics - firms with at least 20 employees

	2006	2007	2008	2009	2010	2011	2012	2013
1. Total number of employed disabled in all firms	50 921	46 919	44 871	44 325	45 928	49 520	48 203	45 241
Firms with at least 20 employees								
2. number of employed disabled in firms above 20 employees	47 358	43 294	41 233	40 609	42 118	45 532	44 926	42 654
3. as a % of total disabled employment (2./1.)	93.0%	92.3%	91.9%	91.6%	91.7%	91.9%	93.2%	94.3%
4. in firms with disabled ratio less than 40%	11 801	11 921	11 509	12 287	19 325	22 220	20 949	18 470
5. ratio of disabled employment in firms below 40% dis. ratio (4./2.)	25%	28%	28%	30%	46%	49%	47%	43%
6. in firms with disabled ratio at least 40%	35 557	31 373	29 724	28 322	22 793	23 312	23 977	24 184
7.share of disabled employees in all firms	2.9%	2.7%	2.5%	2.7%	2.8%	3.1%	3.0%	3.1%
8. share of disabled employees excluding special firms	0.8%	0.8%	0.8%	0.9%	1.4%	1.6%	1.5%	1.4%
*****THRESHOLD=20**								
9.quota (threshold=20)	80 394	79 296	81 162	75 234	75 020	74 158	75 698	69 824
10. missing employees from the quota (threshold=20)	69 360	68 887	70 810	64 063	57 417	53 533	55 856	52 040
11. quota fulfillment, 1–missing employees/quota (1-10./9.)	14%	13%	13%	15%	23%	28%	26%	25%
12. quota fulfillment (excluding special firms)	16%	16%	15%	17%	27%	32%	29%	28%
THRESHOLD=25								
13.quota (threshold=25)							72492	66441
14. missing employees from the quota (threshold=25)							53106	49066
15.quota fulfillment, 1–missing employees/quota (threshold=25) (1-14./13.)							27%	26%
16. quota fulfillment (threshold=25, exluding specials)							29%	28%

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A.6 Treatment effect heterogeneity, parametric RD results with interaction terms

The heterogeneity of the treatment effect and was also investigated parametrically, by extending the naive RD with interaction term of disabled population ratio with the treatment indicator.

Using the labor force survey data (see Table 1.12), regional dummies were replaced by one region- specific variable that captures the share of disabled in total working age population. The variable is normalized to zero:

$dis\_popratio_r = \frac{DP_r}{TP_r} - \overline{\frac{DP}{TP}}$, where DP_r is working age (15-64 years) disabled population in a given region and TP_r is regional total working age population. I also added average wage and productivity of the firm to separate the effect of disabled population ratio from the development of regions.

The results show that if the share of disabled population ratio is lower, firms on average employ less to the quota regulation (see Table A.5). The cross-product of the disabled population ratio with the treatment dummy is significantly positive, even after controlling for wage and productivity differences, which shows that higher share of disabled population yields higher disabled employment effect of the quota regulation on firms. The magnitude of the coefficient is large: it shows that if the ratio of disabled population is higher by 1 percentage point, the employment effect is larger by around 0.03. Consequently, the higher disabled population alone implies more than double treatment effect in the Eastern regions compared to the most developed Central-Hungary.

Table A.5: Parametric RD extended with disabled population ratio(2010 and 2011)

	(1)	(2)
YEARS	2010	2011
VARIABLES	disemp	disemp
D	0.316***	0.273***
	(0.0327)	(0.0317)
emp-c	0.0160***	0.0166***
	(0.00499)	(0.00491)
D*(emp-c)	0.00447	0.00592
	(0.00980)	(0.00949)
lnaverwage	-0.0129	0.00531
	(0.0171)	(0.0160)
lnprod_gdp	-0.000925	-0.00976
	(0.0101)	(0.00989)
D*lnprod_gdp	-0.0447**	-0.0119
	(0.0202)	(0.0199)
D*lnaverwage	-0.0927***	-0.0852***
	(0.0328)	(0.0310)
disabled pop.ratio	0.0159***	0.0150***
	(0.00204)	(0.00198)
D*disabled pop._ratio	0.0343***	0.0280***
	(0.00392)	(0.00379)
Constant	0.249***	0.191**
	(0.0953)	(0.0882)
Observations	7,841	7,888
R-squared	0.131	0.117

Firms between 15-25 employees, c=20, h=5. D stands for the dummy variable if a firm has at least 20 employees is.Standard errors in parentheses,*** p<0.01, ** p<0.05, * p<0.1. source:own calculation based on the NAV database

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Appendix B

Appendix for Chapter 2

B.1 Parametric RD estimations of the effect of reduction in wage ceiling

Table B.1: Parametric RD: wage/minimum wage if working, 12 and 24 months after entrance into RSA

	(1)	(2)	(3)	(4)
Dep.var	wage to mw 12 m	wage to mw 12 m	wage to mw 12 m	wage to mw 12 m
Entry date-cut-off	0.037**	0.002	0.068**	0.001
	(0.017)	(0.007)	(0.032)	(0.008)
(Entry date-cut-off)*New-entrant	-0.064**	0.001	-0.088***	0.002
	(0.026)	(0.009)	(0.033)	(0.009)
New-entrant(τ)	-0.279***	-0.232***	-0.460**	-0.217***
	(0.092)	(0.068)	(0.184)	(0.082)
Wage 12 months before entr	0.151***	0.169***	0.152***	0.169***
	(0.023)	(0.020)	(0.023)	(0.020)
Total econ w to mw			-0.334	0.044
			(0.301)	(0.129)
Age	0.003	0.003	0.003	0.003
	(0.004)	(0.002)	(0.004)	(0.002)
Male	0.122**	0.090**	0.123**	0.090**
	(0.060)	(0.037)	(0.060)	(0.037)
Constant	0.706***	0.608***	1.792*	0.476
	(0.188)	(0.113)	(0.957)	(0.389)
Observations	513	1,093	513	1,093
R-squared	0.196	0.161	0.198	0.161
h	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B.2: Parametric RD: wage/minimum wage if working, 12 and 24 months after entrance into RSA

Dep.var	(1) wage to mw 24 m	(2) wage to mw 24 m	(3) wage to mw 24 m 24 m	(4) wage to mw
Entry date-cut-off	0.037*	0.000	0.056**	-0.000
	(0.020)	(0.009)	(0.028)	(0.009)
(Entry date-cut-off)*New-entrant	-0.058*	-0.005	-0.079*	-0.005
	(0.034)	(0.012)	(0.043)	(0.012)
New-entrant(τ)	-0.164	-0.069	-0.234*	-0.064
	(0.124)	(0.087)	(0.134)	(0.089)
Wage 12 months before entr	0.189***	0.192***	0.189***	0.192***
	(0.027)	(0.026)	(0.026)	(0.026)
Total econ w to mw			-0.239	0.028
			(0.279)	(0.173)
Age	-0.001	-0.002	-0.001	-0.002
	(0.004)	(0.002)	(0.004)	(0.002)
Male	0.108	0.044	0.107	0.044
	(0.070)	(0.041)	(0.070)	(0.041)
Constant	0.861***	0.792***	1.593*	0.712
	(0.229)	(0.131)	(0.819)	(0.485)
Observations	461	1,020	461	1,020
R-squared	0.205	0.151	0.206	0.151
h	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B.3: Parametric RD: probability of earning wage above 80% of the minimum wage if working, 12 and 24 months after entrance into RSA

	(1)	(2)	(3)	(4)
Dep.var	wage above 80% of the mw 12m	wage above 80% of the mw 12m	wage above 80% of the mw 12m	wage above 80% of the mw 12m
Entry date-cut-off	0.029*	0.005	0.039	0.003
	(0.016)	(0.005)	(0.028)	(0.006)
(Entry date-cut-off)*New-entrant	-0.066***	-0.005	-0.074**	-0.005
	(0.025)	(0.009)	(0.030)	(0.009)
New-entrant(τ)	-0.243***	-0.241***	-0.301*	-0.224***
	(0.086)	(0.063)	(0.156)	(0.075)
Wage 12 months before entr	0.029**	0.049***	0.029**	0.049***
	(0.014)	(0.018)	(0.014)	(0.018)
Total econ w to mw			-0.107	0.048
			(0.236)	(0.115)
Age	-0.001	0.001	-0.001	0.001
	(0.003)	(0.002)	(0.003)	(0.002)
Male	-0.018	0.001	-0.018	0.001
	(0.045)	(0.031)	(0.045)	(0.031)
Constant	0.708***	0.529***	1.057	0.383
	(0.162)	(0.106)	(0.786)	(0.366)
Observations	509	1,086	509	1,086
R-squared	0.073	0.060	0.074	0.060
h	6	12	6	12
	(1)	(2)	(3)	(4)
Dep.var	wage above 80% of the mw 24m	wage above 80% of the mw 24m	wage above 80% of the mw 24m	wage above 80% of the mw 24m
Entry date-cut-off	0.049***	0.013**	0.066***	0.011*
	(0.017)	(0.006)	(0.025)	(0.006)
(Entry date-cut-off)*New-entrant	-0.113***	-0.021**	-0.132***	-0.020**
	(0.027)	(0.009)	(0.034)	(0.010)
New-entrant(τ)	-0.186**	-0.174***	-0.246**	-0.162**
	(0.094)	(0.067)	(0.114)	(0.071)
Wage 12 months before entr	0.033**	0.057***	0.033**	0.058***
	(0.015)	(0.019)	(0.015)	(0.019)
Total econ w to mw			-0.208	0.071
			(0.219)	(0.141)
Age	-0.004	-0.005**	-0.003	-0.005**
	(0.003)	(0.002)	(0.003)	(0.002)
Male	0.056	0.033	0.054	0.033
	(0.049)	(0.032)	(0.049)	(0.032)
Constant	0.866***	0.775***	1.506**	0.572
	(0.178)	(0.114)	(0.695)	(0.424)
Observations	450	998	450	998
R-squared	0.083	0.055	0.084	0.055
h	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table B.4: Parametric RD: probability of working 12 and 24 months after entrance into RSA

	(1)	(2)	(3)	(4)
Dep.var	work 12m	work 12m	work 12m	work 12m
Entry date-cut-off	0.006	0.010***	-0.012	0.010**
	(0.008)	(0.003)	(0.031)	(0.004)
(Entry date-cut-off)*New-entrant	-0.013	-0.011***	-0.007	-0.011***
	(0.012)	(0.004)	(0.015)	(0.004)
New-entrant(τ)	-0.087**	-0.114***	-0.105**	-0.115***
	(0.042)	(0.028)	(0.052)	(0.038)
Work 12 months before	0.154***	0.125***	0.155***	0.125***
	(0.028)	(0.017)	(0.028)	(0.017)
ln total economy employment			-4.766	-0.084
			(8.027)	(1.855)
Age	-0.004***	-0.005***	-0.004***	-0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
Male	-0.038*	-0.045***	-0.039*	-0.045***
	(0.021)	(0.013)	(0.021)	(0.013)
Constant	0.497***	0.601***	39.683	1.296
	(0.082)	(0.052)	(66.003)	(15.262)
Observations	2,104	5,009	2,104	5,009
R-squared	0.026	0.024	0.026	0.024
h	6	12	6	12
	(1)	(2)	(3)	(4)
Dep.var	work 24m	work 24m	work 24m	work 24m
Entry date-cut-off	0.007	0.008***	0.008	0.009*
	(0.008)	(0.002)	(0.009)	(0.005)
(Entry date-cut-off)*New-entrant	-0.002	-0.001	-0.003	-0.002
	(0.011)	(0.004)	(0.013)	(0.005)
New-entrant (τ)	-0.119***	-0.131***	-0.130**	-0.130***
	(0.040)	(0.028)	(0.061)	(0.028)
Work 12 months before	0.147***	0.117***	0.147***	0.117***
	(0.026)	(0.016)	(0.026)	(0.016)
ln total economy employment			-0.971	0.571
			(4.208)	(1.985)
Age	-0.006***	-0.007***	-0.006***	-0.007***
	(0.001)	(0.001)	(0.001)	(0.001)
Male	-0.049**	-0.046***	-0.049**	-0.046***
	(0.020)	(0.013)	(0.020)	(0.013)
Constant	0.576***	0.632***	8.539	-4.049
	(0.081)	(0.052)	(34.521)	(16.262)
Observations	2,099	5,000	2,099	5,000
R-squared	0.032	0.026	0.032	0.026
h	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table B.5: Parametric RD: probability of receiving RSA 12 and 24 months after entrance into RSA

	(1)	(2)	(3)	(4)
Dep.var	RSA rate 12m	RSA rate 12m	RSA rate 12m	RSA rate 12m
Entry date-cut-off	0.001	0.000	-0.005	-0.000
	(0.006)	(0.002)	(0.011)	(0.002)
(Entry date-cut-off)*New-entrant	-0.010	-0.001	-0.005	-0.001
	(0.010)	(0.003)	(0.012)	(0.003)
New-entrant(τ)	0.012	-0.005	0.046	0.004
	(0.032)	(0.023)	(0.059)	(0.027)
Wage 12 months before entr	-0.010	-0.012*	-0.010	-0.012*
	(0.010)	(0.007)	(0.010)	(0.007)
Total econ w to mw			0.063	0.027
			(0.089)	(0.043)
age	-0.003***	-0.003***	-0.003***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
Male	-0.069***	-0.047***	-0.069***	-0.047***
	(0.019)	(0.012)	(0.019)	(0.012)
Constant	1.115***	1.112***	0.910***	1.032***
	(0.063)	(0.042)	(0.292)	(0.137)
Observations	1,216	2,708	1,216	2,708
R-squared	0.024	0.016	0.024	0.017
h	6	12	6	12
	(1)	(2)	(3)	(4)
Dep.var	RSA rate 24m	RSA rate 24m	RSA rate 24m	RSA rate 24m
Entry date-cut-off	0.005	-0.001	0.003	-0.002
	(0.009)	(0.003)	(0.012)	(0.003)
(Entry date-cut-off)*New-entrant	-0.025*	-0.002	-0.023	-0.001
	(0.014)	(0.005)	(0.017)	(0.005)
New-entrant(τ)	0.002	-0.013	0.007	-0.007
	(0.046)	(0.033)	(0.056)	(0.035)
Wage 12 months before entr	-0.030***	-0.027***	-0.030***	-0.027***
	(0.008)	(0.008)	(0.008)	(0.008)
Total econ w to mw			0.017	0.037
			(0.111)	(0.075)
Age	-0.004**	-0.005***	-0.004**	-0.005***
	(0.002)	(0.001)	(0.002)	(0.001)
Male	-0.086***	-0.073***	-0.086***	-0.073***
	(0.025)	(0.016)	(0.025)	(0.016)
Constant	1.082***	1.096***	1.029***	0.989***
	(0.091)	(0.061)	(0.352)	(0.228)
Observations	1,214	2,706	1,214	2,706
R-squared	0.030	0.024	0.030	0.024
h	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Table B.6: Parametric RD: outcomes, December 2009

Dep.var	(1) w_to_mw	(2) w_to_mw	(3) above_80mw	(4) above_80mw	(5) work	(6) work	(7) DisT_RSA	(8) DisT_RSA
Entry date-cut-off	0.032	0.007	0.034**	0.015***	-0.005	0.005	0.010	0.010***
	(0.022)	(0.008)	(0.016)	(0.006)	(0.010)	(0.003)	(0.009)	(0.003)
(Entry date-cut-off)*New-entrant	-0.057*	-0.014	-0.076***	-0.026***	-0.001	-0.007	-0.015	-0.001
	(0.031)	(0.010)	(0.026)	(0.009)	(0.016)	(0.005)	(0.014)	(0.004)
New-entrant(τ)	-0.189*	-0.156**	-0.191**	-0.194***	-0.019	-0.074*	-0.000	-0.025
	(0.108)	(0.075)	(0.089)	(0.063)	(0.054)	(0.039)	(0.045)	(0.032)
Wage 12 months before entr	0.162***	0.167***	0.026**	0.048***	0.041***	0.042***	-0.030***	-0.025***
	(0.021)	(0.020)	(0.012)	(0.017)	(0.013)	(0.011)	(0.007)	(0.007)
Age	0.002	-0.000	-0.002	-0.003	-0.006***	-0.007***	-0.004***	-0.004***
	(0.004)	(0.002)	(0.003)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Male	0.043	0.015	-0.003	-0.003	-0.110***	-0.065***	-0.070***	-0.060***
	(0.064)	(0.039)	(0.047)	(0.032)	(0.028)	(0.018)	(0.025)	(0.016)
Constant	0.768***	0.801***	0.788***	0.733***	0.646***	0.728***	1.101***	1.087***
	(0.206)	(0.121)	(0.168)	(0.109)	(0.104)	(0.070)	(0.088)	(0.059)
Observations	495	1,063	489	1,054	1,214	2,704	1,214	2,704
R-squared	0.170	0.120	0.055	0.050	0.031	0.025	0.025	0.035
h	6	12	6	12	6	12	6	12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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Appendix C

Appendix for Chapter 3

C.1 Estimation results with alternative fixed effect specifications

Table C.1: Growth regressions: alternative fixed effect specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
L.dlog_qc_gdp	0.424***		0.232***	0.429***			0.242***	
	(0.042)		(0.074)	(0.041)			(0.069)	
misal	-0.022***	-0.063**	-0.035**			-0.037	-0.014	
	(0.007)	(0.029)	(0.016)			(0.031)	(0.037)	
L.misal				-0.009	-0.015			-0.014
				(0.006)	(0.011)			(0.028)
log_vlc15_gdp_i5	-0.019***	-0.053***	-0.031***	-0.019***	-0.030***	-0.037***	-0.030***	-0.030***
	(0.003)	(0.013)	(0.008)	(0.003)	(0.005)	(0.009)	(0.008)	(0.005)
inv_gdp	0.015	0.219**	0.212***	0.030	0.132***	0.222**	0.216***	0.144***
	(0.031)	(0.088)	(0.067)	(0.031)	(0.051)	(0.087)	(0.061)	(0.048)
infl	-0.007***	-0.007**	-0.057	-0.007***	-0.007***	-0.007**	-0.064*	-0.007***
	(0.002)	(0.003)	(0.038)	(0.002)	(0.003)	(0.003)	(0.038)	(0.003)
gov_def	-0.122***	-0.207***	-0.436***	-0.105***	-0.182***	-0.208***	-0.423***	-0.168***
	(0.035)	(0.059)	(0.141)	(0.036)	(0.040)	(0.058)	(0.150)	(0.041)
free	0.043*	-0.010	-0.016	0.037	0.060	-0.003	-0.031	0.055
	(0.021)	(0.079)	(0.075)	(0.022)	(0.037)	(0.076)	(0.067)	(0.036)
Constant	0.084***	0.220***	0.132***	0.080***	0.100***	0.149***	0.138***	0.098***
	(0.014)	(0.062)	(0.048)	(0.015)	(0.021)	(0.043)	(0.046)	(0.021)
Observations	538	564	511	538	564	563	510	564
R-squared	0.681	0.602		0.675		0.593		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment estimated with country fixed effect

Table C.2: Estimates of asymmetric effects of misalignment: fixed exchange rate countries, alternative fixed effect specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
misal		0.025	0.054			0.041	0.073	
		(0.026)	(0.035)			(0.058)	(0.057)	
fixer		-0.006	-0.006			-0.006	-0.007	
		(0.005)	(0.005)			(0.005)	(0.004)	
misal*fixer		-0.163***	-0.185***			-0.127*	-0.129	
		(0.052)	(0.062)			(0.063)	(0.081)	
L.misal	0.015			0.040**	0.006			-0.022
	(0.011)			(0.018)	(0.015)			(0.040)
L.fixer	-0.005			-0.003	-0.004			-0.003
	(0.003)			(0.003)	(0.003)			(0.003)
L.misal*l.fixer	-0.079***			-0.167***	-0.066***			-0.104
	(0.020)			(0.049)	(0.023)			(0.078)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	564	563	510	564	509	521	493	509
R-squared		0.615				0.637		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment estimated with country fixed effect

Table C.3: Testing for nonlinearity: alternative fixed effect specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
undervalued		0.002	-0.013***			0.004	0.002	
		(0.004)	(0.005)			(0.004)	(0.004)	
umisal		-0.130	-0.575***			-0.050	-0.128	
		(0.154)	(0.183)			(0.205)	(0.210)	
o_misal		0.014	-0.072			0.086	0.023	
		(0.116)	(0.163)			(0.216)	(0.199)	
misal_sq_u		1.591	4.963***			1.979	1.750	
		(1.274)	(1.440)			(1.689)	(2.255)	
misal_sq_o		-0.592	-0.299			-2.333	-0.283	
		(0.547)	(0.976)			(2.030)	(1.791)	
L.under	-0.008			0.005	-0.002			0.001
	(0.006)			(0.005)	(0.004)			(0.003)
L.u_misal	-0.191***			0.038	-0.066			-0.054
	(0.051)			(0.139)	(0.048)			(0.161)
L.o_misal	-0.043			-0.016	-0.068			-0.359*
	(0.055)			(0.131)	(0.073)			(0.198)
L.misal_sq_u	0.613***			-0.152	0.119			0.846
	(0.134)			(1.014)	(0.117)			(1.516)
L.misal_sq_o	0.083			0.201	0.330*			3.219
	(0.121)			(0.978)	(0.182)			(2.628)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	564	563	510	564	509	521	493	509
R-squared		0.601				0.641		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment estimated with country fixed effect

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Table C.4: Estimates for asymmetric effect on CEEU countries, alternative fixed effect specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	GDP price level					Internal relative price		
	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var	Lagged dep. var	Fixed effect	System GMM	Lagged misal lagged dep.var
misal		-0.096*	0.002			-0.041	0.096**	
		(0.049)	(0.058)			(0.043)	(0.043)	
ceeu			-0.005				-0.007	
			(0.006)				(0.005)	
misalceeu		0.096	-0.027			0.029	-0.170***	
		(0.061)	(0.071)			(0.066)	(0.066)	
L.misal	-0.035**			-0.086**	-0.028			-0.042
	(0.014)			(0.041)	(0.020)			(0.035)
L.ceeu	-0.000			-0.000	-0.009			-0.004
	(0.005)			(0.006)	(0.007)			(0.006)
L.misalceeu	0.039*			0.119**	-0.001			-0.055
	(0.021)			(0.052)	(0.031)			(0.069)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	564	563	510	564	509	521	493	509
R-squared		0.599				0.630		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment estimated with country fixed effect

C.2 Estimation results: growth regressions with per capita GDP based misalignments

Table C.5: The effect of misalignment: GDP price level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
L.dlog_qc_gdp	0.432***		0.236***	0.437***			0.242***	
	-0.042		-0.076	-0.041			-0.07	
misal	-0.015	-0.042	-0.008			-0.016	-0.009	
	-0.009	-0.031	-0.016			-0.032	-0.036	
L.misal				0.011	0.014			0.026
				-0.008	-0.013			-0.026
log_vlc15_gdp_i5	-0.019***	-0.048***	-0.030***	-0.017***	-0.029***	-0.036***	-0.030***	-0.029***
	-0.003	-0.013	-0.008	-0.003	-0.005	-0.009	-0.008	-0.005
inv_gdp	0.018	0.198**	0.219***	0.052	0.166***	0.220**	0.211***	0.154***
	-0.031	-0.086	-0.059	-0.031	-0.05	-0.084	-0.063	-0.047
infl	-0.007***	-0.007**	-0.082**	-0.006***	-0.006**	-0.006**	-0.089**	-0.005**
	-0.002	-0.003	-0.039	-0.002	-0.003	-0.003	-0.041	-0.002
gov_def	-0.102***	-0.198***	-0.424***	-0.086**	-0.163***	-0.205***	-0.431***	-0.167***
	-0.036	-0.061	-0.15	-0.035	-0.04	-0.06	-0.153	-0.042
free	0.033	-0.012	-0.039	0.032	0.052	-0.005	-0.044	0.053
	-0.02	-0.075	-0.072	-0.023	-0.037	-0.072	-0.065	-0.035
Constant	0.086***	0.203***	0.141***	0.072***	0.089***	0.146***	0.146***	0.092***
	-0.017	-0.061	-0.049	-0.018	-0.023	-0.043	-0.046	-0.022
Observations	538	564	511	538	564	563	510	564
R-squared	0.676	0.593		0.675		0.589		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

10.14754/CEU.2020.04

Table C.6: The effect of misalignment: internal relative price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
L.dlog_qc_gdp	0.411***		0.241***	0.414***			0.225***	
	(0.049)		(0.080)	(0.046)			(0.074)	
misal	-0.016**	-0.067*	-0.009			-0.020	-0.010	
	(0.007)	(0.035)	(0.021)			(0.038)	(0.041)	
L.misal				-0.004	-0.005			-0.062*
				(0.006)	(0.012)			(0.035)
log_vlc15_gdp_i5	-0.019***	-0.065***	-0.027***	-0.025***	-0.038***	-0.046***	-0.031***	-0.037***
	(0.003)	(0.014)	(0.008)	(0.003)	(0.005)	(0.014)	(0.009)	(0.005)
inv_gdp	0.054*	0.253***	0.224***	0.048*	0.158***	0.279***	0.230***	0.129***
	(0.031)	(0.081)	(0.066)	(0.027)	(0.049)	(0.083)	(0.069)	(0.039)
infl	-0.035	-0.082*	-0.116*	-0.063	-0.074**	-0.096**	-0.115**	-0.065**
	(0.032)	(0.041)	(0.062)	(0.044)	(0.029)	(0.038)	(0.053)	(0.033)
gov_def	-0.075**	-0.142*	-0.418***	-0.085**	-0.153***	-0.178**	-0.422***	-0.119***
	(0.036)	(0.080)	(0.134)	(0.036)	(0.044)	(0.072)	(0.147)	(0.043)
free	0.030	-0.047	-0.067	0.037*	0.053	-0.026	-0.046	0.068*
	(0.023)	(0.086)	(0.075)	(0.021)	(0.036)	(0.082)	(0.069)	(0.035)
Constant	0.083***	0.288***	0.146***	0.110***	0.136***	0.194***	0.150***	0.126***
	(0.016)	(0.080)	(0.048)	(0.016)	(0.021)	(0.061)	(0.045)	(0.022)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	508	522	494	495	509	521	493	509
R-squared	0.694	0.635		0.725		0.630		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

10.14754/CEU.2020.04

Table C.7: Estimates of asymmetric effects of misalignment-level: fixed exchange rate countries, GDP price level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
misal	0.011	-0.009	0.032**			0.041	0.058	
	(0.010)	(0.021)	(0.014)			(0.025)	(0.038)	
fixer	-0.003*	-0.009*	-0.009*			-0.006	-0.007	
	(0.002)	(0.005)	(0.005)			(0.005)	(0.005)	
misalfix	-0.060***	-0.104***	-0.113***			-0.179***	-0.195***	
	(0.016)	(0.024)	(0.026)			(0.047)	(0.066)	
L.misal				0.029**	0.042***			0.056**
				(0.011)	(0.011)			(0.023)
L.fixer				-0.003	-0.005			-0.003
				(0.002)	(0.003)			(0.003)
L.misalfix				-0.051***	-0.087***			-0.115**
				(0.015)	(0.016)			(0.046)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	564	563	510	564
R-squared	0.686	0.617		0.682		0.614		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

Table C.8: Estimates of asymmetric effects of misalignment-level: fixed exchange rate countries, internal relative price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
misal	0.002	-0.027	0.016			0.033	0.044	
	(0.013)	(0.032)	(0.025)			(0.058)	(0.055)	
fixer	-0.004*	-0.010*	-0.010*			-0.007	-0.008*	
	(0.002)	(0.005)	(0.006)			(0.005)	(0.005)	
misalfix	-0.037	-0.082***	-0.065*			-0.103	-0.097	
	(0.022)	(0.021)	(0.035)			(0.064)	(0.081)	
L.misal				0.004	0.008			-0.038
				(0.012)	(0.017)			(0.037)
L.fixer				-0.002	-0.004			-0.003
				(0.002)	(0.003)			(0.003)
L.misalfix				-0.016	-0.044*			-0.045
				(0.018)	(0.026)			(0.071)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	508	522	494	495	509	521	493	509
R-squared	0.698	0.645		0.726		0.635		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

Table C.9: Testing for nonlinear effects, GDP price level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
under	0.001	0.005	0.013*			-0.002	-0.013**	
	(0.005)	(0.005)	(0.007)			(0.004)	(0.006)	
u_misal	-0.076***	-0.063	-0.046			0.012	-0.334**	
	(0.018)	(0.044)	(0.057)			(0.131)	(0.141)	
o_misal	0.053	-0.017	0.153**			-0.154	-0.226	
	(0.056)	(0.068)	(0.071)			(0.110)	(0.174)	
misal_sq_u	0.265***	0.250***	0.183			0.665	3.153***	
	(0.044)	(0.065)	(0.155)			(0.745)	(1.147)	
misal_sq_o	-0.384*	-0.285	-0.566**			0.294	0.599	
	(0.202)	(0.245)	(0.289)			(0.609)	(0.905)	
L.under				0.004	0.004			-0.006*
				(0.006)	(0.005)			(0.004)
L.u_misal				-0.023	-0.009			-0.079
				(0.041)	(0.039)			(0.087)
L.o_misal				0.055	0.047			-0.109
				(0.067)	(0.058)			(0.091)
L.misal_sq_u				0.122	0.128*			0.651**
				(0.081)	(0.066)			(0.328)
L.misal_sq_o				-0.098	-0.102			0.744
				(0.256)	(0.200)			(0.652)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	564	563	510	564
R-squared	0.684	0.609		0.678		0.602		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

Table C.10: Testing for nonlinear effects, internal price level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
under	0.002	-0.002	0.005			-0.001	0.003	
	(0.005)	(0.007)	(0.007)			(0.004)	(0.007)	
u_misal	-0.032	-0.112	0.048			-0.122	-0.130	
	(0.042)	(0.069)	(0.055)			(0.175)	(0.161)	
o_misal	0.014	-0.063	-0.066			-0.136	-0.078	
	(0.072)	(0.106)	(0.108)			(0.216)	(0.360)	
misal_sq_u	0.032	0.139	-0.216			2.204	1.257	
	(0.100)	(0.164)	(0.146)			(1.369)	(1.444)	
misal_sq_o	0.000	0.006	0.363			0.133	1.835	
	(0.223)	(0.236)	(0.305)			(2.543)	(3.772)	
L.under				-0.003	-0.003			-0.003
				(0.004)	(0.005)			(0.004)
L.u_misal				-0.031	-0.041			-0.228
				(0.032)	(0.038)			(0.160)
L.o_misal				-0.039	-0.041			-0.487*
				(0.054)	(0.079)			(0.255)
L.misal_sq_u				0.051	0.077			1.838
				(0.090)	(0.101)			(1.445)
L.misal_sq_o				0.196	0.264			6.248*
				(0.202)	(0.240)			(3.327)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	508	522	494	495	509	521	493	509
R-squared	0.695	0.635		0.727		0.638		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

Table C.11: Estimates for asymmetric effect on CEEU countries, GDP price level

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
misal	-0.028**	-0.073*	-0.030			-0.070	0.004	
	(0.012)	(0.038)	(0.034)			(0.045)	(0.067)	
ceeu	0.000		-0.009				-0.005	
	(0.003)		(0.007)				(0.006)	
misalceeu	0.022	0.050	0.013			0.086	-0.032	
	(0.017)	(0.054)	(0.038)			(0.063)	(0.082)	
L.misal				-0.015	-0.023			-0.050
				(0.009)	(0.014)			(0.031)
L.ceeu				0.006	0.004			-0.001
				(0.004)	(0.006)			(0.006)
L.misalceeu				0.047***	0.067***			0.122***
				(0.015)	(0.019)			(0.047)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	538	564	511	538	564	563	510	564
R-squared	0.678	0.595		0.681		0.594		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

Table C.12: Estimates for asymmetric effect on CEEU countries, internal relative price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Misal estimated without country fixed effect					Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
misal	0.407***		0.264***	0.413***			0.247***	
	(0.050)		(0.071)	(0.045)			(0.067)	
ceeu	-0.014	-0.018	0.003			-0.002	0.080*	
	(0.011)	(0.043)	(0.031)			(0.045)	(0.043)	
misalceeu	-0.004		-0.013*				-0.008	
	(0.004)		(0.007)				(0.005)	
L.misal	-0.010	-0.101	-0.041			-0.034	-0.185***	
	(0.016)	(0.063)	(0.046)			(0.067)	(0.066)	
L.ceeu				-0.010	-0.007			-0.021
				(0.008)	(0.017)			(0.034)
L.misalceeu				-0.001	-0.008			-0.001
				(0.004)	(0.007)			(0.005)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	508	522	494	495	509	521	493	509
R-squared	0.694	0.641		0.726		0.630		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume
Misalignment based on per capita GDP

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Table C.13: Summary statistics for misalignment for fixed and floating exchange rate countries

Variable	Obs	Mean	Std.dev	Min	Max
	Floating exchange rate				
mis_rp_vlw	209	-0.03	0.16	-0.44	0.40
mis_pl_vlw	263	0.00	0.17	-0.44	0.42
	Fixed exchange rate				
mis_rp_vlw	327	-0.01	0.11	-0.36	0.17
mis_pl_vlw	329	0.01	0.12	-0.28	0.36

Table C.14: Average level of development and RER indicators in CEEU and non-CEEU countries, EU15=100

		non CEEU			CEEU		non CEEU	CEEU
	VLC15_GDP	VLW15_GDP	PL15_GDP	VLC15_GDP	VLW15_GDP	PL15_GDP	RP_SG	RP_SG
1995-2016	98	98	97	51	54	52	96	56
1995	94	94	95	39	39	44	94	49
2008	100	100	99	58	60	62	96	60
2016	97	97	98	64	66	59	95	59

Notations: vlc15_gdp: per capita GDP measured on current PPP, EU15==100, vlw15_gdp: per employed person GDP measured on current PPP, EU15==100, PL_GDP: Price level of GDP measured on current PPP, EU15=100; RP_S_g: relative price of services to goods, EU15=100.

Table C.15: Growth effect of (employment based) wage misalignment in CEEU and non-CEEU countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		Misal estimated without country fixed effect				Misal estimated with country fixed effect		
	lagged dep var.	Fixed effect	System GMM	Lagged mis lagged dep var	Lagged mis, fixed effect	Fixed effect	System GMM	Lagged mis, fixed effect
misal	-0.043***	-0.195***	-0.106***			-0.157***	-0.072**	
	(0.015)	(0.051)	(0.037)			(0.048)	(0.032)	
ceeu	0.000		-0.007				-0.009*	
	(0.004)		(0.006)				(0.005)	
misalceeu	0.002	0.067	0.044			0.046	0.024	
	(0.023)	(0.074)	(0.041)			(0.066)	(0.035)	
L.misal				-0.025**	-0.048***			-0.036***
				(0.009)	(0.016)			(0.014)
L.ceeu				0.001	-0.003			-0.003
				(0.003)	(0.006)			(0.006)
L.misalceeu				0.005	0.008			0.002
				(0.017)	(0.028)			(0.027)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Observations	535	560	509	534	559	560	509	559
R-squared	0.684	0.626		0.676		0.611		

Clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.
Dependent variable: annual growth rate of GDP per capita volume

Table C.16: Classification of countries by exchange rate regimes

	Flexible	Fix		Flexible	Fix
AT	1995-96	1997-2016	IE	1995-1997	1998-2016
BE	1995-96	1997-2016	IT	1995-96	1997-2016
BG	1995-98	1999-2016	LT	1995-2001	2002-2016
CY	1995-2006	2007-2016	LV	1995-2006	2007-2016
CZ	1995-2016	.	MT	1995-2003	2004-2016
DE	1995-96	1997-2016	NL	1995-1997	1998-2016
DK	1995-99	2000-2016	PL	1995-2016	.
EE	1995-96	1997-2016	PT	1995-1997	1998-2016
EL	1995-2000	2001-2016	RO	1995-2016	.
ES	1995-96	1997-2016	SE	1995-2016	.
FI	1995-98	1999-2016	SI	1995-2004	2004-2016
FR	1995-98	1999-2016	SK	1995-2008	2009-2016
HR	1995-2016	.	UK	1995-2016	.
HU	1995-2016	.			