Four Essays on Demography and Labour Market Outcomes

Von der Wirtschaftswissenschaftlichen Fakultät der
Gottfried Wilhelm Leibniz Universität Hannover
zur Erlangung des akademischen Grades

Doktor der Wirtschaftswissenschaften
– Doctor rerum politicarum –

genehmigte Dissertation
von

Diplom-Verkehrswirtschaftler MSc Economics and Econometrics
Mario Reinhold
geboren am 20.11.1985 in Riesa

2016

Erstgutachter: Prof. Dr. Stephan L. Thomsen

Zweitgutachter: Prof. Dr. Patrick Puhani

Tag der Promotion: 14.11.2016

Danksagungen

Ich möchte mich bei Prof. Thomsen für das mir entgegengesetzte Vertrauen und die Betreuung dieser Arbeit bedanken. Durch die Tätigkeit am Niedersächsischen Institut für Wirtschaftsforschung konnte ich neben der wissenschaftlichen Qualifizierung im Rahmen dieser Arbeit außerdem anwendungs- und projektbezogene berufliche Erfahrungen sammeln. Seine Kritik, sein Anspruch an die wissenschaftliche Arbeit und die gemeinschaftliche Tätigkeit sowie die von ihm geschaffenen Strukturen am NIW haben diese Dissertation maßgeblich beeinflusst. Ich bedanke mich weiter bei Prof. Puhani für die Begutachtung dieser Arbeit.

Mein besonderer Dank gilt – ohne namentliche Nennung und Rangordnung – meiner Familie, Freunden, Kollegen am NIW, Promotionsmitstreitern und Forschern, die ich auf Tagungen kennengelernt habe. Sie alle haben mich in unterschiedlicher Weise unterstützt, begleitet und diese Arbeit vorangebracht.

Summary

This dissertation analyses the workforce composition and its impact upon labour market outcomes in Germany. The study grounds on an ongoing demographic change within the workforce and various transitions in the German labour market in the past decades. These are a rising wage inequality and a polarisation of employment. Although these shifts are universally observed in industrialised countries, Germany is peculiar with respect to size and timing, but also the causes of these changes. The aim of this dissertation is to empirically assess these shifts in the labour market in the light of a simultaneous transition in the demographic and the skill composition. It illustrates how the composition of the workforce impacts the wage and occupational structure. It further illustrates how even regional differences in the workforce composition results in regional differences in the wage and occupational pattern. A novel method of small-scale local population projection supplements these analyses.

Zusammenfassung

Diese Arbeit untersucht die Zusammensetzung der Bevölkerung und deren Auswirkung auf den Arbeitsmarkt in Deutschland. Der zunehmende demografische Wandel innerhalb der Erwerbsbevölkerung sowie weitere verschiedenartige Veränderungen auf dem Arbeitsmarkt in den letzten Jahrzehnten bilden den Hintergrund dieser Untersuchung. So wird in Deutschland eine zunehmend ungleiche Lohnverteilung und eine Polarisierung der Beschäftungsstruktur hinsichtlich der ausgeübten Berufe beobachtet. Ähnliche Veränderungen werden zwar auch in zahlreichen weiteren Industrieländern wahrgenommen, jedoch weist Deutschland Besonderheiten bezüglich des Ausmaßes und der Zeitlichkeit sowie den Ursachen dieser Veränderungen auf. Ziel dieser Arbeit ist es die Veränderungen auf dem Arbeitsmarkt bezüglich der Veränderungen der demografischen und Bildungsstruktur der Erwerbsbevölkerung empirisch zu beleuchten. Dabei wird der Einfluss der Zusammensetzung der Erwerbsbevölkerung auf die Lohn- und Beschäftigungsstruktur gezeigt. Ferner wird verdeutlicht wie selbst kleinräumige Unterschiede in der Zusammensetzung der Erwerbsbevölkerung innerhalb Deutschlands zu Unterschieden in der Lohn- und Beschäftigungsstruktur führen. Eine neuartige Methode zur kleinräumigen Bevölkerungsvorausberechnung ergänzt diese Betrachtungen.

Schlagwörter

Englisch:

- Demography
- Wage Inequality
- Employment Polarisation

Deutsch:

- Demografie
- Lohnungleichheit
- Polarisierung der Beschäftigung

Contents

Danksagungen i

Summary iii

Zusammenfassung v

Schlagwörter vii

List of Figures xiii

List of Tables xv

1 Introduction 1

Bibliography 5

2 Subnational Population Projections by Age 9

Bibliography 9

3 Demographic Change and the Rising Share of Peak-Earners 11

3.1 Introduction 11

3.2 Background 12

3.3 Data and Methodology 14

3.4 Results 15

3.5 Discussion 18

Bibliography 19

4 The Changing Situation of Labour Market Entrants in Germany 21

4.1 Introduction 21

4.2 Background 22
4.3 Data 25
4.4 Empirical Results 27
4.4.1 Education Attainment 27
4.4.2 Wage Development 30
4.4.3 Development of the Task Composition 32
4.4.4 Development of Young Workers in Top-Paying Jobs 34
4.4.5 Patterns of Labour Market Entry 37
4.4.6 Wage Premia 44
4.5 Conclusion 47
Bibliography 48

5 On the Link between Job Polarisation and Wage Inequality 55

5.1 Introduction 55
5.2 Literature 57
5.2.1 International Literature 57
5.2.2 Literature on German Wage Inequality and Job Polarisation . . . 59
5.2.3 Literature on Wage Inequality and Job Polarisation using Regional Variation as Identification 60
5.3 Data, Trends in Wage Inequality and Job Polarisation in Germany and its Regions 62
5.3.1 Data 62
5.3.2 German Trends in Wage Inequality and Job Polarisation 63
5.3.3 Regional Polarisation 66
5.4 What is the Link between Job Polarisation and Wage Inequality? 70

5.4.1 Regions as the Identification Strategy of Job Polarisation 70

5.4.2 Regional Trends in Wage inequality 71

5.4.3 Distributional Decomposition Method 75

5.4.4 Decomposing Differentials in Wage Inequality between Non-Polarised and Polarised LLM 77

5.4.5 The link between occupational and wage growth 80

5.5 Conclusion 86

Bibliography 87

6 Concluding Remarks **97**

List of Figures

3.1 Ratio Prime Earners vs. Young Workers and Wage Inequality (1980-2010) 13

3.2 Lifetime Log Wage Function – 1980, 1995 and 2010 14

3.3 Wage Index, Observed and Counterfactual (1980 – 2010) 16

3.4 Observed Wage Growth and Demographic Effect (1995-2010) 17

4.1 Education Distribution (Shares, 25-34 Years, 1975-2010) 28

4.2 Education Distribution (Absolute Numbers, 25-34 Years, 1975-2010) . . . 29

4.3 Median Log Real Daily Wages of All and of Young Workers (1975-2010) . 30

4.4 Deviation of the Median Log Real Daily Wage by Main Task (25-34 years, 1975-2010) 31

4.5 Shares of Performed Tasks (25-34 Years) 32

4.6 Shares of Performed Tasks (Education Groups, 25-34 Years) 33

4.7 Job Polarisation (All Workers) 35

4.8 Job Ordering (Four to Six Years of Experience) 36

4.9 Median Log Real Daily Wage Profiles for labour Market Entrants (Potential Experience) 38

4.10 Shares of Workers in Non-Routine Analytical Jobs (by Education, 5 Years of Potential Experience) 39

4.11 Share Profiles of Workers in the Analytical Non-Routine Sector (by Education, Potential Experience) 40

4.12 Median Log Real Daily Wage Profiles for labour Market Entrants in the Non-Routine Analytical Sector (Potential Experience) 42

4.13 Median Log Real Daily Wage Profiles for Labour Market Outside the Non-Routine Analytical Sector (Potential Experience) 43

4.14 Wage Premia for Education Groups (25 to 34 years) 45

4.15 Wage Premia by Task Groups (25 to 34 years) 46

5.1 Indexed Wage Growth (1980-2010), Base Year=1995 63

5.2 Indexed Wage Inequality (1980-2010), Base Year=1995 64

5.3 Occupational Growth – Wage and Skill Percentiles (1980-2010) 65

5.4 Fitted occupational Growth – by Degree of Job Polarisation (1980-2010) 68

5.5 Educational Shares – by Degree of Job Polarisation (1980-2010) 69

5.6 Wage Inequality – by Degree of Job Polarisation (1980-2010) 72

5.7 Relative Wage Gap – by Degree of Job Polarisation (1980-2010) 74

5.8 Occupational shifts, wage shifts, change of skills, and initial education by skill percentile – by Degree of Job Polarisation (1980-2010) 85

5.9 Map of Job Polarisation in Germany 93

5.10 Link between Wage and Occupational change (1980-2010) 94

List of Tables

3.1 Wage and Inequality Growth – Decomposition – F(X) in 1995 reweighted to 2010 18

4.1 Median Log Wage Growth for All labour Market Entrants by Education Group 52

4.2 Median Log Wage Growth for labour Market Entrants in Non-Routine Analytical Jobs by Education Group 53

4.3 Median Log Wage Growth for labour Market Entrants Outside Non-Routine Analytical Jobs by Education Group 54

5.1 Wage Gap in 1980: Quantile Decomposition – Reference Group: Polarised LLM 78

5.2 Regional Wage Gap in 2010 – by Degree of Job Polarisation: Quantile Decomposition – Reference Group: Polarised LLM 79

5.3 Regional Growth Wage Gap in 2010: Quantile Decomposition – Reference Group: Polarised LLM 79

5.4 OLS Regressions: Employment Change on Wage Growth 82

5.5 OLS Regressions: Wage Change on Occupational Change 84

5.6 Wage Gap in 1980: Quantile Decomposition – Reference Group: Strongly Polarised LLM 95

5.7 Regional Wage Gap in 2010 – by Degree of Job Polarisation: Quantile Decomposition – Reference Group: Strongly Polarised LLM 95

5.8 Regional Growth Wage Gap in 2010: Quantile Decomposition – Reference Group: Strongly Polarised LLM 96

1

Introduction

The workforce comprises individuals of different ages and skills. These characteristics directly relate to labour market outcomes, such as wages (Mincer, 1974). In Germany, the past decades faced large transitions in demography and labour market outcomes. At such times, the demographic composition and its impact on labour market outcomes become an important field of study, in particular since demographic change still progresses and will gain pace prospectively.

Demographic change refers to the ageing of the population due to a declining fertility and an increasing life expectancy. Increasing life expectancy and declining fertility are universally observed in rich countries. Notwithstanding, German demographic change, and thereby the fall of fertility, is distinct with regard to timing, size, and its long-term impact: Between 1964 and 1974 only, the number of births dropped by 41 % (Eurostat, 2015b). The reason for the fall in births is the declining fertility after a pronounced baby boom: Total fertility dropped from 2.5 children per woman to 1.5 children per woman from 1964 to 1974, and dropped even further to 1.2 by 1994 (OECD, 2016). Such a strong fall stands alone among industrialised countries. Between 1970 and 1995, Germany had the lowest total fertility rate among all G-20 countries (OECD, 2016). By 2013, the total fertility rate in Germany was still second-lowest among all G-20 countries.

The decline in fertility impacts demographic change in the long run, since it self-amplifies over time. Due to the low number of births, the number of potential mothers a generation later is small. Together with a continuous low fertility rate, this will result in even fewer births and further ageing. Consequently, Germany is the country with the lowest crude birth rate in the EU-28 in 2010, and the lowest crude natural growth among all EU-15 countries (Eurostat, 2015b). As a result of a continuous low birth rate, Germany has the highest median age of the population among all EU-28 countries (Eurostat, 2015a), and all G-20 countries along with Japan (Central Intelligence Agency, 2016).

Demographic shifts will immediately translate into labour market outcomes. The size of the population immediately determines the size of the workforce, i.e. the supply of labour. The supply of labour affects wages, since wages – the price of labour – is regulated by the

interaction of supply and demand. As an example, Goldin and Katz (2009) depict how the supply of high-skilled labour in the U.S. fell short of its demand, since technological change spurred demand for high-skilled labour. This shortage led to rising wages for the high-skilled, and eventually in rising wage inequality. Similarly, the constantly growing supply of high-skilled labour accounts for the long-lasting stability of the German wage structure, at least before the 1990s (Abraham and Houseman, 1995).

Not only the size of the labour supply plays a crucial role in labour market outcomes. The age composition similarly matters. There is an imperfect substitution of labour across age groups (Card and Lemieux, 2001; Prskawetz et al., 2008; Roger and Wasmer, 2009). Skills are age-specific, such as physical capacity, the adaptability to acquire new knowledge, etc. Consequently, the changing age composition of the workforce will similarly alter labour market outcomes. As an example, demographic change induces an ageing of the workforce over time – similarly, wages typically peak around the age of 50 (Heckman et al., 2003; Mincer, 1974). An ageing workforce towards the age of 50 and a rising share of workers around that age must then evoke rising average wages within the workforce.

Next to these demography-related transitions, there are two universally observed shifts in labour market outcomes. They refer to the wage and occupational structure: Rising wage inequality and a polarisation of employment (Acemoğlu and Autor, 2011). Literature suggests technological change as the main trigger for both developments.

Regarding wage inequality, new technologies complement those workers that are most prone to adapt to new technologies (Katz and Murphy, 1992). The aptitude to adapt to new technology increases with the skills of a worker. Technological change affects workers according to their skills, with the highest complementarities for the most-skilled and lowest complementarities for the least-skilled. The productivity rises most for the highest-skilled, and thus their demand increases, while barely affecting the productivity and demand of the least-skilled. It follows increasing wage inequality when growing demand and productivity for high-skilled workers outpaces its supply (Goldin and Katz, 2009; Katz and Murphy, 1992). Wages then rise unbalancedly across skill levels. They rise at the top for high-skilled workers, and do not change at the bottom for low-skilled workers.

With regard to employment polarisation, technological change reshapes the demand for performed tasks within occupations. Technological innovation, especially in Information and Computer Technologies (ICT), can replace workers performing codifiable routine tasks (Autor et al., 2003). These routine tasks are typically performed in medium-paying jobs. It follows a declining share of medium-paying jobs over time. At the same time,

these technologies enhance the productivity of high-skilled workers at the top of the wage distribution, since they heavily rely upon information as an input. It follows an increasing share of top-paying jobs. Concurrently, innovations barely have an impact upon jobs at the bottom of the wage distribution, which are typically non-routine and manual service jobs. Still, these jobs indirectly benefit from the rising share of top-paying occupations: Bottom-paying jobs are typically in the service sector, which need regional proximity to their customers, and who thus benefit from the increasing demand stemming from top-paying workers (Beaudry et al., 2012; Moretti, 2010). It follows an increasing share of workers at the top and bottom, at the cost of middle-paying jobs – employment polarises (Goos and Manning, 2007).

These changes in the wage and occupational structure are universally observed among industrialised countries, including Germany (Acemoğlu and Autor, 2011). Still, Germany stands alone with regard to the timing and the size of these transitions. Wage inequality started to rise a decade later in Germany than in the U.S. or the UK, and was also first limited to the upper tail of the wage distribution, although technology can be assumed alike between these countries (Dustmann et al., 2009). Further, although employment polarisation occurred in Germany; it shortly reversed after the millennium (Antonczyk et al., 2009). Also, the increase in bottom-paying jobs in Germany is much less ample than in other industrialised countries (Dustmann et al., 2009).

There are several recognised reasons to these German peculiarities, such as a comparatively centralised wage setting explaining the long wage stability of the German wage structure, and a deunionisation process that introduces rising wage inequality (Dustmann et al., 2009). Further aspects relate to demography, such as a balanced growth path between supply and demand of high-skilled labour (Abraham and Houseman, 1995), a compression of skills within the German workforce (Freeman and Schettkat, 2001), and supply shocks of low-skilled workers after German reunification (Dustmann et al., 2009).

The aim of this thesis is to empirically shed light upon several aspects of demography and labour market outcomes in Germany. It grounds upon four distinct essays in demography and labour market outcomes. Chapter 2 is about demography, and in particular on a population projection method. The remaining chapters discuss labour market outcomes. In particular, they depict the impact of demography upon the wage structure (chapter 3), the changing occupational and wage patterns for the declining number of young labour market entrants (chapter 4), and the link between occupational and wage patterns within German regions that differ markedly in their workforce composition, and the degree to which they were affected by employment polarisation (chapter 5).

Chapter 2 describes an innovative approach for age-specific small-scale population projections. Small populations are typically difficult to project, since the projection error increases with decreasing population size. At the same time, there is a multitude of decisions on the local level that build upon reliable age-specific population projections, such as the planning of hospitals or schools. For this reason, it is essential to improve small-scale projection methods, but it is also crucial to know potential drawbacks and the level of potential forecast errors to plan efficiently and with long lead times.

The proposed method combines several approved population projection techniques. The precision of this combined method is evaluated ex-post, i.e. the projection error is measured as the difference between projected and actual population, had the population been projected in the past with the data that were available at that time. A combination of various methods yields more precise estimations than each technique solely. Due to its higher accuracy, this method helps policymakers and other decision-makers to tackle the tasks of demographic change. It further quantifies potential forecast errors.

Chapter 3 illustrates how demographic shifts immediately impact labour market outcomes. It shows how the ageing of the workforce, which gained pace by the mid-1990s in Germany, reshapes the wage structure directly. The chapter illustrates how the increasing share of peak-earners in the workforce, i.e. the increasing share of workers around the age of 50 years, shifts up wages along the wage distribution. It thus illustrates the necessity to understand the demographic structure in order to understand the wage structure.

Chapter 4 deals with the changing labour market outcomes for labour market entrants in Germany. It bases upon a peculiar decline in the number of young labour market entrants from the 1990s due to the pronounced decline in fertility. Still, the number of young workers with tertiary education has stayed constant, since the declining absolute number of young workers is counteracted by a continually rising share of young workers with tertiary education. This singularity transfers into distinct wage patterns of young labour market entrants as compared to the U.S.

The chapter grounds upon the observation that young labour market entrants in the U.S. face an unprecedented fall of demand for cognitive skills and a declining share of young workers in top-paying jobs that also translates into falling entry wages and slow wage growth after labour market entry (Beaudry et al., 2013). A decline in demand for cognitive skills and a declining share of young workers in top-paying jobs can also be detected in Germany. Still, entry wages as well as wage growth after labour market entry is unchanged in Germany, which may be related to a decline in the absolute number of young workers.

Chapter 5 connects two labour market outcomes that are universally observed in rich countries: Increasing wage inequality and job polarisation. Both phenomena are distinct, since the first relates to wages and the second to occupations. This chapter analyses how they are related to one another in Germany. I illustrate how the link hinges upon the workforce composition, and notably the demographic composition and educational attainment of the labour force.

The chapter demonstrates a correlation between job polarisation and rising wage inequality at first sight. Going beyond a pure correlation, the link between polarisation and inequality vanishes, once controlling for education within occupations. The presented results indicate how educational expansion is central to the wage formation. Further, it highlights the importance of the skill formation within the workforce for the overall wage structure.

Chapter 6 concludes.

Bibliography

Abraham, K. G. and Houseman, S. (1995). Earnings inequality in Germany. In *Differences and changes in wage structures*, pages 371–404. University of Chicago Press.

Acemoğlu, D. and Autor, D. (2011). *Skills, Tasks and Technologies: Implications for Employment and Earnings*, volume 4 of *Handbook of Labor Economics*, chapter 12, pages 1043–1171. Elsevier.

Antonczyk, D., Fitzenberger, B., and Leuschner, U. (2009). Can a Task-Based Approach Explain the Recent Changes in the German Wage Structure? *Jahrbücher für Nationalökonomie und Statistik*, pages 214–238.

Autor, D. H., Levy, F., and Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, 118(4):1279–1333.

Beaudry, P., Green, D. A., and Sand, B. (2012). Does Industrial Composition Matter for Wages? A Test of Search and Bargaining Theory. *Econometrica*, 80(3):1063–1104.

Beaudry, P., Green, D. A., and Sand, B. M. (2013). The Great Reversal in the Demand for Skill and Cognitive Tasks. NBER Working Papers 18901, National Bureau of Economic Research, Inc.

Card, D. and Lemieux, T. (2001). Can Falling Supply Explain the Rising Return to College for Younger Men? A Cohort-Based Analysis. *The Quarterly Journal of Economics*, 116(2):705–746.

Central Intelligence Agency (2016). The World Factbook 2016-17. Web: https://www.cia.gov/library/publications/the-world-factbook/fields/2177.html. Retrieved June 02 2016.

Dustmann, C., Ludsteck, J., and Schönberg, U. (2009). Revisiting the German Wage Structure. *The Quarterly Journal of Economics*, 124(2):843–881.

Eurostat (2015a). Population: Structure indicators . Web: http://ec.europa.eu/eurostat/data/database. Retrieved June 01, 2016.

Eurostat (2015b). Population change - Demographic balance and crude rates at national level . Web: http://ec.europa.eu/eurostat/data/database. Retrieved June 01, 2016.

Freeman, R. and Schettkat, R. (2001). Skill Compression, Wage Differentials, and Employment: Germany vs the US. *Oxford Economic Papers*, 53(3):582–603.

Goldin, C. D. and Katz, L. F. (2009). *The Race between Education and Technology*. Harvard University Press, Cambridge, MA.

Goos, M. and Manning, A. (2007). Lousy and Lovely Jobs: The Rising Polarization of Work in Britain. *The Review of Economics and Statistics*, 89(1):118–133.

Heckman, J. J., Lochner, L. J., and Todd, P. E. (2003). Fifty years of Mincer earnings regressions. Technical report, National Bureau of Economic Research.

Katz, L. F. and Murphy, K. M. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Mincer, J. A. (1974). *Schooling, Experience, and Earnings*. National Bureau of Economic Research, Inc.

Moretti, E. (2010). Local Multipliers. *American Economic Review*, 100(2):373–777.

OECD (2016). Fertility Rates (Indicator). Web: https://data.oecd.org/pop/fertility-rates.htm#indicator-chart. Retrieved June 01 2016.

Prskawetz, A., Fent, T., and Guest, R. (2008). Workforce Aging and Labor Productivity: The Role of Supply and Demand for Labor in the G7 Countries. *Population and Development Review*, 34:298–323.

Roger, M. and Wasmer, M. (2009). Heterogeneity matters: labour productivity differentiated by age and skills. Working Papers halshs-00575086, HAL.

2

Subnational Population Projections by Age: An Evaluation of Combined Forecast Techniques*

This chapter is published as Reinhold, M. and Thomsen, S. L. (2015). Subnational Population Projections by Age: An Evaluation of Combined Forecast Techniques. *Population Research and Policy Review*, 34(4):593–613.

Bibliography

Reinhold, M. and Thomsen, S. L. (2015). Subnational Population Projections by Age: An Evaluation of Combined Forecast Techniques. *Population Research and Policy Review*, 34(4):593–613.

* This chapter is joint work with Stephan L. Thomsen.

3

Demographic Change and the Rising Share of Peak-Earners – Shifting up Wages, Not Reshaping Wage Inequality

3.1 Introduction

Wage inequality rose in the past decades in most developed countries including Germany (Acemoğlu and Autor, 2011). Among the most popular causes for changing labour market outcomes in recent literature include technological change (Katz and Murphy, 1992), increasing trade (Autor et al., 2013), and changing labour market institutions (DiNardo et al., 1996; Dustmann et al., 2009). Demographic shifts have barely been regarded as a potential trigger.

A possible link grounds upon the age-earnings relationship. Lifetime earnings are typically lowest at the beginning of worklife, and peak around the age of 50 years (Heckman et al., 2003). Wage inequality may thus mechanically change, for example when the share of peak-earners relative to labour market entrants rises, even when lifetime inequality is unaltered. From a normative point of view, this mechanical rise in wage inequality is of little interest for policy-makers, since these imbalances vanish over the course of a work life for each individual worker (Atkinson, 1971). Notwithstanding, these effects appear in wage inequality statistics.

There are further aspects how demographic change may change wages. First, demographic shifts alter the supply of labour (He, 2012). As an example, declining supply of labour affects the capital-labour ratio, thus increasing the returns to labour, while mitigating the returns of capital. Second, declining fertility positively affects human capital accumulation (Lee and Mason, 2010). This leads to increasing returns to labour, while the effect upon wage inequality is a priori unclear, since the ratio between increasing

demand and supply of skills determines increasing or decreasing wage inequality (Tinbergen, 1975). Third, due to an imperfect substitution of labour between age cohorts, the cohort size can negatively affect wages through oversupply (Garloff et al., 2016). Fourth, this effect is counteracted by policies that privilege strong cohorts due to their large share of voters (OECD, 2008). The net effect is unclear.

I empirically assess the impact of the changing workforce composition with respect to age and sex upon the wage structure. The approach follows a counterfactual density function reweighting. It addresses the question: What was the wage distribution had the workforce composition remained constant? The study intentionally ignores skill and occupational shifts within the workforce, since they reflect a response to altering labour markets, whereas demographic shifts are mainly exogenous and occur with a long lead time. It also neglects shifts in the household formation, which also contribute to inequalities, especially in Germany (OECD, 2008).

3.2 Background

German wage inequality has long been served as specimen against the theory of rising wage inequality (Prasad, 2004). Rising wage inequality only hit the German labour market from the mid-1990s (Dustmann et al., 2009), which is displayed in figure 3.1 as the 85-15 interpercentile ratio. This rise coincided with the entry of the baby boomer generation into working life around 1995, who then aged and experienced wage growth with peaking lifetime earnings around the age of 50 years by 2010. This cohort strongly determines the German age structure. As an example, the number of babies born in the 1960s is one third larger than a decade later (OECD, 2016a). The ratio between prime earners (age 45 to 54 years) relative to young workers entering the labour market (25 to 34 years) bottomed in 1995 and almost doubled by 2010 (figure 3.1). The correlation between this ratio and wage inequality is 85% between 1980 and 2010, and even 99% between 1995 and 2010.

Besides demographic shifts, there are multiple other factors that reshape the wage structure over time. To name a few, there are shifts in the institutional framework, and the educational and occupational structure of the labour force. Labour market participation rates and employment-population ratios also change, notably for women. These shifts are nonetheless universal and not constrained to certain age groups (see also OECD (2016b)).

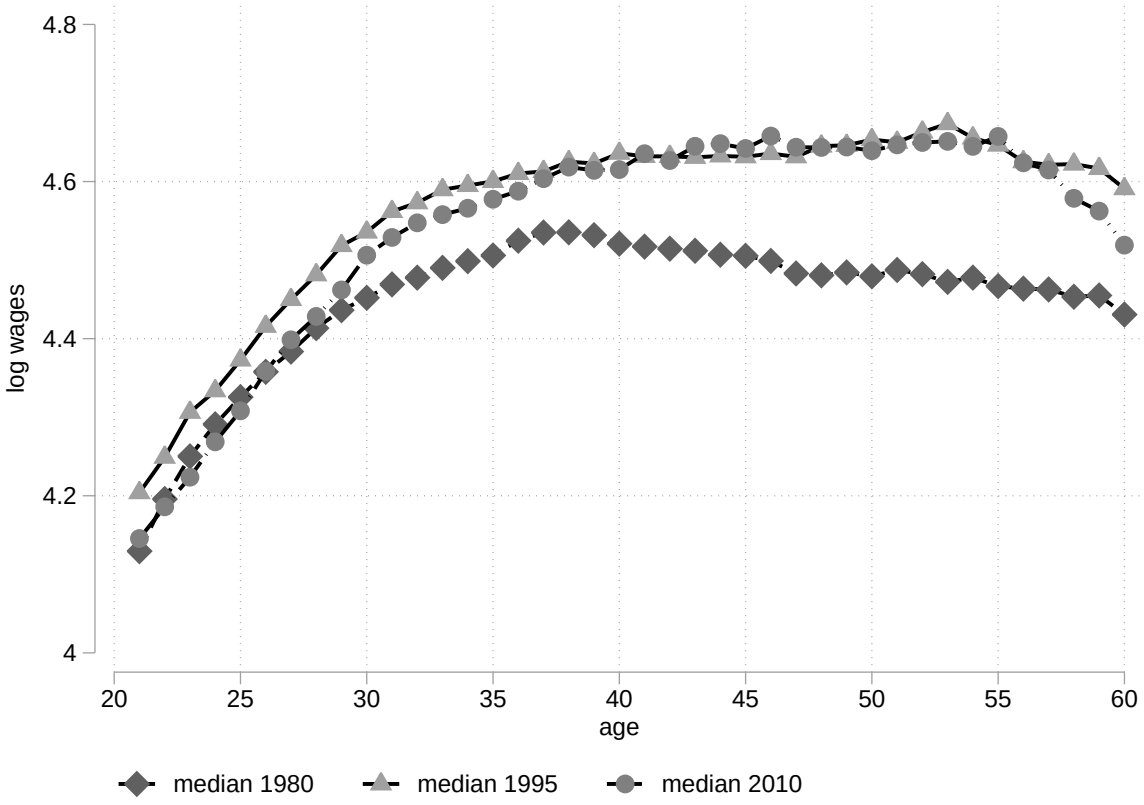
Additional to the demographic shift, lifetime wages' peak also shifted. Figure 3.2 displays lifetime median wages by age in logs. In 1980, lifetime median wages peaked at the age

Figure 3.1: Ratio Prime Earners vs. Young Workers and Wage Inequality (1980-2010)

Ratio: OECD Population and Vital Statistics.
Wage inequality: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany.

of 39 years and fell thereafter. Between 1980 and 1995, wages overall increased. The peak of lifetime wages shifted to the right to the age of 53 years, with almost constant wages between the age of 45 and 55 years. By 2010, the lifetime wage function is nearly unchanged between the age of 40 to 55 years. The peak is at 46 years, which corresponds to the 1964-birth cohort – interestingly, the year 1964 is the high point of the baby boom in Germany. Wages are slightly lower for workers under 40 years of age as compared to 1995, and the decline of wages after the age of 55 years is more pronounced. Overall, changes in median lifetime earnings were larger between 1980 and 1995, when total wage inequality remained stable, as compared to 1995 and 2010, when lifetime earnings were almost unchanged, but total wage inequality started to rise. This coincidence further compels a possible link between the rise in wage inequality and demographic shifts.

Figure 3.2: Lifetime Log Wage Function – 1980, 1995 and 2010



2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany.

3.3 Data and Methodology

I employ data of the Sample of Integrated Labour Market Biographies (SIAB) in Germany, which is described in vom Berge et al. (2013). It reflects a 2 percent random sample of social security data. Due to its administrative character, it guarantees a high reliability and covers roughly 80 percent of the German workforce that are subject to social security contribution. The wage variable is censored above the social security ceiling. For this reason, I restrict the analysis below the 85th percentile of the wage distribution. Wages are daily wages, observed at 30th of June for each year, and inflation-adjusted. The data are constrained to West Germany and workers between 21 and 60 years of age following Dustmann et al. (2009).

The impact of demographic change on the wage distribution is assessed by means of reweighting following DiNardo et al. (1996). In doing so, observed wage shifts over time can be decomposed into parts that can be explained by demographic shifts and

remaining parts that can not be explained by demographic shifts. The concept behind this approach is to integrate the conditional distribution of wages y in one year $t = A$ given demographic characteristics in $t = A$, over the distribution of demographic characteristics of another year $t = B$. It expresses the counterfactual wage distribution in $t = A$, were the demographic characteristics of the workforce such as in time $t = B$. The counterfactual wage distribution $F_{Y_A^c}$, which mixes the distribution of demographic characteristics at $t = B$ with the wage structure at $t = A$ thus is:

$$F_{Y_A^c}(y) = \int F_{Y_A|X_A}(y|X)\Psi(X)dF_{X_A}(X), \tag{3.1}$$

where $\Psi(X) = dF_{X_B}/dF_{X_A}$ is a reweighting factor. The reweighting factor is estimated by a probit of belonging to group B in a pooled data set, which is estimated by demographic characteristics of the workforce. The reweighting thus starts with group A, and replaces the distribution of demographic characteristics of time $t = A$ with the distribution of demographic statistics of time $t = B$ using the reweighting factor $\Psi(X)$.

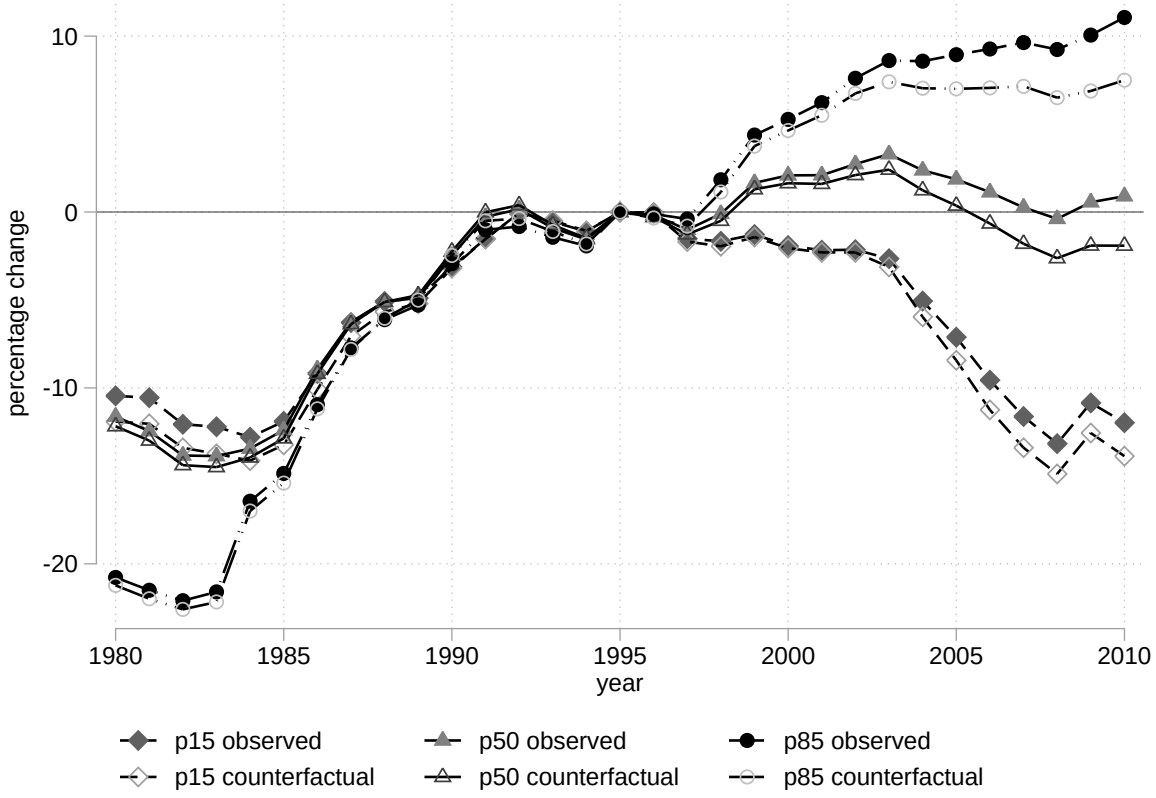
3.4 Results

The observed and counterfactual wage development at the lower tail (15th percentile), median and upper tail (85th percentile) of the wage distribution over time is displayed in figure 3.3. Wages are indexed to the year 1995. Counterfactual wages refer to the workforce composition of the year 1995. Observed wages increase between 1980 and 1990 and then remain stable until the late 1990s. Between 1980 and 1985, wage growth was larger for the upper tail, but wages move in parallel from 1985. Until 1995, observed and counterfactual wage growth is by and large identical.

This pattern changes after 1995. First, the wage distribution spreads: Upper tail wages increase, median wages stagnate, and lower tail wages decline. Second, observed and counterfactual wages grow in a distinct way. Counterfactual wages are lower than observed wages. Wages would have been lower, had the demographic structure of the labour force remained unchanged from the year 1995. The counterfactual wage distribution still spreads. It highlights a pattern in which demographic shifts elevate wages. This elevation occurs along the wage distribution, i.e. is similar in sign and magnitude at the bottom, median and top.

Figure 3.4 gives further insight into wage growth between 1995 and 2010, when wage inequality rises. Observed wage growth follows a monotonic function along the wage

Figure 3.3: Wage Index, Observed and Counterfactual (1980 – 2010)



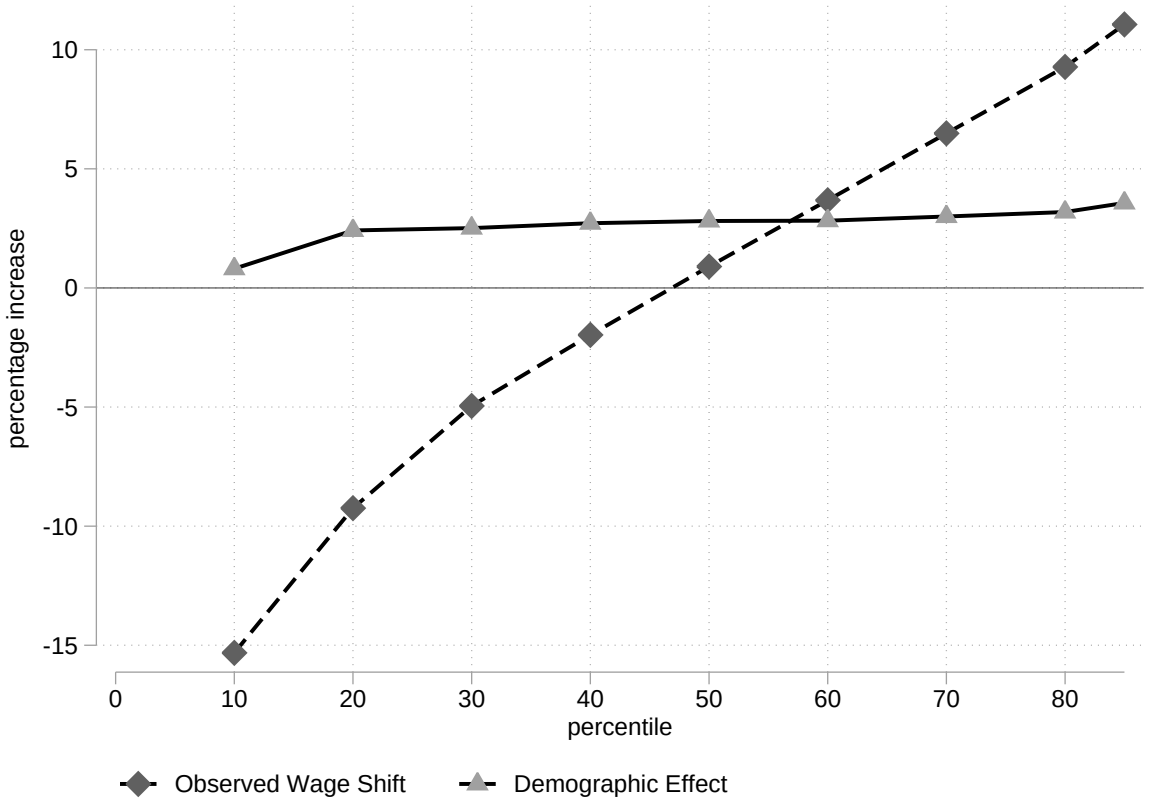
2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany.

distribution. It is negative at the lower tail and increases along the wage distribution, being close to zero at the median and highest at the top of the wage distribution.

The demographic effect, i.e. the difference between observed and counterfactual wages, is positive and comparably small. It is almost constant along the wage distribution, being close to zero at the lower tail and increasing to 3.5 % at the very top.

The impact of demographic change on total wage inequality, measured as the 85-15 interpercentile ratio, then is almost zero, since the demographic effects move in the same direction and thus offset one another. The top panel of table 3.1 illustrates this framework for the total workforce. While observed wage growth is negative at the lower tail and positive at the upper tail, the effect of demography is similar in size and sign. It follows that wage growth can mainly by explained by other factors than demographic shifts. Only 1.7 % of the 23 % increase in observed total wage inequality similarly can be linked to demographic changes. The increase in observed wage inequality, as well as the demographic effect, is equally split between upper (85-50) and lower (50-15) inequality.

Figure 3.4: Observed Wage Growth and Demographic Effect (1995-2010)



2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany.

What was the effect if one ignores sex composition of the workforce and only focuses on the age structure of the workforce? To do so, the bottom panel of table 3.1 describes the wage shifts and the demographic effect of the male workforce only. First and foremost, observed growth in wages and wage inequality are almost identical to the top panel, which displays the wage shifts and the demographic effect for the total workforce. Interestingly, the demographic effect of wage growth resembles even more, leading to an even smaller impact of demographic shifts on wage inequality. Only 0.3 % of the 22.5 % increase in total wage inequality can be associated with age shifts of the male workforce.

It follows that, if anything, the sex composition of the labour force slightly shapes wage inequality. Although demographic shifts have an impact on the wage distribution, i.e. increasing wages due to a higher share of peak-earners, demographic shifts have a very limited power in explaining the wage dispersion after 1995.

Table 3.1: Wage and Inequality Growth – Decomposition – F(X) in 1995 reweighted to 2010

(I) male and female			
wage	observed	demography	remaining
lower tail (p15)	-12.0%	1.9%	-13.9%
median (p50)	0.9%	2.8%	-1.9%
upper tail (p85)	11.1%	3.6%	7.5%
inequality	observed	demography	remaining
total inequality (p85-p15)	23.0%	1.7%	21.4%
upper inequality (p85-p50)	10.2%	0.8%	9.4%
lower inequality (p50-p15)	12.9%	0.9%	12.0%
(II) male only			
wage	observed	demography	remaining
lower tail (p15)	-12.2%	3.3%	-15.5%
median (p50)	1.0%	3.1%	-2.1%
upper tail (p85)	10.3%	3.6%	6.8%
inequality	observed	demography	remaining
total inequality (p85-p15)	22.5%	0.3%	22.2%
upper inequality (p85-p50)	9.3%	0.5%	8.9%
lower inequality (p50-p15)	13.2%	-0.2%	13.4%

2% IABS Sample for full-time workers between 20 and 60 years of age.

3.5 Discussion

The rise in wage inequality from the mid-1990s and the coinciding event of strong demographic shifts towards a higher share of peak-earners in Germany is not related to one another. Still, the ageing of the baby boomers and the increasing share of peak-earners between 1995 and 2010 positively affect wages. There is only a limited effect on wage inequality, since the positive effect occurs along the wage distribution, and is similar at the top and bottom. The results do hardly change whether one considers the total workforce or the male workforce solely.

It follows that wage dispersion after 1995 is mainly spurred by other factors than demography, such as deunionisation and an increasing demand for high-skilled workers (Dustmann et al., 2009). Shifts in the education of workers, especially the increasing share of high-skilled workers and the decline of workers without completed vocational training, also contribute to wage inequality in Germany (Klemm and Weigert, 2014). These findings indirectly support a view that lifetime inequality has increased over generations in Germany, which is expressed in Bönke et al. (2015).

Bibliography

Acemoğlu, D. and Autor, D. (2011). *Skills, Tasks and Technologies: Implications for Employment and Earnings*, volume 4 of *Handbook of Labor Economics*, chapter 12, pages 1043–1171. Elsevier, Amsterdam.

Atkinson, A. B. (1971). The distribution of wealth and the individual life-cycle. *Oxford Economic Papers*, 23(2):239–254.

Autor, D. H., Dorn, D., and Hanson, G. H. (2013). The geography of trade and technology shocks in the united states. *American Economic Review*, 103(3):220–25.

Bönke, T., Corneo, G., and Lüthen, H. (2015). Lifetime Earnings Inequality in Germany. *Journal of Labor Economics*, 33(1):171 – 208.

DiNardo, J., Fortin, N. M., and Lemieux, T. (1996). Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach. *Econometrica*, 64(5):1001–44.

Dustmann, C., Ludsteck, J., and Schönberg, U. (2009). Revisiting the German Wage Structure. *The Quarterly Journal of Economics*, 124(2):843–881.

Garloff, A., Roth, D., et al. (2016). Regional age structure and young workers' wages. Technical report, Institut für Arbeitsmarkt-und Berufsforschung (IAB), Nürnberg.

He, H. (2012). What drives the skill premium: Technological change or demographic variation? *European Economic Review*, 56(8):1546–1572.

Heckman, J. J., Lochner, L. J., and Todd, P. E. (2003). Fifty years of Mincer earnings regressions. Technical report, National Bureau of Economic Research.

Katz, L. F. and Murphy, K. M. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Klemm, M. and Weigert, B. (2014). Does composition matter? Wage inequality and the demographic and educational structure of the labor force in Gemany. Working Papers 06/2014, Sachverständigenrat zur Begutachtung der gesamtwirtschaftlichen Entwicklung.

Lee, R. and Mason, A. (2010). Fertility, human capital, and economic growth over the demographic transition. *European Journal of Population/Revue européenne de Démographie*, 26(2):159–182.

OECD (2008). Growing Unequal? Income Distribution and Poverty in OECD Countries. Technical report, OECD Publishing, Paris.

OECD (2016a). Dataset: Population and Vital Statistics. Web: https://stats.oecd.org/Index.aspx?DataSetCode=ALFS_POP_VITAL. Retrieved 20 April 2016.

OECD (2016b). Income Inequality. Web: https://data.oecd.org/inequality/income-inequality.htm. Retrieved 15 January 2016.

Prasad, E. S. (2004). The Unbearable Stability of the German Wage Structure: Evidence and Interpretation. *IMF Staff Papers*, 51(2):354–385.

Tinbergen, J. (1975). *Income Distribution: Analysis and Policies*. North-Holland Pub. Co., Amsterdam.

vom Berge, P., König, M., Seth, S., et al. (2013). Sample of Integrated Labour Market Biographies (SIAB) 1975-2010. Technical Report 01/2013, FDZ data report.

4

The Changing Situation of Labour Market Entrants in Germany: A Long-Run Analysis of Wages and Occupational Patterns*

4.1 Introduction

During the last decades, Germany and many other countries have experienced an up-skilling of the workforce accompanied by a technological shift towards highly-educated labour. Despite these developments, recent evidence for the US labour market indicates declining wages for college graduates in the aftermath of the Tech Bust in 2000, while post-college workers face continuously high employment and wage opportunities (Beaudry et al., 2014, 2016). If similar patterns would have occurred in Germany, this would indicate "*declining fortunes of the young*" (Beaudry et al., 2014) to be more than a phenomenon of the US labour market.

We analyse a set of employment indicators for graduates entering the labour market in Germany. Based on information of a comprehensive sample of registered employees in the German social security system for the years 1975 to 2010 with about 11.5 million observations, we study the development of wages and occupational quality of job market entrants with consideration of different education levels. We focus on young workers since general changes in the labour market are first apparent for them (Kambourov and Manovskii, 2009). The data allow conducting a detailed descriptive analysis comparing a large number of job market entry cohorts over time. In order to capture the effects of both – supply-side and demand-side changes – different qualifications and different occupational task groups are regarded. Our analysis comprises the developments of educational attainment, wages and the composition of tasks. In addition, we take the job

* This chapter is joint work with Stephan L. Thomsen.

quality into account and consider changes in patterns of labour market entry and wage premia over the three and a half decades of observation.

The empirical picture obtained from these indicators implies that around the year 2000, there was a turning point of the labour market chances of young job market entrants: highly-educated workers have faced declining employment opportunities in the top-paying jobs and in analytical jobs since then. Real entry wages have fallen for each new entry cohort since the turn of the century. However, compared to the US, the decline of wage growth in the first five years after job market entry is less profound but wages after five years have declined for cohorts entering the labour market after 2000 in Germany, too. These patterns are particularly strong for medium-skilled job market entrants.

Whereas the share of young high-skilled workers performing analytical jobs declined slightly only after the tech bust (similar to the US), our results indicate a general decline of wages for young workers, both in and outside analytical jobs. Falling wages are more profound for medium-skilled and low-skilled workers than for high-skilled workers. Wage premia for higher education slightly rose relative to medium-skilled and low-skilled workers, while they did not change for high-skilled workers. In and outside analytical jobs, wage premia are paid for high-skilled workers. These patterns, therefore, depict relatively rising employment and wage opportunities for high-skilled workers outside analytical jobs. Moreover, the displacement effects, shrinking wages, and flattening wage growth for medium-skilled and low-skilled workers further signify the relevance of the increase in graduation rates in higher education.

The remainder of the paper is organised as follows. The next section gives a more detailed discussion of related literature for the analysis at hand. Section 4.3 introduces the data used for the empirical analysis. The empirical results of the considered aspects are presented in section 4.4. The final section provides the conclusions.

4.2 Background

Wage inequality in the US labour market increased during the 1980s, notably at the upper tail of the wage distribution (Katz and Murphy, 1992). In particular, technological change complementing high-skilled workers and substituting low-skilled workers contributed as a major driving force to this process (Acemoğlu, 2002). Related to this, the skill-biased technological change hypothesis (SBTC) emphasised the exceeding growth in the demand for high-skilled workers with respect to its supply at the expense of less-skilled workers (Katz and Autor, 1999). Despite the convincing character in explaining the labour market

development during the 1970s and 1980s, more recent literature puts stronger focus on the increasing concentration of employment at both tails of the wage distribution associated with a strong decline of medium-skilled occupations (job polarisation, e.g. Autor et al. (2003, 2006, 2008); Autor and Dorn (2013), or routine-biased technological change, see Goos et al. (2014)).

Increasing wage inequality has long been thought of being a phenomenon solely present in Anglo-Saxon labour markets. From this perspective, wage inequality in Anglo-Saxon countries and high unemployment rates of low-skilled workers in Continental Europe appeared as 'two sides of the same coin', both stemming from the relative fall in the demand for low-skilled labour (Krugman, 1994). Labour market adjustment in Germany occurred through an alteration of employment rather than wages (Antonczyk et al., 2010; Naticchioni et al., 2014).

Despite the developments of the US labour market until the early 2000s, a recent strand of the literature on inequality portrays the demand for high-skilled labour as a boom-bust cycle ceasing with the Tech Bust in 2000. Beaudry et al. (2016) argue that the reversal in the demand for high-skilled workers led to a cascade effect in which college workers perform jobs that have been previously performed by medium-skilled workers who, for their parts, pushed low-skilled workers further down on the occupational ladder or even out of employment. Beaudry et al. (2014) underline the trend of an increasing share of the working-age population with a college degree but declining cognitive employment shares, i.e. a declining share of workers in jobs with high intensity of abstract thinking, and declining wages after 2000. In contrast to that, job entrants with a post-college degree faced stable cognitive employment shares and wage profiles.

Starting in the 1990s, rising wage inequality has also been documented for Germany. The high and rising (long-term) unemployment after German reunification forced several fundamental reforms of the labour market. At the same time, wage setting in Germany began to erode due to a diminishing importance of collective bargaining between employer associations and unions (Ochel, 2005). A sharp decline in union coverage, especially at the end of the 1990s accompanied this development and has been shown to explain a major part of the lower tail inequality (Dustmann et al., 2009). In the course of slow growth and persistent unemployment after 2000, the 'sick man of Europe' (The Economist, 1999) reformed the labour market even further (the so-called 'Agenda 2010' reforms). These reforms lowered implicit minimum wages by reducing benefit entitlement with respect to level and duration. All in all, the reforms were particularly designed for decreasing wages and increasing employment at the lower tail of the wage distribution (Dustmann et al., 2014).

In stark contrast with most European countries, unemployment in Germany was hardly affected neither by the 2008/2009 recession, despite a dramatic fall in gross domestic product, nor the recent Euro crisis. The relative strength of the labour market can be assigned to a number of reasons, including, first, the extensive labour market reforms that have increased flexibility and allowing greater wage inequality and, second, also declining unit labour costs for the past two decades, i.e. productivity growth exceeding wage growth (Dustmann et al., 2014). For that reason, Fitzenberger et al. (2011) note that the process of increasing lower tail wage inequality in Germany was characterised by episodic events, and not due to the lower tail polarisation hypothesis suggested by Autor and Dorn (2013). Decomposing wage variance into transitory and permanent parts, Myck et al. (2011) found that permanent inequality peaked in 2001 and declined afterwards. However, a polarisation of wages still occurred thereafter but seems to be caused by transitory factors only.

In comparison, the influence of institutional factors upon upper tail wage inequality is limited in Germany. It slightly increased during the 1980s, mainly driven by the changing composition of the workforce (Dustmann et al., 2009). In contrast to the US, growth in supply and demand for high-skilled workers moved in parallel, resulting in less upper tail wage inequality (Acemoğlu, 2003). The share of high-skilled workers increased at a roughly linear rate. Similarly to the US in the 1970s (Katz and Murphy, 1992), the expansion in the supply of high-skilled workers occurred at the pace of demand for these qualifications (Antonczyk et al., 2010).

Autor et al. (2003) describe that the growth of information and communication technology (ICT) is the crucial trigger for job polarisation. ICT has caused a rapid decline of costs due to increasing speed of performing codifiable tasks by computers, which has induced employers to substitute technology for labour. These tasks were characteristic for medium-skilled workers. Advanced communication technologies also support offshoring to foreign worksites for information-based tasks (Blinder, 2007). At the same time, they may enhance the productivity of abstract tasks, such as managing or programming, at the top of the wage distribution where productivity strongly relies upon information as an input (Autor et al., 2003). Over the last decades, the impact of information technology can be supposed to have reached some kind of limit for jobs at the bottom of the wage distribution, where tasks are typically non-routine manual and require non-codifiable physical, verbal or visual activities. The increasing importance of ICT has thus be supposed to have intensified job polarisation that complements high-paying jobs and substitutes medium-paying jobs, while having a small impact on low-paying jobs.

In the past decade, ICT became a general purpose technology affecting the entire economy. The shrinking costs and simplification of usage led to a breakthrough in private households and firms. In 2014, 99% of German firms had access to the internet (Eurostat, 2015b). Similarly, 89% of private households in Germany had access to a computer (Eurostat, 2015c). In 2014, 72% of the individuals used the internet daily (Eurostat, 2015d). Also, computerisation and digitalisation found its broad way into employment. The share of workers using a computer increased from 45% in 2003 to 61% in 2013 (Eurostat, 2015a). Thus, with the increasing coverage of ICT in the workplace, ICT might also gain importance for routine jobs resulting in complementarities rather than substitution (see e.g. Autor (2014)).

However, evidence on the increasing importance of ICT in routine jobs is scarce. Using regional differences in broadband internet coverage, Akerman et al. (2015) show that access to high-speed internet further complements skilled workers in non-routine abstract jobs and impairs labour market outcomes of unskilled workers in routine jobs. Moreover, Forman et al. (2012) find that, despite vast internet investment across US counties, only 6% of the counties with the highest concentration in IT activities before the investment benefit from this investment in terms of wages, while the remaining counties do not. Similarly, Acemoğlu et al. (2014) conclude that increasing IT intensity across manufacturing industries does not increase productivity outside computer manufacturing. Hence, a potential reversal of the job polarisation thesis in the recent decade through a higher adaptability of ICT skills among unskilled workers and higher IT intensity in manufacturing cannot be empirically affirmed. To the contrary, the available literature indicates that the introduction of ICT in these sectors seems to have further amplified job polarisation.

4.3 Data

The empirical analysis is based on data for West Germany for the years 1975 to 2010. Information is taken from the Sample of Integrated labour Market Biographies (SIAB), a 2 percent random sample of the German social security records provided by the Institute for Employment Research (IAB) containing more than 11.5 million observations. The social security records represent about 80% of the working population in Germany, excluding e.g. civil servants, soldiers, and self-employed.

The data are highly reliable due to the mandatory and administrative nature, where misreporting on wages would cause severe penalties for the employer. Since the data are obtained from administrative processes, wages are right-censored at the social security

contribution assessment ceiling. For male workers, the share of censored wages varies between 9% and 14% annually, for women less than 5% of the wage distribution is censored. However, right-censoring will only marginally affect our analysis since we will mainly focus on median wages. Wages are defined as the inflation-adjusted gross daily income from employment. Since exact information on working hours is not provided, we restrict the sample to full-time employed persons. We further restrict the analysis to employees under 35 years of age, and will focus in particular on the group between 25 and 34 years. Since labour market entry is not directly observable in the data, we approximate it by potential experience calculated as the difference between the individual age and the typical qualification-controlled starting age in the labour market.[1]

For the investigation of the role of education level, we distinguish between three types of higher education. They all comprise education with at least admittance to the university. The highest education is graduates from university (high-uni-skilled) and the second highest graduates from university of applied sciences (*Fachhochschule*, high-fh-skilled), a system which is unique in German-speaking countries. University has a more theoretical-based education and duration of education is typically longer than at university of applied sciences. The latter is further characterised by typically shorter duration and a lower focus on abstract skills. The shorter duration is also reflected by a younger age of labour market entry. The third group are individuals with admittance to tertiary education (*Abitur*) and a completed vocational training in the German apprenticeship system (high-abi-skilled). The International Standard Classification of Education (ISCED) of 1997 classified university of applied sciences and university both as tertiary-type A (OECD, 2014). In the 2011 classification (OECD, 2015), university of applied sciences (Germany) is assigned level 6, i.e. programs designed to provide intermediate academic skills leading to a first degree with a typical duration of three to four years. University (Germany) is defined as level 7, covering scientifically more complex studies designed to provide advanced academic skills leading to a second degree. In addition to these three groups, we regard low-skilled (persons who did not complete any vocational training and did not accomplish a university entrance qualification) and medium-skilled workers (persons that completed secondary school and vocational training (apprenticeship) or that accomplished a university entrance qualification (*Abitur*) without vocational training) for comparison.

To analyse the composition of tasks over time, jobs are assigned to tasks according to the classification by Dengler et al. (2014) for the year 2011 (annual variation of the task composition is low). It is comparable to the US dictionary of occupational titles.

[1] Assuming that at age 35 the final education attainment has been reached, we compute the fraction of observations for each education attainment and age based on the number of observations for each education attainment at age 35. The typical age of labour market entry is defined as the median.

Each occupation is composed of five tasks, the main task is determined by the largest task fraction: (1) *analytical non-routine* (e.g. research, evaluation, planning, interpret rules), (2) *interactive non-routine* (e.g. negotiate, teach, entertain, manage personnel), (3) *cognitive routine* (e.g. calculating, measuring, book-keeping), (4) *manual routine* (e.g. operate, control machines), and (5) *manual non-routine* (e.g. repair, renovate, restore, nurse).

4.4 Empirical Results

4.4.1 Education Attainment

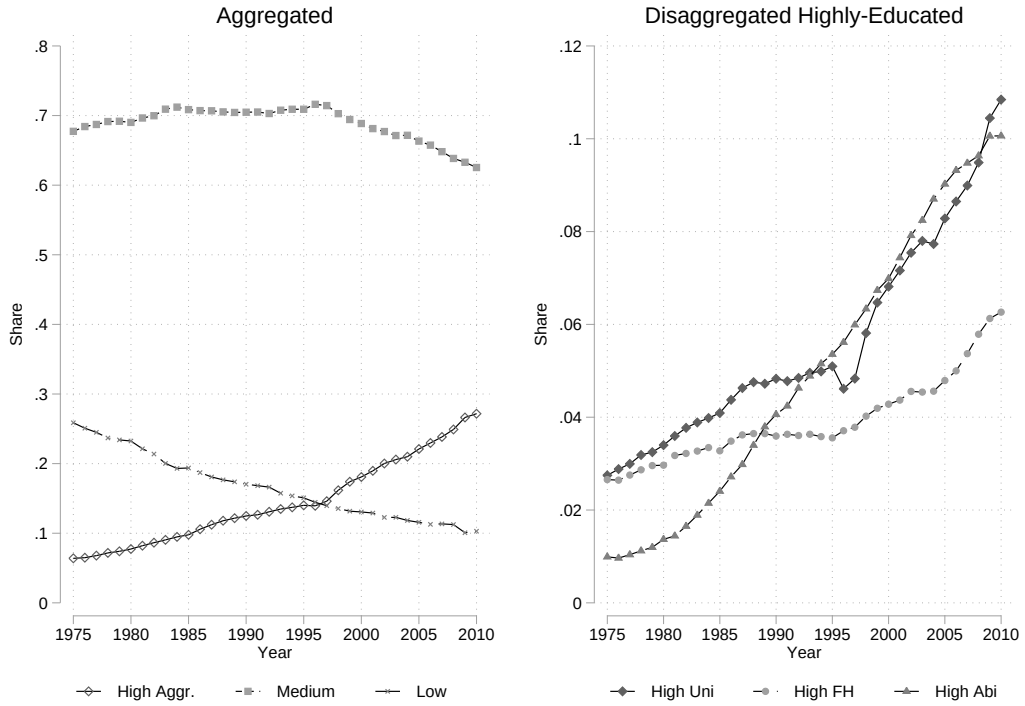
Regarding the long-run trends of the German labour market in terms of education composition, Figure 4.1 displays the patterns for young workers aged 25 to 34 from 1975 to 2010. Germany faced a constant increase in education attainment and, vice versa, the number of young workers without any vocational qualification decreased considerably (from about one quarter in 1975 to about one tenth in 2010). The proportion of medium-skilled workers remained roughly constant until the mid-1990s, and has started to shrink thereafter by roughly ten percentage points until 2010. In 1975, the group of workers with university admittance and vocational training represented only about 1% of the total young workforce, but its share rose tremendously to more than 10% in 2010. Since the mid-1990s, also the share of individuals with a degree from a university or from a university of applied sciences began to increase strongly and doubled for both subgroups until 2010.

However, when we consider the development in absolute numbers, the proportional shift observed for shares of education attainment is not present anymore. Although the share of high-skilled workers increased over time and doubled from 1995 to 2010, the absolute number remained nearly constant (figure 4.2). Beginning in the 1990s, the effects of demographic change in Germany induced a sharp decrease in the number of young persons.[2] The number of 25-year-old persons decreased from 1990 to 1999 by more than one third and maintained this level during the 2000s (East and West Germany combined).[3] Due to that, even though the relative number of high-skilled workers continually increased, it is important to note that the absolute number hardly changed.

[2] Until the mid 1960s, Germany grew strong due to a pronounced "baby boom" generation. However, it was followed by a lack of subsequent strong birth cohorts and 1964 to 1974, the number of births shrunk by roughly 41%.

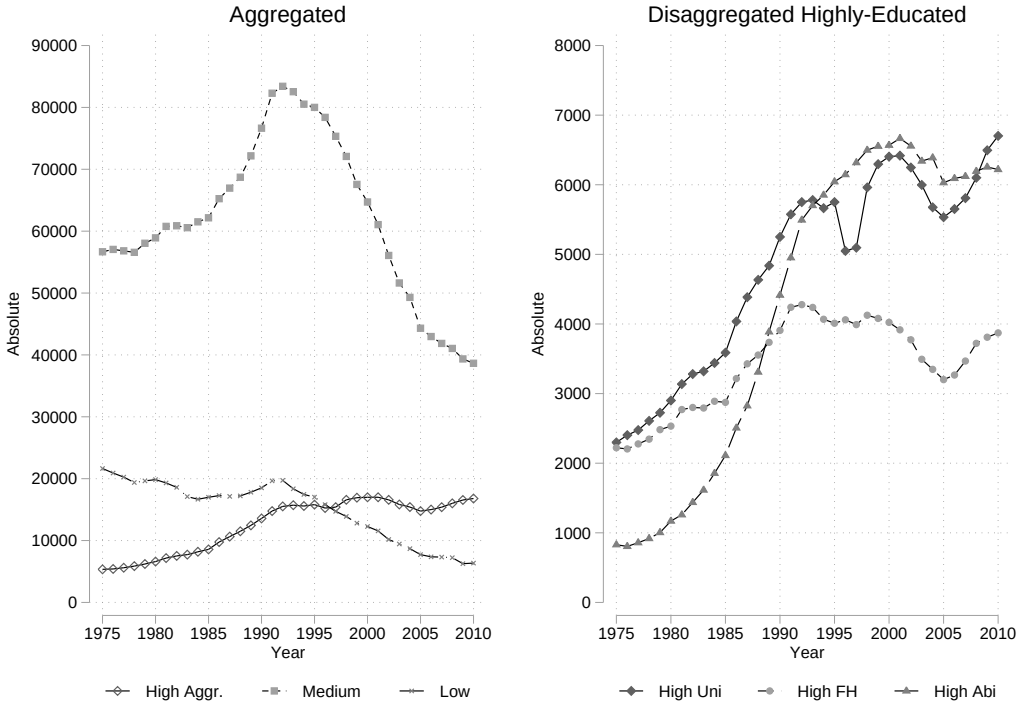
[3] The decreases in other industrialised countries were much smaller, e.g. about 4.5% in metropolitan France, 19.4% in the United Kingdom, and 12.1% in the US (Eurostat, 2015e; U.S. Census Bureau, 2012).

Figure 4.1: Education Distribution (Shares, 25-34 Years, 1975-2010)



Source: 2% IABS Sample for full-time workers between 25 and 34 years of age. N=3,225,195.
Note: Displayed are fractions of young workers by education attainment. The left panel comprises all education groups, the right panel only the high-skilled. The annual number of observation varies between 61,805 in 2010 and 116,633 in 1992. Non-specified observations are omitted when computing the shares.

Figure 4.2: Education Distribution (Absolute Numbers, 25-34 Years, 1975-2010)

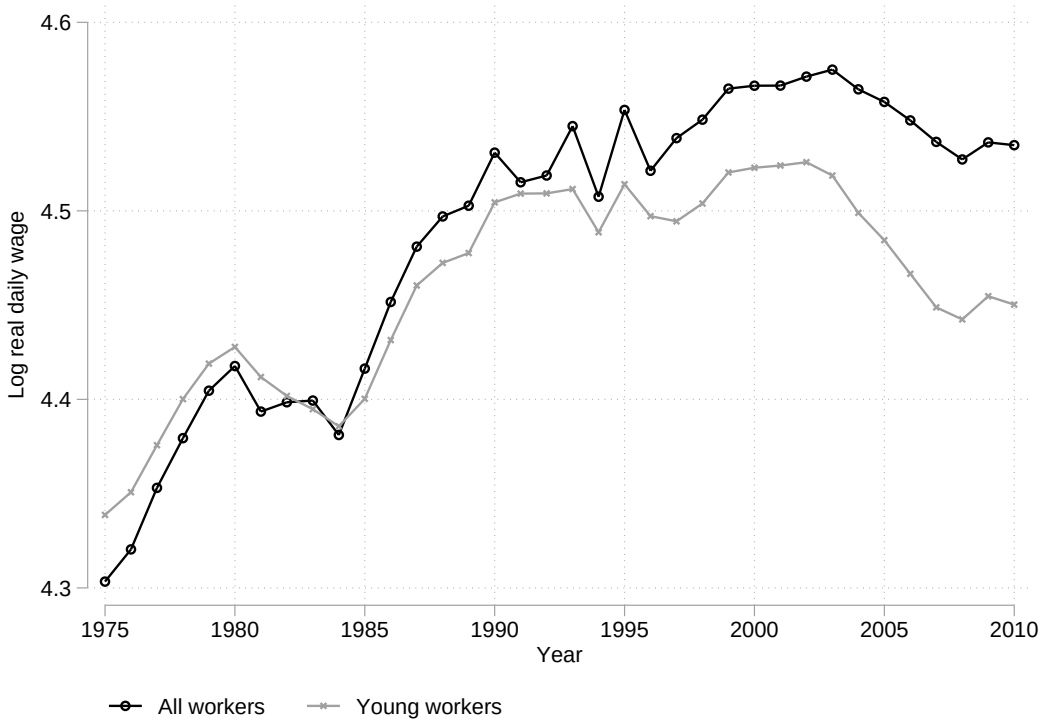


Source: 2% IABS Sample for full-time workers between 25 and 34 years of age. N=3,225,195.
Note: Displayed are absolute numbers of young workers by education attainment. The left panel comprises all education groups, the right panel only the high-skilled. The annual number of observation varies between 61,805 in 2010 and 116,633 in 1992. Non-specified observations are omitted.

4.4.2 Wage Development

How did these shifts of the skill distribution affect the wage structure? Figure 4.3 displays the development of log median daily wages separately for all workers and for young workers. The median real wage increased monotonously from 1975 to 1990 – with a short episode of negative growth between 1980 and 1984. This process was followed by a volatile but more or less stable development of wages during the 1990s.

Figure 4.3: Median Log Real Daily Wages of All and of Young Workers (1975-2010)



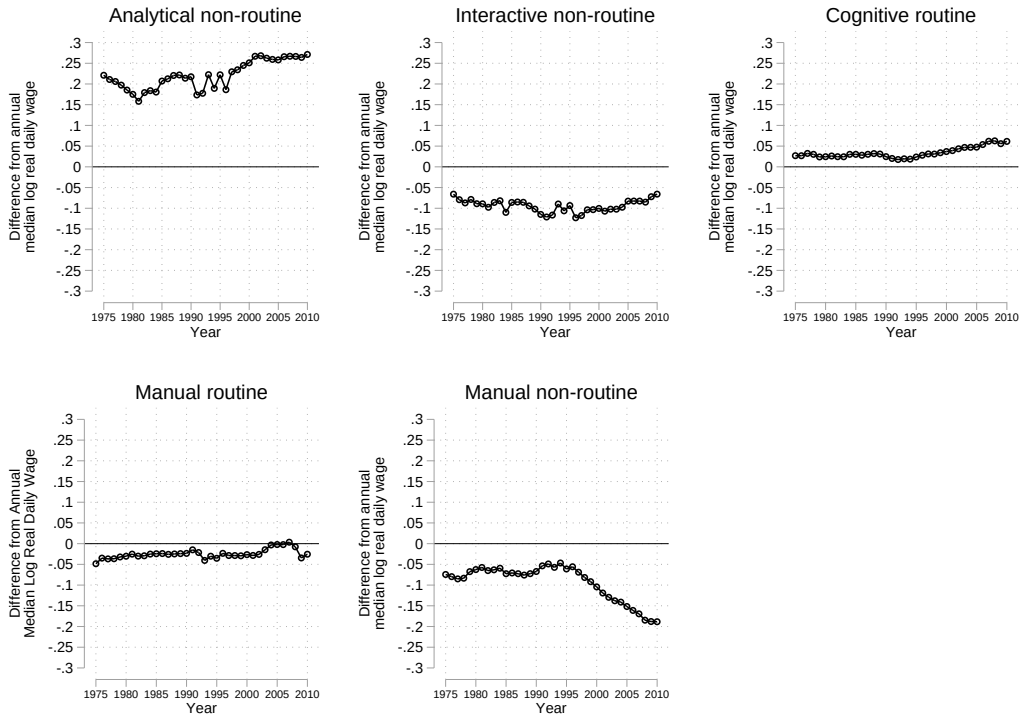
Source: 2% IABS Sample for full-time workers with a positive wage spell. N=11,487,359 for all workers and N=3,471,061 for young workers.
Note: Lines represent the median log real daily wage. It is computed as the logarithm of the inflation-adjusted daily wage of workers with a non-negative wage spell. The annual number of observation varies between 294,778 in 2005 and 349,498 in 1993 for all workers and between 75,440 in 2009 and 123,654 in 1993 for young workers (25-34 years).

After 2003, real wages started to decrease for all workers but more considerably for the group of young workers. More importantly, the figure indicates that the wages of all workers and that of young workers started to diverge over time. Until 1982, young workers tended to gain a higher median wage than the total workforce with a narrowing difference over time. Beginning in 1985, however, young workers started to earn a lower median wage than the overall workforce. Moreover, this wage gap has widened, especially after the implementation of the 'Agenda 2010' labour market reforms in 2003. This evidence

may be interpreted as a rise in wage inequality, notably for the young (and) labour market entrants, see e.g. Gernandt and Pfeiffer (2007), Antonczyk et al. (2010) or Eichhorst and Tobsch (2014).

The wage development in each of the five occupational task groups is similar to the wage development of the total young labour force. Figure 4.4 displays the deviation of the median real wage for each task group from that of all young workers: analytical non-routine jobs pay the highest wages; manual non-routine jobs pay the lowest ones. In addition, the deviations from the median wage for analytical non-routine and manual non-routine jobs increased slowly over time which is in line with the SBTC literature (see e.g. Katz and Autor (1999); Acemoğlu (2002)).

Figure 4.4: Deviation of the Median Log Real Daily Wage by Main Task (25-34 years, 1975-2010)



Source: 2% IABS Sample for full-time workers between 25 and 34 years of age with a positive wage spell and job that can be assigned a task field. N=3,379,587.
Note: Lines display the deviation of the median log real daily wage in one task from that of all workers by years. A positive gap indicates a higher wage for the task in consideration. The number of observations varies between 6,146 for non-routine interactive workers in 1975 and 41,309 for routine cognitive workers in 1992.

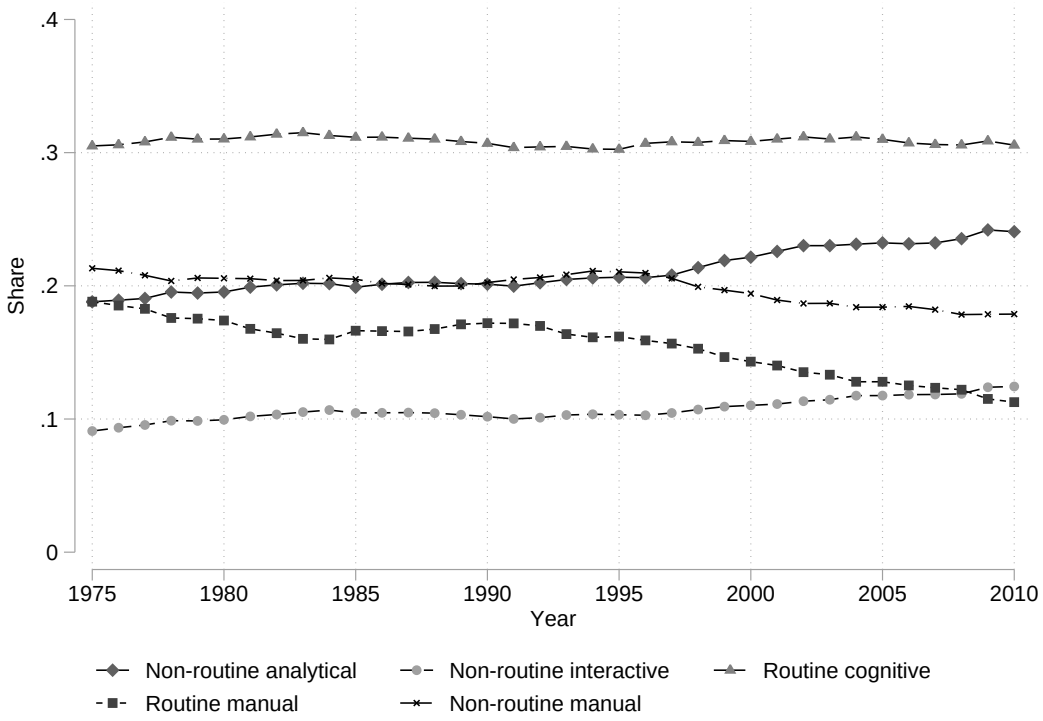
It should be noted that the median wage gap for workers performing analytical non-routine jobs increased notably between 1995 and 2001 from 22% to 27%. Even after the burst of the tech bubble in 2000, relative wages for these jobs remained high. The

negative wage differential for manual non-routine jobs started to widen in 1995, overall from 6% to 19%. Compared to these strong changes, the deviations from the median for the remaining task groups show a higher persistence. For routine cognitive and non-routine interactive occupations, there was a minor but monotonous increase after 1995. Similar patterns indicating some hollowing-out tendency of the labour market for the period until 2000 have been reported by Spitz-Oener (2006) based on other data.

4.4.3 Development of the Task Composition

Jobs usually comprise a variety of tasks, and tasks' composition may change over time. Figure 4.5 displays the average task share of young workers. The patterns show that the share of non-routine analytical tasks went up monotonously, especially after 1997. This corresponds to increasing wages in non-routine analytical jobs and the increase of highly-educated workers. Moreover, the fractions of routine and non-routine manual jobs declined constantly. The share of routine cognitive tasks, however, did not change; it represents the largest proportion of all tasks.

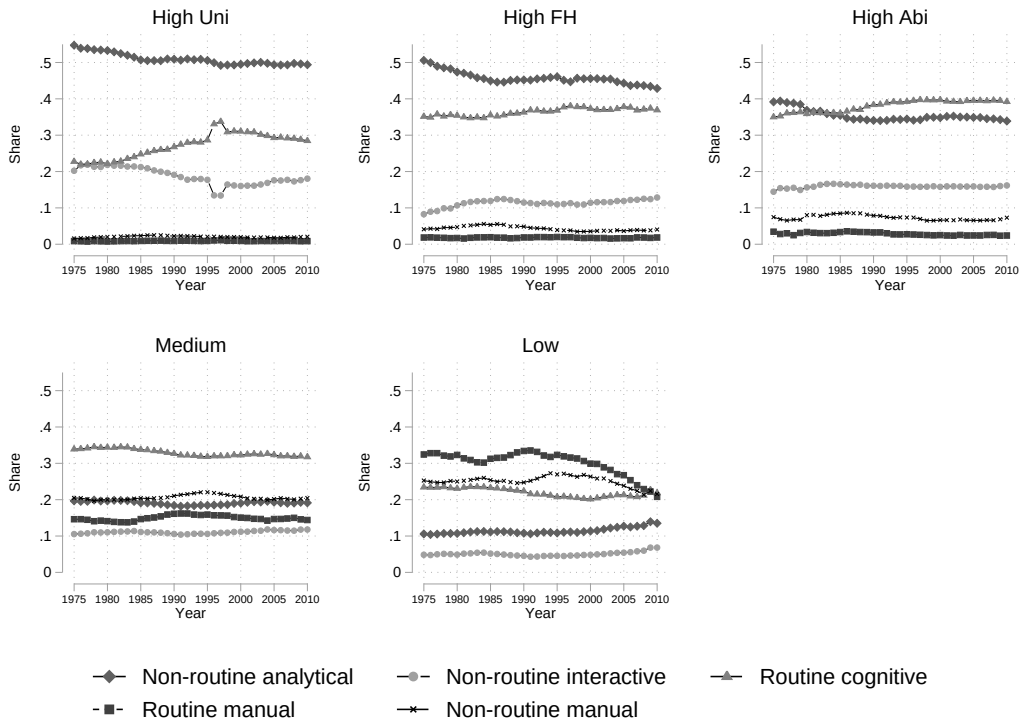
Figure 4.5: Shares of Performed Tasks (25-34 Years)



Source: 2% IABS Sample for full-time workers between 25 and 34 years of age. N=3,508,893. Number of observations vary from 125,295 in 1992 and 76,576 in 2009.
Note: Lines display annual fractions of tasks. Task shares may not add up to 1 since some jobs cannot be classified into tasks. See text for further details.

While the workforce became more skilled due to the share of high-skilled workers increasing, the average employment share of non-routine analytical tasks grew to a lesser extent only. This can imply some kind of occupational downgrading for high-skilled workers. It would be likely if the average task share of non-routine analytical tasks shrunk for high-skilled workers. We, therefore, decompose the average task performance by education groups to reveal a potential shift of high-skilled workers to jobs that do not require their expected analytical skills (Figure 4.6).

Figure 4.6: Shares of Performed Tasks (Education Groups, 25-34 Years)



Source: 2% IABS Sample for full-time workers between 25 and 34 years of age. N=3,508,893.
Note: Lines represent the annual means of each performed task. The number of observations varies from 125,295 in 1992 and 76,576 in 2009. Annual proportional average task shares by education attainment may not add up to 1 since some jobs cannot be classified into tasks. See text for further details.

The average employment share in analytical jobs is sorted according to the duration of education attainment (upper left panel). It is highest for employees with a university degree and lowest for persons without vocational training. Overall, the average shares show a high persistence but there was a small decline for high-skilled workers until 1985. For the high-fh-skilled workers, we further observe a decrease after 2000. However, the share of non-routine analytical tasks for each education group maintained a rather stable level over time, which could imply a transition to more non-routine analytical tasks due to a shift in education attainment.

The non-routine interactive employment share that slightly increased for the young workforce overall decreased for high-uni-skilled until the mid-1990. For the two lower high-skill groups (high-fh-skilled and high-abi-skilled workers), it remained stable after 1990. Contrary to that, a rise of importance can be established for routine cognitive tasks for high-skilled workers until 1997. After that year, their fraction in the task composition began to fall slowly. For the high-fh-skilled and the high-abi-skilled the share rose similarly until the mid-1990s, and remained on that level since then. For high-skilled workers, routine manual and non-routine tasks played a minor role only.

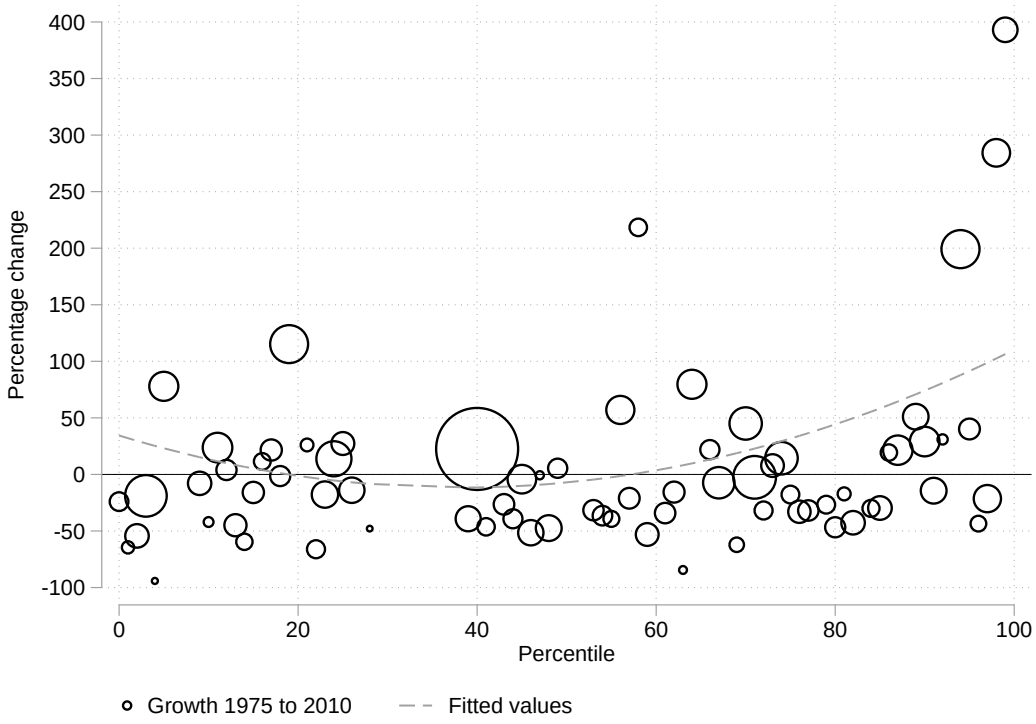
To summarise, the figures indicate that the share of high-skilled workers performing non-routine analytical jobs has remained constant. Also, the employment share of routine cognitive jobs has not changed for high-skilled workers. Therefore, a clear cascading pattern – as described in Beaudry et al. (2014) – cannot be confirmed for the groups of the high-skilled workers in Germany. Nevertheless, with the increase of high-skilled workers in routine cognitive jobs, we find an increasing relative wage gap for this task group (see Figure 4.4). This may hint at an academisation of jobs. For the high-uni-skilled, the share of routine cognitive tasks increased constantly at the expense of non-routine interactive tasks, whereas the remaining task shares remained on rather constant levels over time. For the high-fh-skilled, the share of routine cognitive tasks increased similarly, at the expense of two groups. First, the share of non-routine analytical tasks before 1985 and after 2003 decreased, and second, non-routine interactive tasks decreased between 1987 and 1992. The task composition for high-abi-skilled workers remained rather constant after 1990. Only until 1990, the share of non-routine analytical tasks decreased while that of routine cognitive tasks increased.

4.4.4 Development of Young Workers in Top-Paying Jobs

To analyse the development of job quality over time, we order jobs in percentiles according to their mean wage in 1975. Figure 4.7 plots the growth of jobs between 1975 and 2010. The fitted line indicates a u-shaped pattern, in which top-paying jobs and bottom-paying jobs grew more profoundly than medium-paying occupations. Hence, our results indicate some job polarisation. Moreover, they imply that coinciding with the increasing education attainment of the workforce, the number of top-paying jobs increased. However, if the increase of high-skilled workers exceeds that of top-paying jobs, there could still be a cascading pattern in which high-skilled workers perform jobs previously performed by medium-skilled workers. The latter are crowded out of their jobs and will then perform jobs previously done by the low-skilled. This effect may have been ampli-

fied, since medium-paying occupations grew at a slower pace than occupations at both tails of the wage distribution in Germany.

Figure 4.7: Job Polarisation (All Workers)

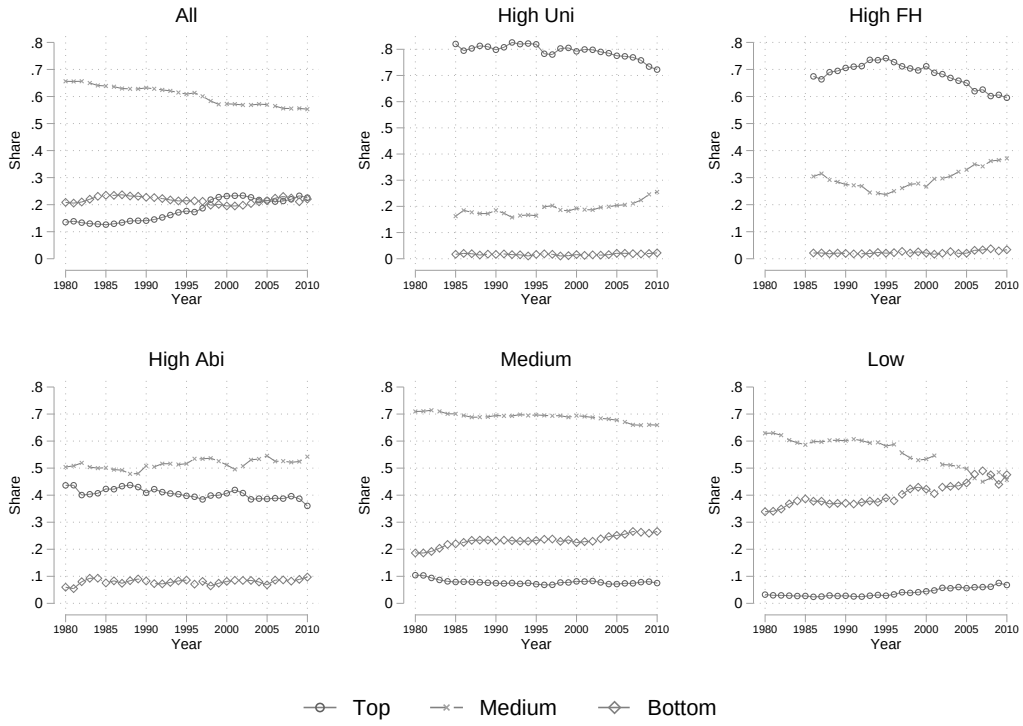


Source: 2% IABS Sample for full-time workers and information on job. N=296,771 in 1975, N=317,198 in 2010.
Note: Jobs are ordered according to their 1975 mean wage and assigned a percentile in the 1975 wage distribution. The percentage change represents the growth of jobs from 1975 to 2010. The size of the circles denotes the number of observations in each percentile in 1975. Fitted values are obtained by linear regression of growth onto percentiles and percentiles squared which are weighted with the number of observations in each percentile in 1975.

Did high-skilled labour market entrants receive the best-paying jobs? To answer this question, we order jobs according to their average wage over all years. We distinguish three job qualities: top-paying jobs pay above the 70th wage percentile, bottom-paying jobs below the 30th wage percentile; all other jobs are referred to as medium-paying. Figure 4.8 plots the development and shares of high-skilled labour market entrants with four to six years of potential experience in top-paying jobs over time. The share of labour market entrants in top-paying occupations after four to six years of experience rose from 15% (1975) to 22% (1998) for all workers but stagnated thereafter. Moreover, this rise mainly occurred during the 1990s. At the same time, the fraction of workers in the bottom-paying jobs remained constant over the full observation period. Hence, these

patterns imply that the shift towards more workers in top-paying occupations came at the expense of workers in medium-paying jobs.

Figure 4.8: Job Ordering (Four to Six Years of Experience)



Source: 2% IABS Sample for full-time workers between 25 and 34 years of age with information on job. N=933,434 for all workers. N=63,477 for high-uni, N=39,319 for high-fh, N=45,257 for high-abi, N= 640,205 for medium, N=144,936 for low.
Note: Jobs are ordered according to their mean wage and assigned to a percentile in the wage distribution. Top-jobs have a mean wage above the 70% percentile, bottom-jobs below the 30% percentile, the others are medium-jobs. Lines represent annual shares of workers with four to six years of potential experience.

To get a more detailed picture, distinguishing between education attainments can further reveal adverse opportunities for high-skilled workers. University graduates faced a decreasing chance of working in top-paying jobs. The fraction declined from 82% (1985) to 71% (2010). A major part of this drop occurred after the year 2000 and notably in support of medium-paying jobs. The shift is similarly profound for high-fh-skilled workers, who faced a drastic drop in top-paying jobs from 74% to 60% between 1995 and 2010 in favour of medium-paying jobs. The share of high-abi-skilled workers in top-paying occupations declined from 41% to 36% between 1990 and 2010.

For high-skilled workers, the chance of working in a bottom-paying job was relatively low in all years. The fraction of medium-skilled and low-skilled workers in bottom-paying jobs increased over time. For low-skilled workers, other than for medium-skilled

workers, this was correlated with a decreasing chance of working in the medium-paying sector. Hence, we find a cascading pattern across skill groups, where relatively better skilled groups crowd out relatively lower skilled groups. Nevertheless, this picture is not apparent within the group of high-skilled workers.

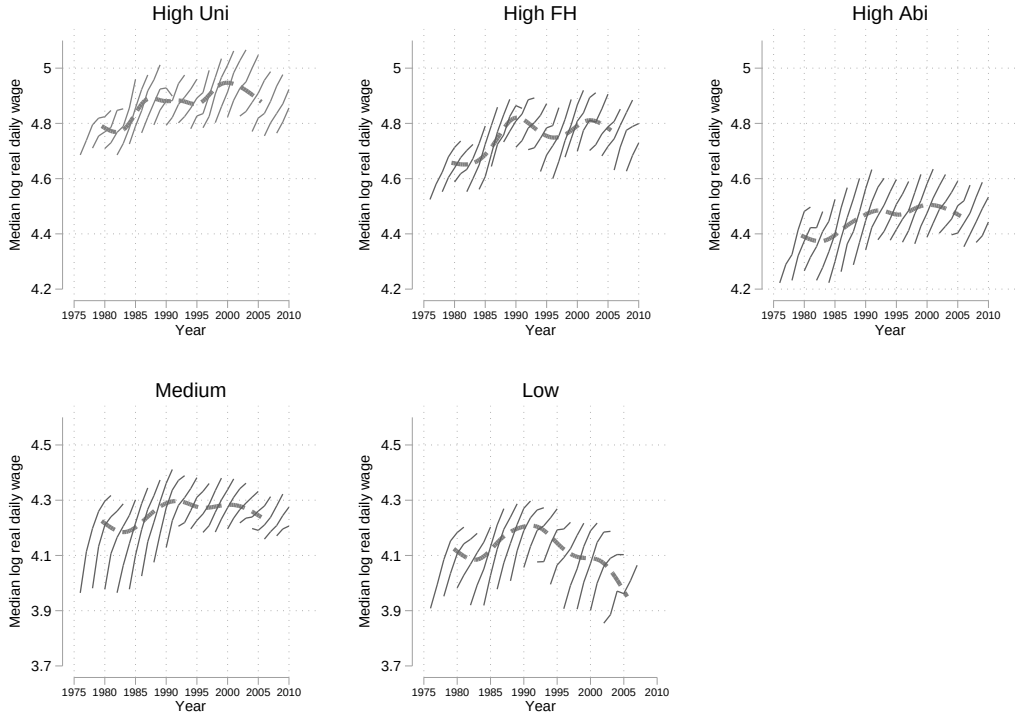
4.4.5 Patterns of Labour Market Entry

Figure 4.3 above displayed the increasing wage gap between the young and all workers that has widened notably after 2003. To take a closer look at this development, Figure 4.9 shows how job entrants have performed in their first five years of work with consideration of education attainment and potential experience. Each line refers to two consecutive annual entry cohorts. As becomes obvious, both starting wages and wages after 5 years tended to increase until the year 2000. After that year, however, entry wages have started to fall. Moreover, wage growth slowed down considerably (indicated by the shorter wage profiles), resulting in lower wages after five years of work (see also tables 4.1 to 4.3 in the appendix for details).

In more detail, wage growth declined for high-uni-skilled workers from 27% (1996-cohort) to 16 % (2002-cohort). Over the same period, newly arriving cohorts of the high-fh-skilled were faced with an even stronger reduction from 32 to 15%, and the high-abi-skilled from 27 to 17 %. All other groups experienced quite substantial declines of wage growth, too: from 19 % to 10 % for medium-skilled and from 31 to 21% for low-skilled workers. Hence, the moderation of wage growth affected all skill groups.

Furthermore, the observed wage growth for high-uni-skilled and high-fh-skilled workers of cohorts entering the labour market after 2000 (15 to 22%) is of similar magnitude as for the cohorts of 1986 to 1992. At that time, wage growth lay between 13 to 21%. To some extent, these patterns therefore denote a kind of cyclicality in wage growth for high-skilled workers, which was exceptionally high for entry cohorts in the late 1990s. For high-skilled workers, the magnitude of wage growth for cohorts entering the labour market after 2002 was similar to the wage growth of cohorts that entered the labour market around the year 1990. In contrast to these patterns for the high-skilled, median wages and wage growth for low-skilled workers have already started to fall from the early 1990s. Wage growth for medium-skilled workers has slowed down since the 1990s.

Figure 4.9: Median Log Real Daily Wage Profiles for labour Market Entrants (Potential Experience)

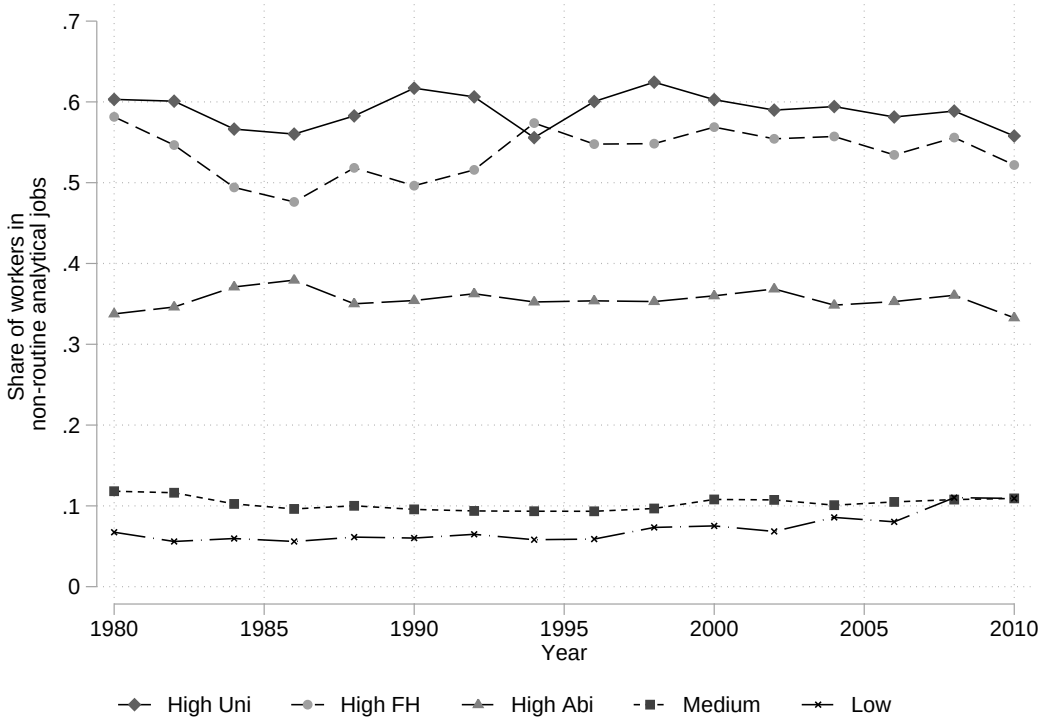


Source: 2% IABS Sample for full-time workers with less than five years of potential experience and a positive log real daily wage. N=1,395,276. N=103,839 for high-uni-skilled, N=59,874 for high-fh-skilled, N=79,068 for high-abi-skilled, N=939,279 for medium-skilled, N=213,216 for low-skilled.

Note: Displayed are log real median wage by potential experience for two-year-cohorts (solid lines). Dashed lines denote the median of the 1976 to 2008 cohort (where information for 0 to five years of potential experience is available). Panels refer to levels of education attainment.

According to the complexity and task requirements of occupations, analytical jobs can be expected to be associated with higher wages, and should also match the skill of high-skilled workers. Figure 4.10 therefore displays the analytical employment shares by education attainment over time for workers with five years of potential experience. As expected, the higher the obtained education, the higher is the share of workers performing analytical jobs. Moreover, the fraction of workers in analytical jobs was quasi-constant for all skill groups. There was only small variation for the high-skilled workers. After 2000, the share of workers in analytical jobs started to slightly but monotonously decrease for the two highest skill groups. However, this is not accompanied with a drastic decline of the opportunity of performing an analytical job after five years of potential experience.

Figure 4.10: Shares of Workers in Non-Routine Analytical Jobs (by Education, 5 Years of Potential Experience)

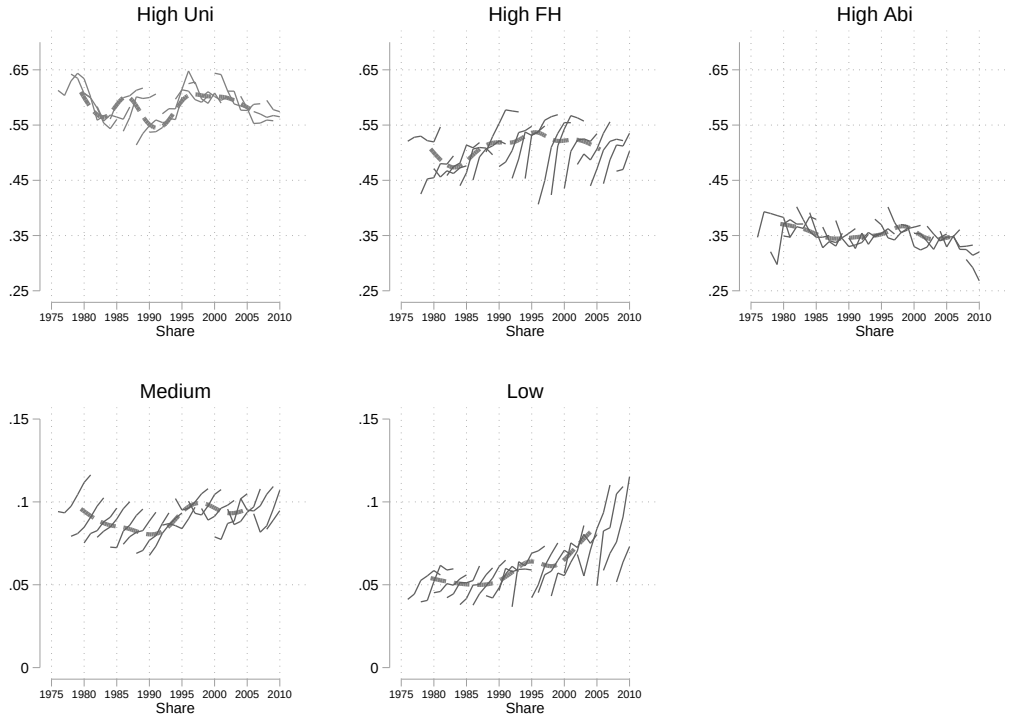


Source: 2% IABS Sample for full-time workers with less than five years of observed experience and a positive log real daily wage. N=288,258. N=20,640 for high-skilled, N=12,744 for high-fh-skilled, N=14,897 for high-abi-skilled, N=199,449 for medium-skilled, N=40,528 for low-skilled.
Note: Displayed are fractions of workers after five years of potential experience that perform a non-routine analytical job (two-year-cohorts). Lines refer to levels of education attainment.

To analyse this further we can refer to the development of the conditional probabilities of entering analytical jobs over time. Figure 4.11 plots the fraction of workers in analytical jobs for each cohort as profiles after labour market entry by education groups. The positive slopes indicate that with increasing potential experience the shares of persons

working in these jobs increase. Differences in the shares across cohorts reflect business cycle effects to some extent. A simple Roy model would predict that workers sort into the occupation where they expect the highest wages. Given that occupation-specific and task-specific knowledge may reduce the chances of switching with increasing potential experience, it can be expected that workers sort themselves into jobs with the highest expected lifetime earnings at the beginning of their career. In line with that explanation, for most cohorts and education attainments, the share of workers performing analytical jobs, therefore, increases with potential experience.

Figure 4.11: Share Profiles of Workers in the Analytical Non-Routine Sector (by Education, Potential Experience)



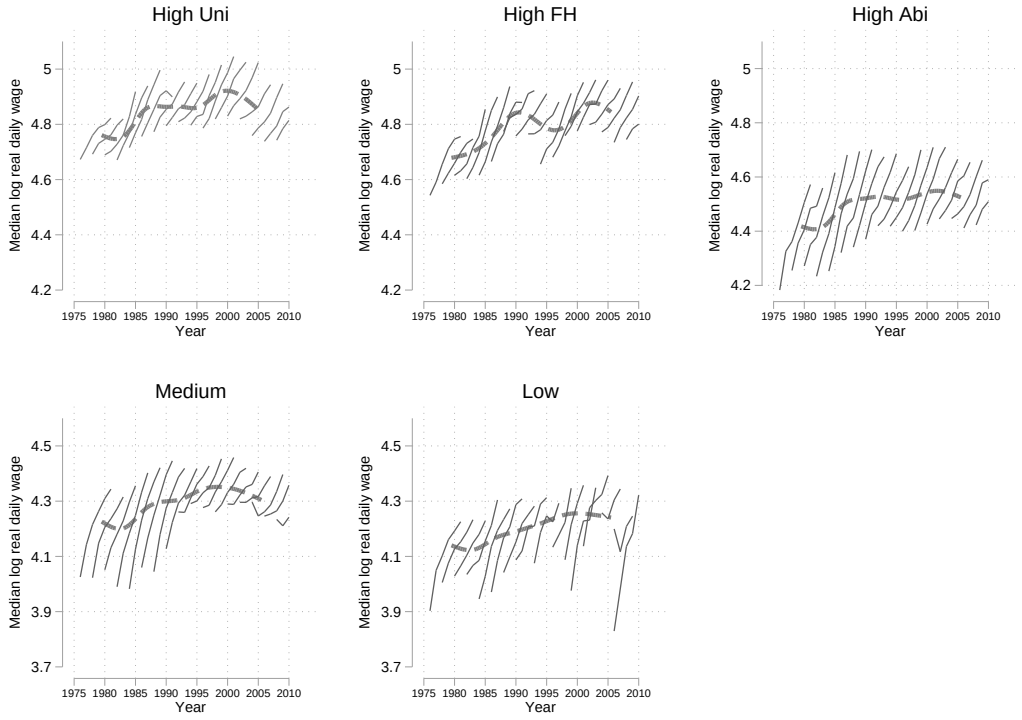
Source: 2% IABS Sample for full-time workers with less than five years of observed experience and a positive log real daily wage. N=1,525,826, N=112,458 for high-skilled, N=64,638 for high-fh-skilled, N=80,583 for high-abi-skilled, N=1,041,385 for medium-skilled, N=226,762 for low-skilled.
Note: Displayed are shares of workers performing a non-routine analytical job by potential experience for two-year-cohorts (solid lines). Dashed lines denote the median of the years 1976 to 2004 cohorts (where information for 0 to five years of potential experience is available). Panels refer to levels of education attainment.

However, the patterns further indicate some variation between as well as within cohorts. Regarding the opportunities between cohorts, the share of high-skilled workers in analytical jobs decreased for cohorts after the late 1990s. In the decade before, to the contrary, it tended to increase. Comparing inter-cohort shares of workers in analytical jobs, an

increase for high-fh, medium-skilled and low-skilled workers with increasing potential experience for all cohorts can be observed. For high-uni-skilled workers, there was a sorting out of analytical jobs for cohorts after 1996. This similarly holds for high-abi-skilled workers and is very profound for the last observed cohort in 2008. The declining share of analytical employment within cohorts conditional on potential experience may hint for potentially decreasing wages in these jobs.

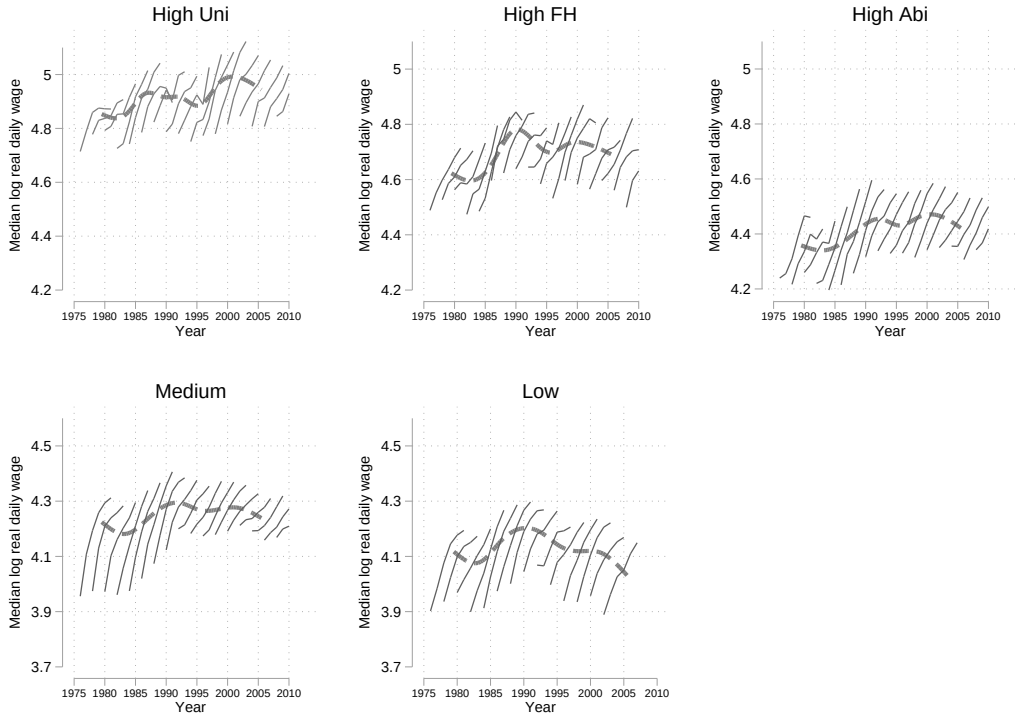
To reveal more information on potentially decreasing wages, we distinguish workers in- and outside analytical jobs in the following. Figures 4.12 and 4.13 display the wage profiles for workers in and outside analytical occupations. Independently of education attainment and working in an analytical job or not, the figures show that starting wages and wage growth declined after 2000. For the high-skilled, however, the decline of wage growth was smaller compared to that of medium-skilled workers. With consideration of the whole time horizon of our analysis, we again see the kind of cyclicality of the pattern of wage growth for high-skilled workers. Wage growth had increased tremendously for cohorts that entered the labour market in the late 1990s. This development was then reversed and returned to earlier magnitudes for the cohorts that entered the labour market after the year 2000. For medium-skilled workers, wage growth continually declined in contrast (see tables 4.1 to 4.3 in the appendix for further details).

Figure 4.12: Median Log Real Daily Wage Profiles for labour Market Entrants in the Non-Routine Analytical Sector (Potential Experience)



Source: 2% IABS Sample for full-time workers with less than five years of observed experience and a positive log real daily wage. N=212,817. N=61,016 for high-skilled, N=30,516 for high-fh-skilled, N=27,344 for high-abi-skilled, N=83,595 for medium-skilled, N=10,346 for low-skilled.
Note: Displayed are profiles of log real median wage by potential experience for two-year-cohorts (solid lines). Dashed line denotes the median of the 1976 to 2004 cohorts (where information for 0 to five years of potential experience is available). Panels refer to levels of education attainment.

Figure 4.13: Median Log Real Daily Wage Profiles for Labour Market Outside the Non-Routine Analytical Sector (Potential Experience)



Source: 2% IABS Sample for full-time workers with less than five years of observed experience and a positive log real daily wage. N=1,145,450. N=42,260 for high-skilled, N=29,007 for high-fh-skilled, N=51,191 for high-abi-skilled, N=841,029 for medium-skilled, N=181,963 for low-skilled. Note: Displayed are profiles of log real median wage by potential experience for two-year-cohorts (solid lines). Dashed line denotes the median of the 1976 to 2004 cohorts (where information for 0 to five years of potential experience is available). Panel refer to levels of education attainment.

4.4.6 Wage Premia

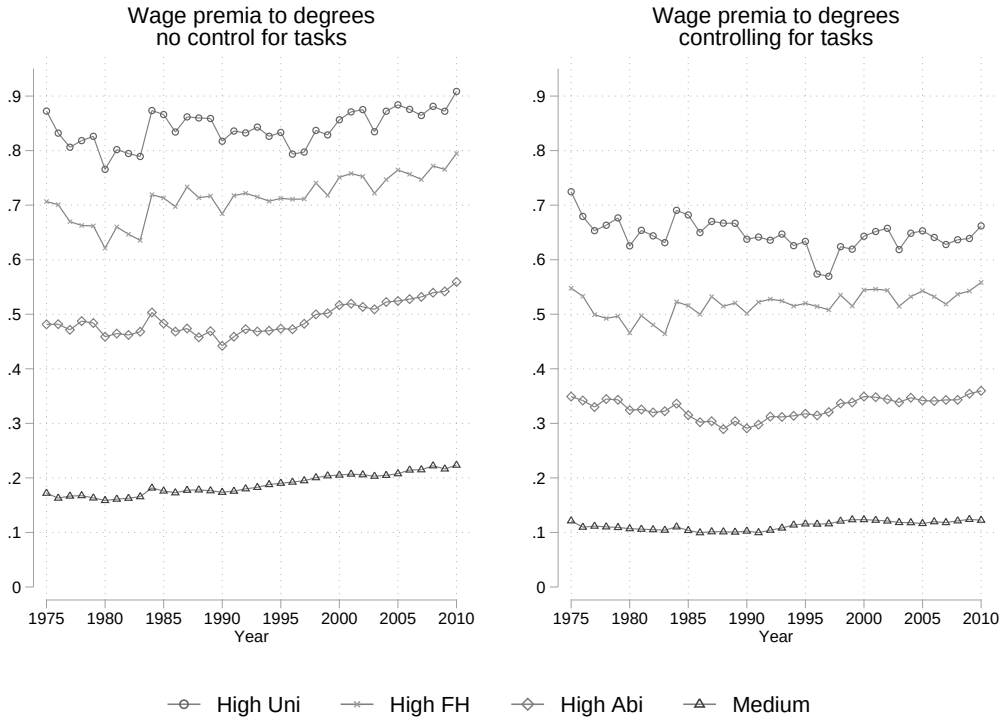
Having discussed aspects of education, jobs and wages, we will consider the development of returns to education (wage premia) over time as the final step in analysing the chances of job market entrants. Declining opportunities of young high-skilled workers getting a high-paying job can also result in lower wage premia for higher degrees (see e.g. Pikos and Thomsen (2016)). We estimate a variant of the Mincer earnings equation that considers the effect of potential experience, education level (categorical) and gender (dummy). We augment the model in a second step by dummy variables for tasks (reference category: non-routine manual jobs). To analyse wage premia over time, we estimated the models for each year separately.

Figure 4.14 plots the estimated coefficients of wage premia over time, both with and without controlling for tasks (left and right panel). Wage premia continually increased from the mid-1990s for high-skilled individuals. The wage premium for the medium-skilled, however, increased only slightly. The wage gap between medium-skilled and high-skilled workers, therefore, increased over time. Higher education, independently of having a degree from a university, from a university of applied sciences, or of holding a high-school admittance and a completed vocational training was thus associated with an increasing wage premium relative to low and medium education. Nevertheless, the gaps in the wage premia between the different groups of higher education remained rather persistent. This could be interpreted as a relative fall of wages and, therefore, as a relative fall of demand for low-skilled and medium-skilled workers from the early 1990s to the early 2000s.

When task groups are considered in the estimation, they reduce the absolute level and the relative increase of the estimated wage premia of high-skilled workers. Despite this level effect, the relative increase of wage premia followed a similar pattern. For high-skilled workers, wage premia increased after the mid-1990s. The relative premia for the three subgroups of high-skilled remained stable. However, the increase in the wage premium of medium-skilled workers relative to low-skilled workers almost vanished.

Both panels show the increase in wage premia relative to low-skilled and medium-skilled workers. Figures 4.8 and 4.9 above revealed already a decline of starting wage for low-skilled workers. The increase in wage premia of high-skilled workers may thus imply a relative fall of demand and of wages for low-skilled workers. With respect to the timing, it should be noted that most of the increase of the wage premia occurred after the mid-1990s. From the beginning of the 2000s, however, real wages of high-skilled labour market entrants fell, but not as strong as those of low-skilled and medium-skilled workers.

Figure 4.14: Wage Premia for Education Groups (25 to 34 years)

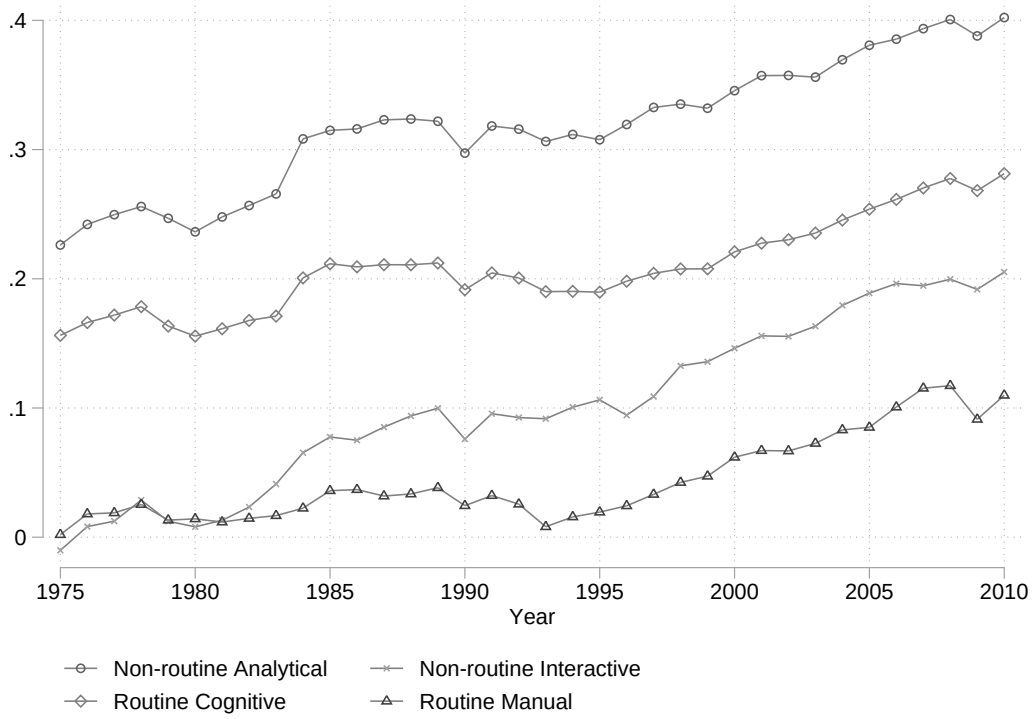


Source: 2% IABS Sample for full-time workers between the age of 25 and 34 years and a positive log real daily wage. Left panel: N=6,502,733. Number of observations vary for each regression between 166,053 in 1975 and 190,530 in 2001. Right panel: N= 6,345,509. Number of observations vary for each regression between 161,084 in 1975 and 185,779 in 2001.

Note: Wage premia are indicated by coefficients obtained from year-by-year estimations of Mincer earnings equations with education attainment (in reference to low education), potential experience, potential experience squared and a female dummy variable (left panel), and task categories in addition (right panel). All coefficients plotted are statistically significant at the 1% confidence level. Wages above the social security contributions ceiling (right-censoring) have been imputed using a Tobit estimation.

Similar to the fall of wages for low-skilled workers, our results showed a fall of relative wages in the non-routine manual sector (see Figure 4.4 above). Figure 4.15 adjoins this result by displaying wage premia estimates by task groups over the years. The non-routine analytical sector had the highest premium for all years which increased monotonously from the mid-1990s. Although routine cognitive tasks yielded the second highest wage premia over the total time horizon, the wage gap to non-routine interactive jobs decreased. This is in accordance with findings reported in the routine-biased technological change literature (Goos et al., 2014). However, the wage gap persists at a constant level since the mid-1990s.

Figure 4.15: Wage Premia by Task Groups (25 to 34 years)



Source: 2% IABS Sample for full-time workers between the age of 25 and 34 years and a positive log real daily wage. N=6,345,509. Number of observations vary for each regression between 161,084 in 1975 and 185,779 in 2001.
Note: Wage premia are indicated by coefficients obtained from year-by-year estimations of Mincer earnings equations with education attainment (in reference to low education), potential experience, potential experience squared and a female dummy variable (left panel), and task categories in addition (right panel). All coefficients plotted are statistically significant at the 1% confidence level. Wages above the social security contributions ceiling (right-censoring) have been imputed using a Tobit estimation.

Correspondingly to the falling wages of non-routine manual jobs after the mid-1990s, relative wage premia increased. During the same period, analytical and routine cognitive jobs were associated with higher wage premia. These stable wage gaps in routine cognitive

jobs after 1995 may thus entail an academisation of these jobs, since workers holding a higher degree received higher wages.

4.5 Conclusion

We have analysed the labour market patterns of job market entrants in Germany over a long period of time from 1975 to 2010 considering aspects of education attainment, wages and jobs. The results indicate that real wages stagnated from the mid-1990s onwards and even declined for young workers since the mid-2000s, a period characterised by an increasing importance of ICT. Also since the mid-1990s, the share of young workers with a higher education attainment started to increase markedly in Germany. At the same time, a shrinking size of young cohorts revealed the effects of the accelerated demographic change. Relative wages of workers performing analytical jobs, mostly performed by high-skilled workers, increased continually. They also increased for routine-cognitive jobs, coinciding with a larger share of high-skilled workers in these occupations. For non-routine manual jobs, mainly performed by low-skilled and medium-skilled workers, relative wages decreased to the contrary. This process was accompanied by a relative wage increase in routine cognitive tasks, along with a rising share of high-skilled workers in routine cognitive jobs, and a relative wage decline for routine and non-routine manual jobs. The relative wage increase and the academisation of routine cognitive jobs, in contrast to a decline of wages and a stable education composition of routine manual jobs, may imply that ICT has also found its way into routine cognitive jobs complementing the tasks performed there.

Our results can further indicate a slight job polarisation in Germany over the period in our analysis. The number of occupations at the top and bottom of the wage distribution increased at the expense of medium-paying occupations. Although the share of young workers in top-paying occupations rose, the chances of obtaining a top-paying occupation fell for high-skilled young workers. Besides the reduced probability of getting a top-paying job, wage growth declined overall, too. However, wage growth within the group of high-skilled workers is similar, and is less profound than the fall of wage growth for medium-skilled workers. For this reason, we do not find evidence for a distinct reversal in the wage expectations of high-skilled workers; wage growth for cohorts entering the labour market after 2000 recaptured its magnitude from around the year 1990. In contrast, wages and wage growth for medium-skilled labour market entrants have continually declined.

The most remarkable results of our analysis are the indications of a cascading pattern in which the decline in the share of young workers in top-paying jobs was more profound for high-uni-skilled workers than for high-fh-skilled workers. In addition, the share of high-skilled workers in medium-paying jobs increased at the expense of the share in top-paying jobs. The share of medium-skilled and low-skilled workers in bottom-paying positions rose, while the share of medium-paying jobs fell. In contrast to the results reported for the US by Beaudry et al. (2014), we cannot confirm the same kind of cascade of jobs within the group of high-skilled workers based on the evidence provided. Wage premia within this group remained stable over time and grew relative to medium-skilled and low-skilled workers. Nevertheless, the results indicate some similarities between the development of the US and Germany during the last decade with regard to displacement effects of lower qualifications in the labour market. However, the obtained patterns differ in terms of the particular skill groups affected.

Bibliography

Acemoğlu, D. (2002). Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, 40(1):7–72.

Acemoğlu, D. (2003). Cross-Country Inequality Trends. *The Economic Journal*, 113(485):F121–F149.

Acemoğlu, D., Autor, D., Dorn, D., Hanson, G. H., and Price, B. (2014). Return of the Solow Paradox? IT, Productivity, and Employment in US Manufacturing. *American Economic Review*, 104(5):394–99.

Akerman, A., Gaarder, I., and Mogstad, M. (2015). The Skill Complementarity of Broadband Internet. NBER Working Papers 20826, National Bureau of Economic Research, Inc.

Antonczyk, D., DeLeire, T., and Fitzenberger, B. (2010). Polarization and rising wage inequality: comparing the US and Germany. ZEW Discussion Papers 4842, Centre for European Economic Research, Mannheim.

Autor, D. (2014). Polanyi's Paradox and the Shape of Employment Growth. Working Paper 20485, National Bureau of Economic Research.

Autor, D. H. and Dorn, D. (2013). The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market. *American Economic Review*, 103(5):1553–97.

Autor, D. H., Katz, L. F., and Kearney, M. S. (2006). The Polarization of the U.S. Labor Market. *American Economic Review*, 96(2):189–194.

Autor, D. H., Katz, L. F., and Kearney, M. S. (2008). Trends in U.S. Wage Inequality: Revising the Revisionists. *The Review of Economics and Statistics*, 90(2):300–323.

Autor, D. H., Levy, F., and Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, 118(4):1279–1333.

Beaudry, P., Green, D. A., and Sand, B. M. (2014). The Declining Fortunes of the Young since 2000. *American Economic Review*, 104(5):381–86.

Beaudry, P., Green, D. A., and Sand, B. M. (2016). The Great Reversal in the Demand for Skill and Cognitive Tasks. *Journal of Labor Economics*, 34(S1):S199–S247.

Blinder, A. S. (2007). How Many U.S. Jobs Might Be Offshorable? Working Papers 142, Princeton University Center for Economic Policy Studies.

Dengler, K., Matthes, B., and Paulus, W. (2014). Occupational Tasks in the German Labour Market. FDZ Methodenreport, Institute for Employment Research, Nürnberg.

Dustmann, C., Fitzenberger, B., Schönberg, U., and Spitz-Oener, A. (2014). From Sick Man of Europe to Economic Superstar: Germany's Resurgent Economy. *Journal of Economic Perspectives*, 28(1):167–88.

Dustmann, C., Ludsteck, J., and Schönberg, U. (2009). Revisiting the German Wage Structure. *The Quarterly Journal of Economics*, 124(2):843–881.

Eichhorst, W. and Tobsch, V. (2014). Not So Standard Anymore? Employment Duality in Germany. IZA Discussion Papers 8155, Institute for the Study of Labor, Bonn.

Eurostat (2015a). Employees - availability of computers (NACE Rev. 2 activity). Web: http://ec.europa.eu/eurostat/data/database. Retrieved October 07, 2015.

Eurostat (2015b). Enterprises - level of internet access (NACE Rev. 2 activity). Web: http://ec.europa.eu/eurostat/data/database. Retrieved October 07, 2015.

Eurostat (2015c). Households - availability of computers. Web: http://ec.europa.eu/eurostat/data/database. Retrieved October 07, 2015.

Eurostat (2015d). Individuals - frequency of internet use. Web: http://ec.europa.eu/eurostat/data/database. Retrieved October 07, 2015.

Eurostat (2015e). Population on 1 January by age and sex. Web: http://ec.europa.eu/eurostat/data/database. Retrieved August 20, 2015.

Fitzenberger, B., Kohn, K., and Wang, Q. (2011). The erosion of union membership in Germany: determinants, densities, decompositions. *Journal of Population Economics*, 24(1):141–165.

Forman, C., Goldfarb, A., and Greenstein, S. (2012). The Internet and Local Wages: A Puzzle. *American Economic Review*, 102(1):556–75.

Gernandt, J. and Pfeiffer, F. (2007). Rising Wage Inequality in Germany. *Journal of Economics and Statistics*, 227(4):358–380.

Goos, M., Manning, A., and Salomons, A. (2014). Explaining Job Polarization: Routine-Biased Technological Change and Offshoring. *American Economic Review*, 104(8):2509–26.

Kambourov, G. and Manovskii, I. (2009). Occupational Mobility and Wage Inequality. *Review of Economic Studies*, 76(2):731–759.

Katz, L. F. and Autor, D. H. (1999). Changes in the wage structure and earnings inequality. In Ashenfelter, O. and Card, D., editors, *Handbook of Labor Economics*, volume III of *Handbook of Labor Economics*, chapter 26, pages 1463–1555. Amsterdam: Elsevier.

Katz, L. F. and Murphy, K. M. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Krugman, P. (1994). Past and prospective causes of high unemployment. *Economic Review-Federal Reserve Bank of Kansas City*, 79:23–23.

Myck, M., Ochmann, R., and Qari, S. (2011). Dynamics in transitory and permanent variation of wages in Germany. *Economics Letters*, 113(2):143–146.

Naticchioni, P., Ragusa, G., and Massari, R. (2014). Unconditional and Conditional Wage Polarization in Europe. IZA Discussion Papers 8465, Institute for the Study of Labor, Bonn.

Ochel, W. (2005). Decentralizing Wage Bargaining in Germany - A Way to Increase Employment? *LABOUR*, 19(1):91–121.

OECD (2014). Education at a Glance 2014: OECD Indicators. Technical report, OECD Publishing.

OECD (2015). ISCED 2011 Operational Manual: Guidelines for Classifying National Education Programmes and Related Qualifications. Technical report, OECD Publishing.

Pikos, A. K. and Thomsen, S. L. (2016). Rising Work Complexity But Decreasing Returns. IZA Discussion Paper 9878, Institute for the Study of Labor, Bonn.

Spitz-Oener, A. (2006). Technical Change, Job Tasks, and Rising Educational Demands: Looking outside the Wage Structure. *Journal of Labor Economics*, 24(2):235–270.

The Economist (1999). The sick man of the Euro. The Economist. June 1999.

U.S. Census Bureau (2012). National Intercensal Estimates (1990-2000). Web: http://www.census.gov/popest/data/intercensal/national/files/US-EST90INT-09.csv. Retrieved August 20, 2015.

Appendix to Chapter 3

Table 4.1: Median Log Wage Growth for All labour Market Entrants by Education Group

Cohort	High-Uni	High-FH	High-Abi	Medium	Low
1974	21.8	22.7	29.5	35.0	34.5
1976	16.1	21.2	27.4	35.3	29.4
1978	14.2	17.1	24.9	30.6	22.8
1980	25.0	20.3	25.8	32.4	22.0
1982	29.0	30.6	33.6	38.0	34.9
1984	28.6	32.6	37.8	39.5	36.8
1986	13.3	21.0	37.0	38.6	31.9
1988	18.0	15.9	31.3	31.4	26.5
1990	16.7	15.8	25.5	25.3	21.2
1992	19.0	15.2	21.1	15.5	14.3
1994	25.4	26.1	23.8	18.4	22.1
1996	27.8	32.0	26.5	19.4	31.0
1998	26.3	23.3	25.1	17.7	28.2
2000	22.4	20.7	20.2	13.6	20.2
2002	16.1	15.0	17.4	9.5	21.0
2004	20.6	20.2	19.0	12.5	43.9

Source: 2% IABS Sample for full-time workers under 35 years of age. N=409,972.
Note: The table displays the difference between the median log wage for workers with a potential experience of five years and a potential experience of 0 years multiplied by 100 for each educational attainment.

Table 4.2: Median Log Wage Growth for labour Market Entrants in Non-Routine Analytical Jobs by Education Group

Cohort	High-Uni	High-FH	High-Abi	Medium	Low
1974	20.0	23.3	29.7	34.4	35.8
1976	14.9	21.3	38.9	31.8	32.3
1978	12.7	16.2	30.4	29.2	22.7
1980	22.9	23.9	34.5	30.4	19.9
1982	26.8	29.6	44.8	41.2	27.0
1984	28.1	32.1	44.2	43.9	32.6
1986	14.3	21.4	38.0	38.6	33.7
1988	18.1	14.8	33.3	37.4	24.0
1990	15.4	15.2	31.6	29.1	22.6
1992	17.1	11.5	21.8	16.7	
1994	21.8	25.6	28.2	16.2	
1996	25.9	27.1	31.0	18.1	
1998	20.6	20.2	30.8	15.8	
2000	19.4	18.4	23.9	11.6	
2002	12.4	13.1	20.9	9.3	
2004	18.7	18.1	21.5	10.0	

Source: 2% IABS Sample for full-time workers under 35 years of age. N=65,051.
Note: The table displays the difference between the median log wage for workers working in non-routine analytical jobs with a potential experience of five years and a potential experience of 0 years multiplied by 100 for each educational attainment.

Table 4.3: Median Log Wage Growth for labour Market Entrants Outside Non-Routine Analytical Jobs by Education Group

Cohort	High-Uni	High-FH	High-Abi	Medium	Low
1974	21.8	24.1	32.9	34.9	35.2
1976	15.8	22.5	22.1	35.6	29.2
1978	12.9	17.7	20.1	30.8	23.6
1980	17.3	16.9	18.7	32.3	23.1
1982	28.9	32.1	27.9	37.8	36.8
1984	30.0	34.2	36.7	39.1	37.4
1986	11.1	21.8	38.1	38.6	32.3
1988	18.7	21.7	30.5	31.1	26.7
1990	20.6	14.8	22.9	25.2	21.9
1992	24.6	16.0	21.5	15.4	13.8
1994	32.3	24.3	23.0	18.9	22.5
1996	31.0	33.8	25.4	19.5	29.6
1998	34.3	20.9	25.8	17.9	28.6
2000	25.3	24.1	20.8	13.6	21.1
2002	20.9	17.7	18.0	9.7	26.0
2004	22.5	22.5	17.6	12.6	45.7

Source: 2% IABS Sample for full-time workers under 35 years of age. N=359,850.
Note: The table displays the difference between the median log wage for workers working outside non-routine analytical jobs with a potential experience of five years and a potential experience of 0 years multiplied by 100 for each educational attainment.

5

On the Link between Job Polarisation and Wage Inequality – A Regional Approach for Germany

5.1 Introduction

Rising wage inequality and job polarisation are thoroughly analysed in the labour market literature. Wage inequality refers to the wage dispersion, and job polarisation to employment dispersion. Increasing wage inequality describes the larger wage growth at the top of the wage distribution relative to the bottom (Acemoğlu and Autor, 2011). Job polarisation describes the relative decline in the share of medium-paying jobs relative to top- and bottom-paying jobs (Goos and Manning, 2007). Numerous rich countries, including Germany, meet rising wage inequality and job polarisation (Dustmann et al., 2009). Both phenomena are closely linked to technological change in the literature.

Autor et al. (2008) and Katz and Murphy (1992) found evidence for a direct link between technological change and wage inequality in the U.S. Still, the stable German wage structure until the mid-1990s instanced against the conjecture of such a link (Beaudry and Green, 2003; Prasad, 2004). Notwithstanding, since the mid-1990s, also German wage inequality started to rise (Dustmann et al., 2014; Kohn, 2006). The question arises whether this rise in wage inequality can be linked to job polarisation, since wage decompression finally started with emerging job polarisation.

The impact of job polarisation upon wage inequality consists of a mechanical and a wage effect. Job polarisation must ceteris paribus mechanically drive up wage inequality, since the share of top-paying and bottom-paying jobs increases. Besides, employment polarisation may also influence wages within occupations, or the return to skills. The direction of the latter link is not a priori clear. There are three possible outcomes: First, there is a demand-driven link. The changing demand for workers by occupation drives employment shifts. Assuming constant supply, the increased demand in high- and low-paying occu-

pations induces upper and lower tail wages to rise, while the demand and in consequence the wages for medium-paying occupations falls (Autor et al., 2008; Katz and Murphy, 1992). The relationship between job polarisation and wage inequality then is positive. Second, occupational changes may also be supply-driven. Occupational upgrading may lag behind the expansion of higher education, pushing down high-skilled workers in lower positions and creating an oversupply of skills associated with eroding wages (Åberg, 2003; Beaudry et al., 2014). Displaced medium-skilled workers formerly employed in routine occupations orientate downwards and create an oversupply in bottom-paying occupations, causing falling wages at the bottom. At the same time, wages in medium-paying occupations rise, since the most talented and productive workers hold their positions. The relationship then is negative. Third, technological change may also increment skill requirements within occupations, and educational expansion and increasing demand for higher skills follow a balanced growth path. This leads to rising productivity for all occupations, and eventually rising wages. The direct relationship then is unclear, and both wages and employment rather depend upon the skill formation within occupations than employment shifts.

This study shows that skills as well as skills shifts within occupations are an essential driver of employment and wages, while there is no direct link between job polarisation and rising wage inequality. Two methods assess this link, which should be interpreted separately.

The first includes an innovative approach by exploiting regional variation in job polarisation as identification. The results suggest that job polarisation and wage inequality occur concurrently in the same regions, but are barely linked to one another. Job polarisation raises wage inequality mechanically, since the share of top-paying and bottom-paying occupations rise. Nonetheless, the wage effect is small and limited to upper tail wage inequality. Regional differentials in the workforce composition and skill formation almost fully explain altering patterns in the rise of wage inequality.

The second approach extends the approach by Autor et al. (2008), who find a positive link between occupational and wage growth applying OLS regressions. I include skills and skill shifts within occupations as further explanatory variables to this regression. Once accounting for skills, the positive link between occupational and wage growth fully vanishes.

Section 5.2 discusses the literature on wage inequality, job polarisation, and its link, both internationally and in Germany. It also introduces literature on regional wage inequality and job polarisation. Section 5.3 describes the data and trends in labour market outcomes

in Germany as well as its regions. The analysis on the link between wage inequality and job polarisation is conducted in section 5.4. Section 5.5 concludes the paper.

5.2 Literature

5.2.1 International Literature

Two main approaches have sought to explain recent changes in rich countries' labour market outcomes that both rely heavily on technological change: Skill-biased and routine-biased technological change. The first approach, skill-biased technological change, aims at explaining monotonic relative labour demand growth along the skill distribution (Katz and Murphy, 1992). Technological change supplements workers with increasing skills, since they are more prone to adapt to new technologies (Tinbergen, 1975). Skill-biased technological change implies rising relative demand and productivity for high-skilled workers in relation to low-skilled workers.

The impact of skill-biased technological change upon the wage structure became first empirically noticeable in the U.S. from the 1970s, when the supply of high-skilled labour fell short its increasing technology-driven demand (Goldin and Katz, 2009; Katz and Murphy, 1992). Relative demand at the top of the wage distribution increased, while the supply of high-skilled workers expanded at a slower pace. In conclusion of the shortage, wages at the top of the wage distribution grew more than at the middle and bottom. This shortfall eventually causes rising wage inequality. It also implies a positive link between employment and wage shifts.

The second approach, routine-biased technological change, came up with developing Information and Communication Technologies (ICT), which caused altering patterns of occupational employment growth from the late 1980s. Employment growth shifted to a u-curved pattern, in which relative employment growth at both tails of the wage distribution outpaces employment growth in the middle. It is closely associated with rising computer capital as well as the rising speed at which computers perform tasks (Autor et al., 2003).

Autor et al. (2003) argue that computers are capable of performing codifiable routine tasks. Computer-based technologies hence substitute routine labour which is typically in the middle of the wage distribution. Their relative demand falls. At the same time, these technologies enhance productivity in abstract tasks that typically rely on information as an input and are typically performed in top-paying jobs and by high-skilled workers.

Productivity and labour demand in top-paying occupations then rises. Concurrently, the increase in computer capital has hardly any impact on tasks that are non-routine and manual, such as waiting a table or caring. These tasks are typically present in occupations at the bottom of the wage and skill distribution. These occupations, although not directly affected by technological change, nonetheless witness increasing demand due to higher incomes of the high-skilled workers demanding these services and a necessity of regional proximity of such services (Beaudry et al., 2012; Florida and Mellander, 2016; Leonardi, 2015; Moretti, 2010).

Goos and Manning (2007) introduced the term job polarisation to describe these employment shifts. They assessed occupational demand shifts in the UK. They empirically illustrate a u-curve of occupational growth along the skill distribution, where the mean wage of a job proxies its required skills. They further show how these shifts implied rising wage inequality. In a similar vein, Autor et al. (2008) draw a direct link between occupational and wage shifts in the U.S. They illustrate how employment growth shifts from a monotonic pattern in employment growth until the end of the 1980s to a u-shaped pattern thereafter, which equal wage shifts mirror.

Shifts in employment structure are universally observed in rich countries and are linked to Information and Communication technology. Michaels et al. (2014) confirm the polarisation hypothesis using industry-specific ICT investment as identification for occupational changes in the U.S., Japan and nine European countries, including Germany. They find that ICT investment is explanatory for changes in occupational shares, increasing the demand for top-paying, and mitigating the demand for middle-paying occupations while having little impact upon low-paying occupations.

Acemoğlu and Autor (2011) note that occupational shifts are comparable across many advanced labour markets, but shifts in the wage distribution differ. Cross-country comparisons show different responses to occupational shifts, which may lay in distinct growth paths in the supply and demand of high-skilled workers, but also distinct national regulations and legislations. Goos et al. (2009, 2014) investigate job polarisation in 16 European countries, including Germany, and confirm job polarisation as well as an increase in wage inequality. They suggest technological change as fruitful in explaining occupational shifts. Concurrently, they find no link between job polarisation and wage inequality in a cross-country analysis. Green and Sand (2015) similarly find evidence of job polarisation in Canada, while wage growth was monotonic. Their results contrast the view on a relationship between job polarisation and rising wage inequality.

5.2.2 Literature on German Wage Inequality and Job Polarisation

Job polarisation and the rise in wage inequality are also present in (West) Germany. In comparison to the U.S. and the UK, the rise in wage inequality in Germany was less pronounced and only started to grow from the 1980s and was first limited to upper tail inequality (Dustmann et al., 2009). From the 1990s, wage inequality started to grow at both tails of the wage distribution. Dustmann et al. (2009) further find job polarisation applying a task approach, where abstract tasks are predominantly performed in top-paying occupations and routine and manual tasks are performed both in the middle and the lower tail of the wage distribution. Occupational shifts slightly vary from a typical u-pattern. Although employment growth is similarly highest at the top, and declining in the middle, it scarcely changes at the bottom. The pattern of occupational growth is rather j- than u-curved. Dustmann et al. (2009) depict these occupational shifts both for the 1980s, when wage inequality only raised at the upper tail, and the 1990s, when wage inequality raised at both tails. In both periods, occupational changes are similar, but changes in the wage distribution alter – suggesting no link between occupational and wage shifts. They propose other reasons that shape the wage distribution, such as supply shocks, and changes in labour market institutions.

Spitz-Oener (2006) utilises four waves of the German Qualification and Career Survey for the years 1979, 1985/86, 1991/92, and 1998/99 to analyse job polarisation. The unique data set comprises individualised information on tasks, computer usage, etc. She finds support for routine-biased technological change in Germany. In particular, she finds increasing employment shares in low-paying non-routine manual tasks and top-paying non-routine cognitive tasks, as well as declining employment shares in routine cognitive tasks. She directly links these shifts to computerisation.

Antonczyk et al. (2009) claim that the task approach by Spitz-Oener (2006) can only explain occupational shifts within the time period she observed. They extend the observed time horizon beyond 1999, and analyse two waves of the Qualification and Career Survey in the years 1999 and 2006. Antonczyk et al. (2009) find declining employment shares in low-paying non-routine manual tasks, and a rise in medium-paying routine cognitive tasks – implying a reversal of job polarisation. A rise in wage inequality accompanies this reversal. They conclude that 'changes in task assignments strongly work towards reducing wage inequality' and that 'the task-based approach can not explain the recent increase of wage inequality in Germany' (Antonczyk et al., 2009, p. 214).

Beaudry and Green (2003) conduct a comparative analysis of the impact of technological change upon the labour market between the U.S. and Germany. Next to human capital

accumulation over time, they further take physical capital into account to build a model in which deficient physical capital is harmful for low-skilled workers in the course of technological change. They reason that the fall of wages for the low-skilled workers in the U.S., while wages for the low-skilled grew in Germany, is due to divergent paths of physical capital formation between both countries. The U.S. face an under-accumulation of physical relative to human capital, while Germany followed a balanced growth path. The abundant physical capital accumulation in Germany results in increasing wages in the course of technological change for low-skilled workers, and thus relatively constant wage inequality.

Freeman and Schettkat (2001) argue that differences in the degree of wage compression between the U.S. and Germany lay in the skill compression. Other than in the U.S., jobless workers in Germany have comparative skills to employed workers. The skill formation in the U.S. is by contrast decompressed. Although they find that skill compression is a major driver of the larger inequality in the U.S., they further find institutional factors explanatory.

5.2.3 Literature on Wage Inequality and Job Polarisation using Regional Variation as Identification

The implementation of technological change and the resulting job polarisation is spatially unequally distributed within countries. Accetturo et al. (2014) enrich the canonical model proposed by Acemoğlu (2002) with a regional variation of skills. They show that the adaptation of new technologies requires a certain regional skill level of the workforce. Skilled regions adapt to new technologies faster and therefore further attract workers from less-skilled regions. Regional skill differentials thus diverge over time. Technical progress is then regionally self-enforcing and path-dependent.

Empirical studies support this phenomenon: Marinelli (2013) observes migration behaviour of Italian students at two points: At the beginning of their studies, and at the beginning of their first job. They find that students willing to migrate to study are more willing to migrate after their studies. These students face a better skill-match due to a larger job market, and are more concentrated in skilled regions. Consoli et al. (2013) find that graduates are generally prone to migrate to high-skilled regions. They further document that in times of rapid technological progress, migration to skilled regions similarly gains pace.

There further exist studies directly linking regional variation in technological change and job polarisation to the wage distribution. Florida and Mellander (2016) find higher

wage inequality in U.S. counties with a greater concentration of high-technology industry. Workers in these counties have higher average skills. Employment in bottom-paying jobs in these counties similarly grows faster, resulting in job polarisation. There is a positive correlation between wage inequality and high-technology as well as human capital formation. Yet, there are also hints that the higher average income in high-tech counties narrows the wage distribution. They conclude that job polarisation accompanies rising wage inequality, but does not necessarily imply it.

Autor and Dorn (2013) argue that U.S. commuting zones (CZ) that are initially specialised in routine jobs are more prone to computerisation, which eventually leads to higher job polarisation. Routine-intensive CZ face a steeper growth of employment and wages at the tails of the wage distribution, and a larger fall in employment in the middle. Lower tail wage growth counteracts the rise in wage inequality. They conclude that technical change and job polarisation do not need to enhance wage inequality.

In a similar vein, Beaudry et al. (2010) show that U.S. metropolitan areas with a high supply, i.e. low price, of high-skilled workers adopt computer technology faster. Demand for skills and returns to skills grow faster in these areas. They show that implementing new technologies, initially triggered by a relative oversupply of high-skilled workers, creates both job polarisation and wage inequality. Yet, Beaudry et al. (2012) report a positive effect on average wages in local labour markets that were subject to large employment growth in the high-wage sectors. Technological shocks lift overall wages due to general equilibrium effects.

Lee et al. (2013) document similar findings for the UK. They analyse wage inequality and polarisation in British cities. The most polarised cities are the most unequal. The attraction of high-skilled workers induces wage inequality, but also improves labour market prospects of low-skilled workers. At the same time, the most equal cities have a small share of high-skilled workers, i.e. few high earners. These cities are overall poor. Average income and wage inequality are positively correlated.

All studies foreground one pattern: Polarised regions experience a larger rise in wage inequality. Still, no study suggests that (regional) job polarisation implies higher wage inequality.

5.3 Data, Trends in Wage Inequality and Job Polarisation in Germany and its Regions

5.3.1 Data

This study grounds upon data of the Sample of Integrated Labour Market Biographies (SIAB) in Germany. Other studies exploit these observations to explore the German wage structure and the wage distribution, e.g. Dustmann et al. (2009) and Card et al. (2013). Vom Berge et al. (2013) give a detailed description of the data set.

The SIAB is a 2 % random sample of German social security records from 1975 to 2010 covering circa 11 million observations. It is drawn from the Integrated Employment Biographies Sample (IEB) of the Institute for Employment Research (IAB). Social security records are reliable due to their administrative character. They contain information on all jobs subject to social security contribution in Germany – which is roughly 80 % of the German workforce. The data exclude civil servants, self-employed, and soldiers, since they are not subject to social security contribution.

The main limitation of the data is the right-censoring of the wage variable. Social security contribution of an employer limits to a certain margin of income. The social security contribution does not increase with increasing income from this ceiling. Since the wage variable grounds upon the social security contribution, the wage variable is fixed at that margin level. This social security ceiling varies annually. As an example, it amounts to an annual income of €66,000 in the year 2010. This censoring affects roughly 10 % of the wage variable of men and 2 % of the wage variable of women with low annual variation. Measurement of wage inequality is typically measured as the 90-10 inter-decile range. The analysis here refers to the 85-15 inter-percentile range to avoid the censoring.

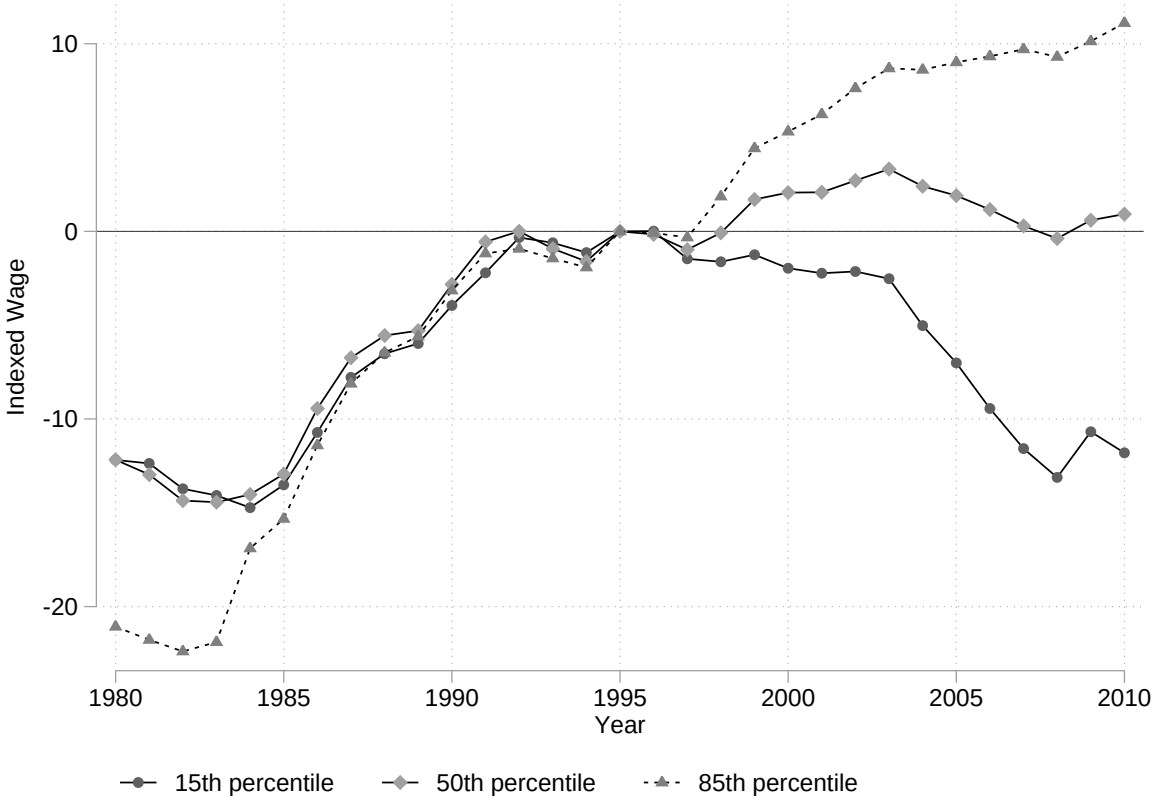
Wages are daily wages in the data set, and are those observed on June 30th for each year and each worker. They are inflation-adjusted regarding the consumer price indices from the German federal office of statistics (Statistisches Bundesamt, 2016). Price indices are generally sensitive to quality change, and new products (Moulton, 1996). They should be treated with caution.

The analysis restricts to workers with workplace and residence in West Germany, since East German data are only available after 1992. Germany refers to West Germany in the following. Data are for full-time employees only, whereby full-time is defined as at least 20 hours a week until 1978, 15 hours between 1979 and 1987, and 18 hours from 1988.

5.3.2 German Trends in Wage Inequality and Job Polarisation

I will first discuss general trends in Germany and later examine regional distinctions of job polarisation and wage inequality. Figure 5.1 plots the indexed wage growth for the 85th, 50th, and 15th percentile of the wage distribution, where the base year is 1995. Two periods segregate wage development: Harmonised wage growth until the mid-1990s, and diverging wage growth thereafter (see also Card et al. (2013); Dustmann et al. (2009)).

Figure 5.1: Indexed Wage Growth (1980-2010), Base Year=1995



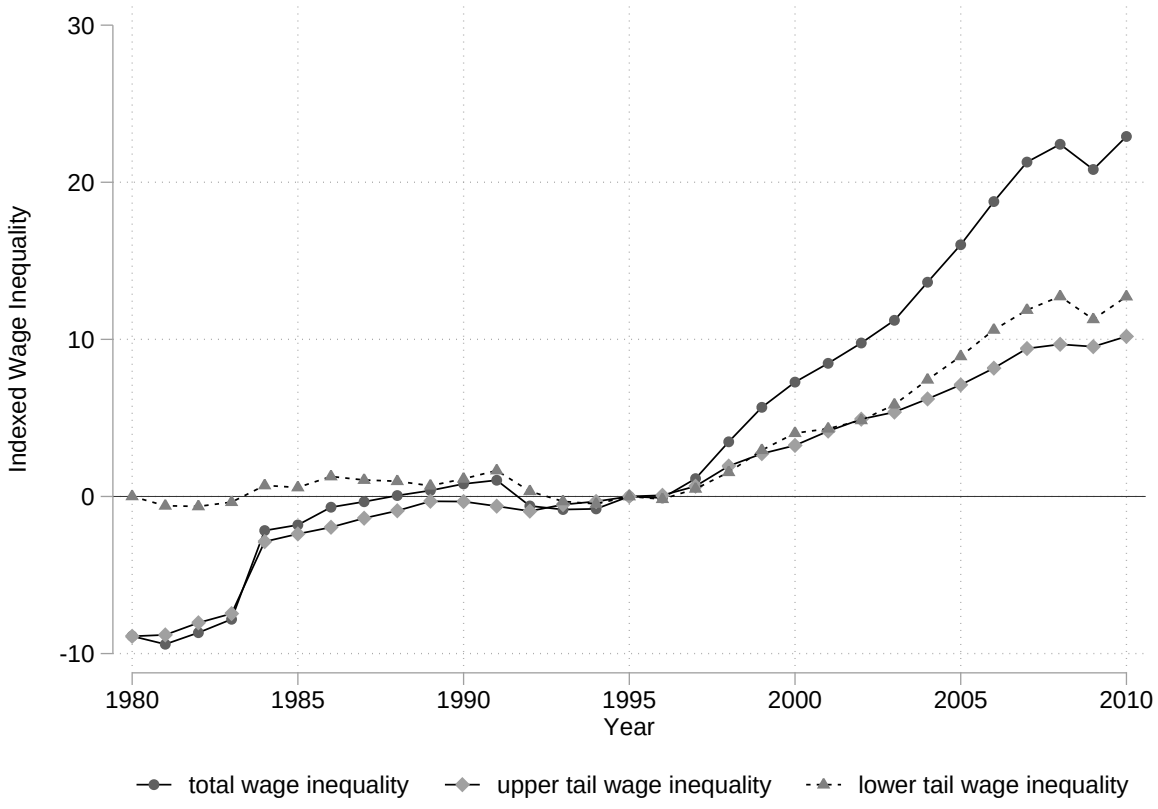
Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,888,775.

Wages grow in parallel until the mid-1990s. Apart from an episodic strong wage increase at the upper tail between 1983 and 1984, wages stagnate in the early 1980s and start to grow from the mid-1980s until the early 1990s. The immediate post-unification era is then characterised by steady wages. Wage dispersion starts from the mid-1990s. Wages at the top and bottom diverge. Bottom wages first decline slowly and plummet from 2003. The strong decline of bottom wages only ceases in 2008. Wages at the middle slightly grow

from the mid-1990s to 2003, followed by a small decline. Top wages constantly rise from 1995 to 2003 and remain constant thereafter.

These wage trends directly translate into changes in wage inequality. Figure 5.2 displays the development of the indexed wage inequality, where the base year is 1995. Prior to the mid-1990s, the rise in total wage inequality fully attributed to upper tail wage inequality, more specifically the episodic ascent in upper tail wages between 1983 and 1984. Wage inequality is constant between the mid-1980s to the mid-1990s. Between 1995 and 2008, wage inequality started to continuously grow at both tails. Thereby, the rise in lower wage inequality is larger than the rise in upper tail wage inequality.

Figure 5.2: Indexed Wage Inequality (1980-2010), Base Year=1995



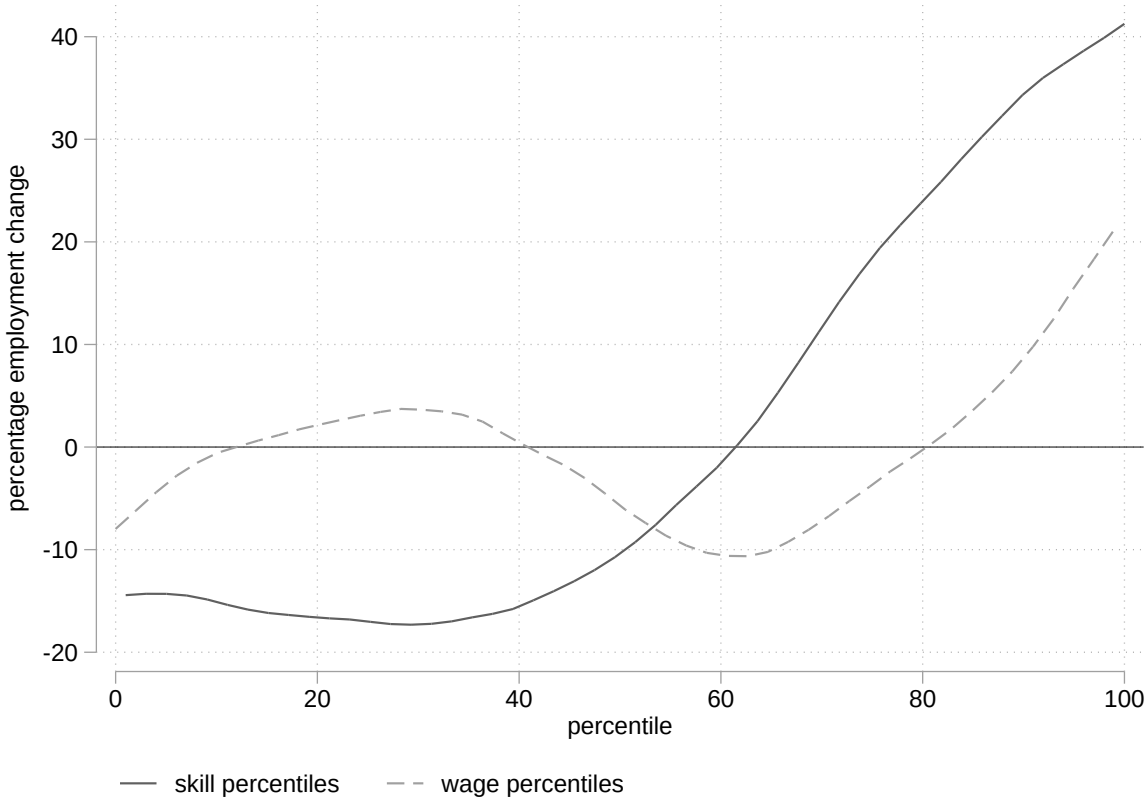
Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,888,775.

Job polarisation can similarly be detected in the data set. The pattern of employment growth varies depending from whether the wage distribution is sorted according to mean wages or mean skills. Average wages are not necessarily increasing with average skills, especially for occupations at the bottom of the wage distribution. Generally, job polarisation in Germany rather follows a j-form than a typical u-form, which is similar to

Dustmann et al. (2009). Figure 5.3 illustrates smoothed occupational growth between 1980 and 2010 by 1980 wage percentiles and skill percentiles.

Regarding wage percentiles, gains are highest at the top of the wage distribution and lowest around the 60th percentile. A second mode emerges around the 30th percentile. Occupational growth is negative at the absolute bottom. The pattern does not show a j-form. It rather reflects an inverse s-form. Still, partitioning the distribution in tertiles as in Acemoğlu and Autor (2011), upper and lower tail's rise in employment shares are larger than the decline in the middle of the distribution. Sorting the distribution according to skills results in a clear j-form of employment growth. There is a mode at the top and bottom. Occupational shares in the middle decline.

Figure 5.3: Occupational Growth – Wage and Skill Percentiles (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=305,996 in 1980, N=272,279 in 2010. Changes are smoothed using a local smoothing epanechnikov kernel function and a bandwith of 5.

5.3.3 Regional Polarisation

This study takes advantage of regional differences in job polarisation. The observed regions are 204 local labour markets (LLM from now on) in Germany. Commuting patterns define these LLM (Kropp and Schwengler, 2011). That way, they represent local economies and labour markets better than county boundaries. German local labour markets are similar to U.S. Commuting Zones, which among others Autor and Dorn (2013) employ to analyse regional employment polarisation.

This study follows the exploration by Dauth (2014) to distinguish regional job polarisation. Dauth (2014) analyses regional polarisation in Germany accounting for regionally varying employment shifts. He thereby follows the implementation by Goos and Manning (2007), who introduced the term job polarisation. Occupations are ranked according to mean wages in the initial year 1980. Employment growth by the rank of occupation is then computed over time. An OLS regression of occupational growth with the rank and squared rank as the explanatory variables is then run. The squared term gathers the u-shaped pattern of occupational growth, i.e. growing employment shares at both tails of the wage distribution relative to the middle.

Dauth (2014) follows this method for German data. He estimates occupational growth from 1980 to 2010 by the rank and squared ranked of occupations – sorted according to 1980 mean wages. For Germany, he estimates (t-values in brackets):

$$\widehat{\%Emp_{1980-2010}} = -11.118 - \underset{(-3.5)}{.605} rank_{1980} + \underset{(4.76)}{.003} rank^2_{1980}. \tag{5.1}$$

Dauth (2014) repeats this estimation for all LLM and explores the squared parameter that determines the u-shape of occupational growth to quantify the regional degree of job polarisation. He then categorises regional labour markets with differing patterns of occupational change:

1. negative job polarisation: a negative t-ratio (6 LLM, 1.2 % of the workforce),
2. weak job polarisation: a t-ratio between zero and the 5 %-significance level (54 LLM, 10.4 % of the workforce),
3. job polarisation: a t-ratio between the 5 %-significance level and the t-ratio estimated for Germany (124 LLM, 55.4 % of the workforce),
4. strong job polarisation: a t-ratio above the t-ratio estimated for Germany (20 LLM, 33.1 % of the workforce).

The t-ratio marks the identification of regional job polarisation. It is important to note that the t-ratio largely depends on the coefficient, but also on the number of observations. One may argue that the size of the regions, and in consequence the number of observations, differ from one region to another. While it is true that these sizes vary, this will not influence the t-ratio in the above estimation. The estimations makes use of occupations, or its rank along the wage distribution. Assuming all jobs exist in each region, the number of observations then is equal for each region. In conclusion, the size of the local labour market will not influence the t-ratio.

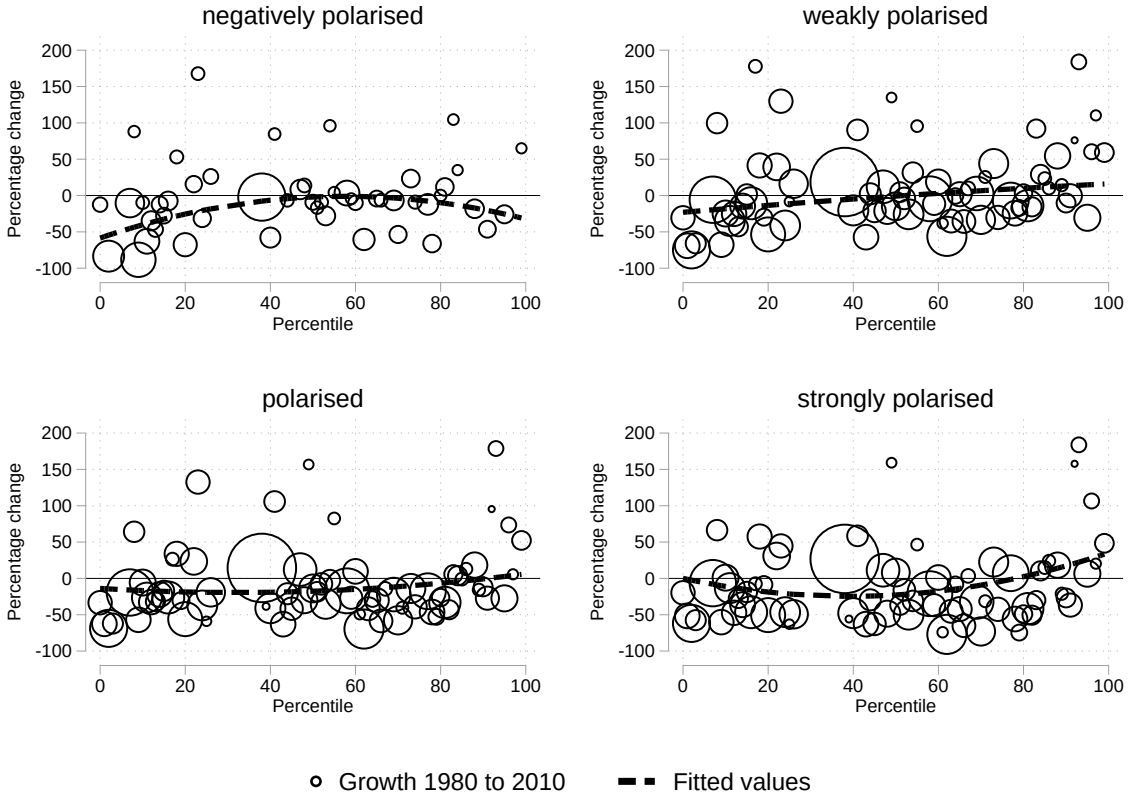
Job polarisation occurs in most local labour markets, where the majority of the workforce concentrates. Figure 5.9 in the appendix displays a map of (West) Germany and its LLM with different degrees of job polarisation. Significant employment polarisation occurs in 144 out of 204 LLM that represent 88 % of the workforce. German employment polarisation is significant, since the main part of the workforce is employed in regions, where employment polarisation occurs. Nonetheless, job polarisation is not omnipresent. Job polarisation does not affect only represent 60 LLM, with nothing but 12 % of the total German workforce. Out of these, 6 LLM or 1 % of the workforce experience negative job polarisation. Only one region is negatively polarised at the 5 % level of significance.

Figure 5.4 depicts the different patterns of employment polarisation for each group of region. It plots job growth between 1980 and 2010 for each percentile according to 1980 wages by occupation.[4] The size of the circles denotes the number of occupations in 1980. The dashed line represents the estimated occupational growth applying a weighted OLS regression with percentile and squared percentile as the explanatory variables.

Fitted occupational growth is negative at both ends of the wage distribution in negatively polarised LLM, which leads to an inverse u-shape of occupational growth. Near-monotonic occupational growth characterises weakly polarised local labour markets. Fitted employment growth is positive at the top, and negative occupational growth at the bottom. Fitted occupational growth is positive at both tails in polarised and strongly polarised LLM. The curvature of the u is larger in strongly polarised LLM.

[4] Due to data restriction, I use percentiles instead of the rank of the job to increase the number of observations.

Figure 5.4: Fitted occupational Growth – by Degree of Job Polarisation (1980-2010)

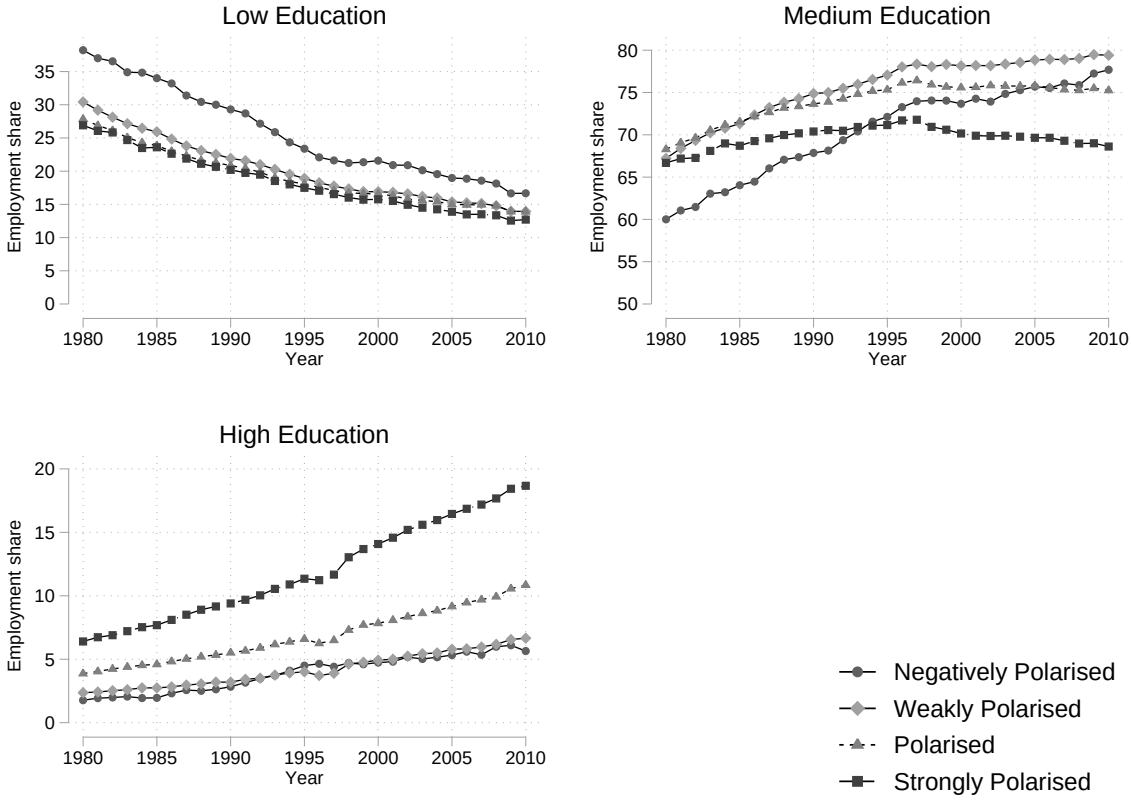


Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=577,829.
Wage growth could not be computed due to data non-disclosure in negatively polarised local labour markets for rank percentiles with less than 20 observations.
Observations are not displayed for percentage changes above 200% for the sake of visibility.

The initial share of high-skilled employment is relevant to the acquirement of new technologies that finally leads to employment polarisation (Accetturo et al., 2014; Beaudry et al., 2010; Marinelli, 2013). German data confirm this finding: Figure 5.5 plots regional employment shares by skills.[5] There is an educational sorting of regions with respect to higher education. Throughout the observation period, the employment share of workers with higher education is larger the more a region is subject to job polarisation.

[5] Low education is defined as having not completed vocational training, medium education as having completed a vocational training, and high education as having completed a university degree.

Figure 5.5: Educational Shares – by Degree of Job Polarisation (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,898,110.

Regional disparities in high-skilled employment shares rise over time. An initial higher share in higher education triggers the adoption of new technologies, and is self-amplifying. Regional human capital differentials, therefore, increase over time (Consoli et al., 2013; Marinelli, 2013). Differences in higher education between negatively and weakly polarised LLM barely exist. Both types of regions do not experience significant job polarisation. Due to this similarity, they will be pooled in some parts of the following analysis.

Low- and medium-skilled employment shares seem irrelevant for employment polarisation. Low-skill employment shares are similar across regions. Only negatively polarised LLM hold a diverse low-skilled employment share that converges to the remaining regions. The trends in medium-skilled employment shares distinguish regionally, but follow an unclear pattern.

5.4 What is the Link between Job Polarisation and Wage Inequality?

5.4.1 Regions as the Identification Strategy of Job Polarisation

Both cross-country and within-country analyses on the link between the employment and wages structure should be treated with care when drawing a link between the two. Cross-country analyses, such as Goos et al. (2009), capture variation in occupational and wage shifts between countries. Within-country analyses, such as Autor et al. (2008), typically compare the wage structure before and after emerging job polarisation. Difficulties arise from a possible variation between countries or between different time periods in (1) the supply of skills, the (2) adaptation of new technologies resulting in varying demand for skills, and (3) the institutional framework – influencing the wage formation notably at the bottom end.

First, the growth rate of higher education has a crucial impact on wage inequality. Wage inequality increases when technological change outpaces educational expansion, and shrinks when educational expansion outpaces technological change (Tinbergen, 1975). Katz and Murphy (1992) incorporate this argument. They explain the increase in wage inequality in the U.S. by a relative shortage in educational expansion from the 1970s. In contrast, Beaudry and Green (2003) find a balanced path of human capital accumulation in Germany as explanatory for its wage stability in contrast to the U.S. Abraham and Houseman (1995) further describe how the constantly growing supply of higher education in Germany, which fell short in the U.S., explains its stability of the wage structure.

Second, differences also appear with respect to the implementation of technological change. Expenditure on Research and Development (R&D) is largely higher in the U.S. than in European countries. Gross domestic expenditure on R&D as a percentage of GDP is 2.79 in the U.S., as compared to an OECD average of 2.4, and only yielding 1.97 in EU-28 countries in 2012 (OECD, 2014). Similarly, the role of Information and Communication Technology is more pronounced in the U.S.: The share of ICT value added in business sector value added in the U.S. amounts to 7.1 % as compared to an OECD average of 6.0 %. Crescenzi et al. (2007) further find differences in the dynamics of innovation in the U.S. and Europe, where the European innovation system lags behind. Lastly, the U.S. population is more optimistic about new technologies, rendering U.S. workers more open to adapting to innovative technologies (Gaskell et al., 2005). This variety may cause differing demand shifts for high-skilled workers.

Third, institutions vary between countries. Blau and Kahn (2002) find that technological change results in a rise in wage inequality in the U.S., while increasing unemployment among the low-educated in Europe due to a rigid wage setting. In a comparative analysis on the impact on innovation on wage inequality, Lee and Rodríguez-Pose (2013) find divergent trends between the U.S. and European cities. Innovation triggers job polarisation both in the U.S. and Europe. While job polarisation mitigates inequality through higher wages for low-skilled workers in the U.S., it increases inequality in Continental Europe since polarisation entices low-skilled workers into the labour market. In contrast, low-wage workers are likely already in employment in the U.S. and are not pulled into the labour market, since the U.S. welfare state is less benevolent than their Continental European counterparts (OECD, 2015).

These issues render cross-country as well as within-country analyses difficult to assess the impact of job polarisation upon wage inequality. It is difficult to distinguish whether wage inequality is higher in one country than another due to differences in the institutional framework, supply and demand for high-skilled labour, or the degree of job polarisation. Likewise, it renders within-country analyses between two points in time difficult. It is unclear whether a rise in wage inequality occurs due to shifts in the institutional framework, a shortage in the supply of high-skilled labour, or increasing demand for high-skilled labour due to increasing innovation.

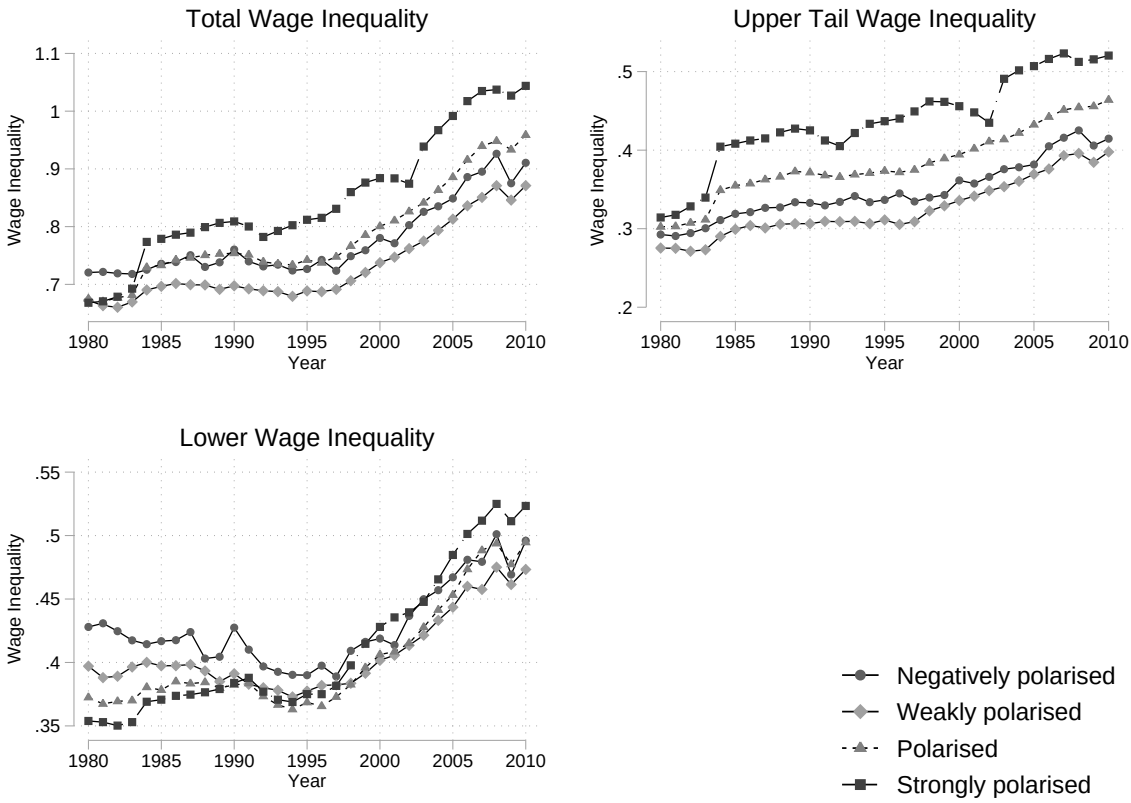
I use regional variation in job polarisation in Germany to overcome these issues. Institutional factors, such as employment law, union coverage, or social preferences to wage compression can be assumed alike between regions of one country. Supply of high-skilled labour, arguably an essential trigger of the implementation of technological innovation, is harmonised within a country. Further, curricula and the definition of educational levels do hardly vary within a country. Although universities may be more present in cities than in rural areas, within-country migration can compensate these differentials due to the free movement of workers, non-existing language barriers, and rather small geographic distances between polarised and non-polarised LLM (see also figure 5.9). Lastly, access to technology can be assumed alike within a country.

5.4.2 Regional Trends in Wage inequality

First and foremost, the rise in wage inequality occurs universally in Germany no matter the degree of regional job polarisation, but it differs in magnitude. Figure 5.6 illustrates wage inequality for each type of region over time. The upper-left panel describes the rise in total wage inequality. In all regions, total wage inequality remains hardly unchanged up until the mid-1990s, and accelerates subsequently until 2008, whereupon it stagnates.

The rise in total wage inequality is both fuelled by upper and lower wage inequality. While upper tail inequality steadily grows, lower inequality expands abruptly from the mid-1990s. These patterns largely correspond to the development described in Germany in section 5.3.2.

Figure 5.6: Wage Inequality – by Degree of Job Polarisation (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,886,214.

Although the patterns of the rise in wage inequality resemble between regions, there are some distinctions. In 1980, strongly polarised LLM are most equal. In 2010, these LLM were most unequal. Similarly, negatively polarised LLM are most unequal in 1980, while they are second-most equal in 2010. There is clearly a larger rise in wage inequality in polarised local labour markets. This hints at a possible relationship between job polarisation and wage inequality. Clearly, in 2010, when technological change reshaped the wage structure, strongly polarised and polarised LLM are more unequal than non-polarised LLM.

What drives this divergence? The divergence in wage inequality is mostly due to differences in lower inequality. Relative gaps in upper inequality are constant. The higher the

degree of job polarisation is in a region, the higher is upper inequality. This excludes the rapid ascent in upper inequality from 1983 to 1984, which is larger in polarised LLM. Other than that, developments in upper inequality are harmonised, and relative gaps remain unchanged over time.

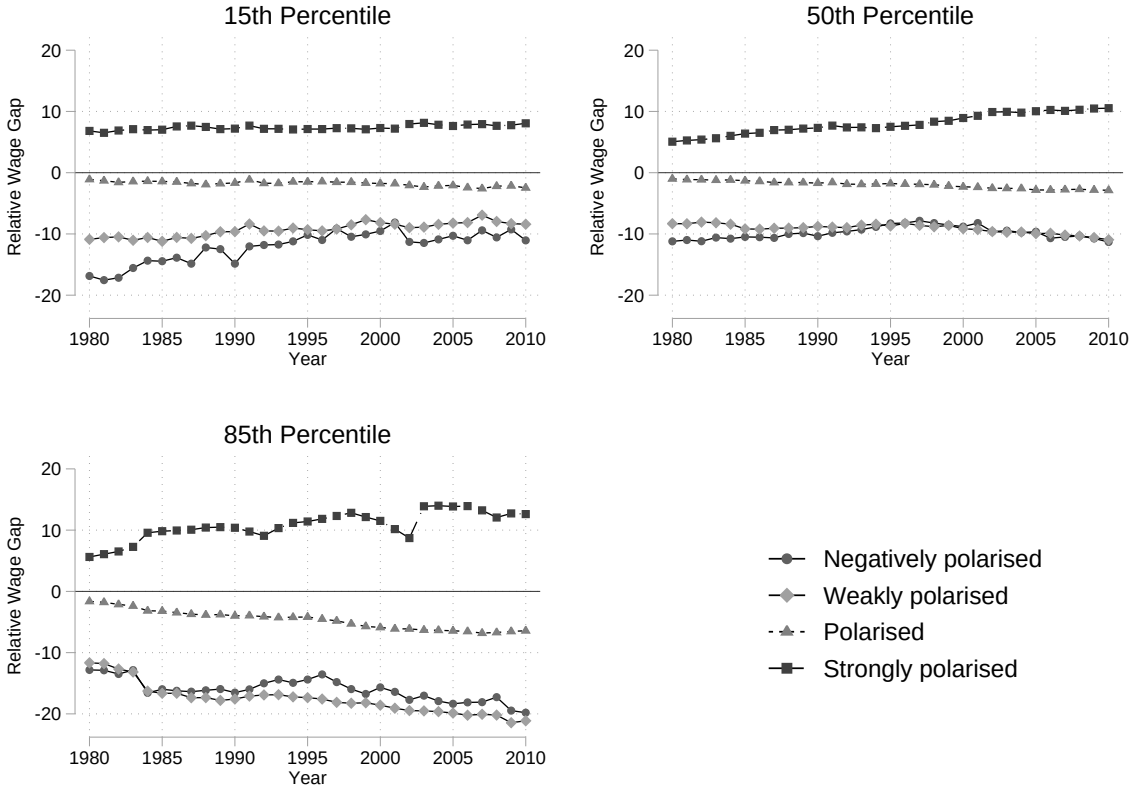
Differentials in lower inequality are larger. In 1980, differences are broad, while strongly polarised LLM are distinctly more equal than negatively and weakly polarised LLM. The period until the mid-1990s is an adjustment of lower inequality and a disappearance of regional differences – while lower inequality of the total sample remains constant (see figure 5.2). While lower wage inequality strongly declined in negatively and weakly polarised LLM, it only slightly falls for polarised LLM, and remained stable for strongly polarised LLM. A harmonisation in lower inequality between regions characterises this period – since there are no regional differences by the mid-1990s. It also implicitly speaks in favour of a stiff wage setting, and workers opting out of the labour market, when workers do not find occupations with comparative wages.

Lower inequality abruptly rises from the mid-1990s in all regions. The size of the rise in lower inequality differs regionally. The more a region is polarised, the larger is the rise in lower inequality. Still, given the parallel movements, and relative small inequality gaps between regions, and the abrupt rise from the mid-1990s, it seems unlikely that market forces stemming from occupational changes trigger the rise in lower inequality. By contrast, it may stem from a deunionisation process and flexibilisation of wages that occurred in this era and mainly affect bottom wages (Dustmann et al., 2009, 2014).

Understanding the wage growth at different points of the wage distribution is essential to understand what drives the gaps in inequality. Figure 5.7 plots relative wage gaps for each region relative to the total workforce in Germany over time. Throughout the sample period, there is a clear ordering of wages regarding the degree of polarisation. Wages are highest in strongly polarised LLM, and lowest in negatively polarised LLM. Wages in strongly polarised LLM are constantly highest and above the sample mean – this is similar to findings in the UK, where polarised cities reach the highest wages at all points of the wage distribution (Lee et al., 2013).

The upper left panel of figure 5.7 illustrates the wage gap at the 15th percentile for each region relative to the full sample. The wage gaps in strongly polarised and polarised LLM are constant over the years. By contrast, the relative wage gap in weakly and negatively polarised LLM catches up until the mid-1990s, and remain constant thereafter. The adjustment process prior to the mid-1990s was larger in negatively polarised LLM than in

Figure 5.7: Relative Wage Gap – by Degree of Job Polarisation (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,886,214.

weakly polarised LLM. This adjustment process also hints at the institutional framework contracting relative regional wage gaps at the lower tail.

Wage gaps at the median of the wage distribution are overall constant. Relative wage gaps in strongly polarised LLM slowly and constantly rise throughout the years, while they slightly but constantly fall in polarised LLM. A constant wage gap until the mid-1990s, which declines thereafter, describes weakly polarised LLM. The relative wage gap narrows in negatively polarised LLM until the mid-1990s, and then falls in parallel to weakly polarised LLM. In all, the comparably stark increase in strongly polarised LLM's lower tail inequality can be attributed to a larger rise in median wages as compared to wages at the 15th percentile. At the same time, the relative wage gaps at the median are more stable than at the lower tail in weakly and negatively polarised LLM – explaining why the increase in lower inequality is smaller in these regions than in strongly polarised LLM.

At the 85th percentile, relative wage gaps steadily rise in strongly polarised LLM, and fall for the remaining regions. The fall in the relative wage gap in polarised LLM is minor to weakly and negatively polarised LLM, whose wages are similar. Bearing in mind the similar development in the wage gap at the median, this explains why differences in upper inequality are comparably constant over time.

Regional wage differentials are comparably constant, in contrast to the strong rise in wage inequality. It points to rising wage inequality as a universal phenomenon, and a low impact of employment shifts on the wage structure, since relative wage gaps are constant and, in contrast to lower inequality, do not rise abruptly. The decline in wages at the bottom (see also figure 5.2) thus is universal and may be attributed to a universal loosening of the institutional framework (Dustmann et al., 2009).

5.4.3 Distributional Decomposition Method

Shifts in wage inequality are shifts in wages at different points of the wage distribution. This may occur mechanically. The share of high-skilled workers and top-paying occupations constantly increased in the past three decades. Assuming unchanged wages within occupations, and a constant return to higher education; upper as well as total wage inequality must mechanical shift upwards due to a numerical rise in the share of high-skilled workers and top-paying occupations. The term composition effect refers to this mechanical shift (Firpo et al., 2009).

The wage structure may also reshape structurally, i.e. due to shifts in wages within occupations, the return to education, etc. For example, the increasing demand for high-skilled workers in top-paying occupations may create an over-demand, which is followed by increasing wages in these occupations and increasing returns to education. This study aims at explaining how job polarisation shapes the wage structure structurally, i.e. how the wage structure reshapes if one accounts for the changing composition of the workforce such as occupations and skills.

I apply distributional decomposition methods to disentangle the structural from the composition effect. More specifically, the approach introduced by DiNardo et al. (1996) is applied. They evolved this method to analyse the impact of institutional and labour market factors upon the wage structure in the U.S. The analytic framework grounds upon the seminal work by Oaxaca (1973). The latter decomposition grounds on the question, what a worker with certain characteristics would earn in one group, e.g. a certain year, region, etc., had she worked in another group, e.g. another year, region, etc. It thus divides observed wage differentials between two groups into an explained part (composition effect)

and unexplained part (structural effect). The explained part refers to differences in the workforce composition, such as education, experience, etc. The unexplained component or structural effect corresponds to the remaining wage differentials.

While the method established by Oaxaca (1973) only decomposes differentials at the mean, the method suggested by DiNardo et al. (1996) goes beyond the mean. The suggested distributional decomposition method is capable of capturing composition and wage structure effects along the wage distribution. It represents an appropriate means to analyse the wage structure along the wage distribution and wage inequality. This method has been among others been applied in Autor and Dorn (2013) and Dustmann et al. (2009) to analyse the impact of occupational changes on the wage structure.

The idea behind this distributional decomposition is to replace the workforce characteristics distribution X of one group A, $F_{X_A}(X)$, with the distribution of X of the other group B, $F_{X_B}(X)$. The counterfactual wage distribution $F_{Y_A^c}(y)$ is the distribution of wages y in group B, had they get paid like workers in group A. It is computed using a reweighting factor of the following form:

$$F_{Y_A^c}(y) = \int F_{Y_A|X_A}(y|X)\Psi(X)dF_{X_A}(X), \tag{5.2}$$

where

$$\Psi(X) = \frac{dF_{X_B}X}{dF_{X_A}X} \tag{5.3}$$

is the reweighting factor. The reweighting factor is computed by pooling both groups and estimating a probit for the probability of belonging to group B as a function of the characteristics of the workforce X. The reweighting factor is:

$$\Psi(X) = \frac{Pr(X|D_B = 1)}{Pr(X|D_B = 0)} = \frac{\frac{Pr(D_B=1|X)}{Pr(D_B=1)}}{\frac{Pr(D_B=0|X)}{Pr(D_B=0)}}. \tag{5.4}$$

The observed differentials in the wage structure are decomposed into an explained composition effect, and unexplained wage structure effect. The observed differential is the sum of explained and unexplained effect. The composition effect then is the difference between the counterfactual density function and the density function for group A.

$$\Delta_X^{f(y)} = f_{Y_A^c}(y) - f_{Y_A}(y). \tag{5.5}$$

Observed differentials between two groups in total wage inequality, which the 85th-15th percentile wage differential defines here, are the difference between the wage difference at the upper tail between both groups, and the difference at the lower tail:

$$\Delta_X^{85-15} = [Q_{A,.85} - Q_{B,.85}] - [Q_{A,.15} - Q_{B,.15}], \tag{5.6}$$

and the composition effect of total wage inequality is the difference between the wage differentials at the upper tail between the counterfactual and actual group, and the same difference at the lower tail:

$$\Delta_X^{85-15^c} = [Q_{A,.85}^c - Q_{A,.85}] - [Q_{A,.15}^c - Q_{A,.15}]. \tag{5.7}$$

The wage structure effect is the subtraction of the composition effect (equation 5.5) from observed total wage inequality (equation 5.7).

5.4.4 Decomposing Differentials in Wage Inequality between Non-Polarised and Polarised LLM

The following analysis conducts the aforementioned decomposition method addressing what a worker with certain characteristics in a region that is not subject to employment polarisation would have earned, had she worked with the same characteristics in a region subject to job polarisation. Negatively and weakly polarised LLM are pooled into one group, where job polarisation did not occur (denoted 'non-polarised' henceforth). Polarised and strongly polarised LLM are pooled into another group, where job polarisation did occur (denoted 'polarised' henceforth). This approach guarantees two clear-cut statuses. The probability of working in a polarised region is conducted using a probit estimation using dummy variables for 5 educational dummy variables, and interaction terms thereof with potential experience and squared potential experience. Dummy variables for occupations are further included.

First, wage differentials are observed in 1980, before the emerging job polarisation, and second, in 2010, when job polarisation has emerged. The wage differentials and differences in wage inequality are then analysed and decomposed to assess the impact of job polarisation upon wages and wage inequality.

Table 5.1 displays wage differentials between both groups in 1980, and its decomposition in composition and structural effects. The observed differences are universally positive, meaning observed wages are higher in polarised than in non-polarised LLM (see also figure

5.7). The observed wage gap is roughly 13 % at both tails, and 10 % at the median. The differing composition of the workforce explains about half of the wage gap.

Table 5.1: Wage Gap in 1980: Quantile Decomposition – Reference Group: Polarised LLM

wage	difference	composition	structural
85th percentile	13.0%	6.7%	6.3%
50th percentile	9.8%	3.9%	5.9%
15th percentile	13.1%	5.0%	8.1%
inequality measure	difference	composition	structural
total wage inequality	-0.1%	1.7%	-1.9%
upper tail wage inequality	3.2%	2.8%	0.4%
lower tail wage inequality	-3.3%	-1.1%	-2.2%

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N= 306,455, N= 34,460 for non-polarised LLM and N= 271,995 for polarised LLM.

These wage gaps are directly reflected by the differences in wage inequality. Total wage inequality is identical in polarised and non-polarised LLM in 1980. This occurs since observed upper inequality is higher in polarised LLM (+3.2 %), but lower tail inequality is smaller (-3.3 %). The structural wage effect reduces wage inequality (-1.9 %), and levels off the effect of workforce composition, suggesting higher total wage inequality in polarised LLM (1.7 %). While the composition and the structural effects offset one another regarding total wage inequality, they add on one another regarding upper and lower inequality, when observed separately. In sum, structural wage inequality differentials are comparably low as compared to larger differentials in wages at the observed points of the wage distribution.

Table 5.2 illustrates the same differentials in 2010. Observed wage differentials ascent pronouncedly at the top, and moderately at the median, while they shrink at the bottom. The relative wage gap is now highest at the top of the wage distribution, and lowest at the bottom. Wages at the top diverge, converge at the bottom and are constant at the median – which has also been described in figure 5.7. Observed wage differentials are similarly equally split between the composition and wage structure effect at the top and median. The observed wage gap is mainly compositionally at the bottom. The composition effect is positive at the top and median, and negative at the bottom.

Differentials in wage inequality rise – both regarding upper and lower inequality. Total wage inequality, identical in 1980, now amounts to 13 %. Though these differentials seem fuelled by differentials in upper tail wage inequality (11 %) at first sight, it should be borne in mind that upper and lower inequality rise homogeneously by 7.6 and 5.9

Table 5.2: Regional Wage Gap in 2010 – by Degree of Job Polarisation: Quantile Decomposition – Reference Group: Polarised LLM

wage	difference	composition	structural
85th percentile	23.4%	12.8%	10.7%
50th percentile	12.6%	5.3%	7.4%
15th percentile	10.1%	1.0%	9.1%
inequality measure	difference	composition	structural
total wage inequality	13.3%	11.8%	1.5%
upper tail wage inequality	10.8%	7.5%	3.3%
lower tail wage inequality	2.5%	4.3%	-1.8%

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N= 32,681, N= 241,041 for non-polarised LLM and N= 273,722 for polarised LLM.

percentage points. Differences in the workforce composition gain weight in explaining these differences. The structural difference in total wage inequality is small. As in 1980, structural differentials in upper and lower inequality level off one another. Structural differences in lower inequality are considerably unchanged and still negative. Though structural upper inequality rises, this is due to noticeable relative growth in structural differentials of upper tail wages.

How to interpret these findings? It is necessary to analyse the growth in the relative wage and wage inequality gap over time, which table 5.3 displays. Higher wage growth at the top and median, and the fall of relative bottom wage gaps characterises polarised LLM. Shifts in the workforce composition explain the main part of the rise at the top and median, as well as the fall at the bottom. Still, the wage gap increases structurally at all points of the wage distribution, and notably at the top.

Table 5.3: Regional Growth Wage Gap in 2010: Quantile Decomposition – Reference Group: Polarised LLM

wage	difference	composition	structural
85th percentile	10.4 pp	6.0 pp	4.4 pp
50th percentile	2.8 pp	1.3 pp	1.5 pp
15th percentile	-3.0 pp	-4.0 pp	1.0 pp
inequality measure	difference	composition	structural
total wage inequality	13.5 pp	10.1 pp	3.4 pp
upper tail wage inequality	7.6 pp	4.7 pp	2.9 pp
lower tail wage inequality	5.9 pp	5.4 pp	0.5 pp

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N=580,177.

The relative rise in total wage inequality is equally split by a rise in upper and lower inequality. The workforce composition can account for the major part of the relative increase. The rise in structural inequality is small and limited to upper tail inequality. Structural wage growth at the top of the wage distribution explains this rise. Polarised LLM, characterised by comparably small inequality in 1980, and higher relative lower inequality in 2010 (see figure 5.7), shifted their workforce composition – structural shifts in lower inequality do almost not occur. At the same time, the shift in structural upper inequality accounts for the rising structural gap in upper tail wages.

The presented results show that job polarisation only barely reshapes the wage structure – the main shifts occur to upper tail wages and the upper tail wage inequality. By contrast, the relative wage gaps rise throughout the years, positively affecting wages in regions, where job polarisation occurs. The relative increase in wage inequality in polarised regions occurs mainly through composition effects, i.e. shifts in the workforce composition.

Are these results robust? Tables 5.6, 5.7, and 5.8 in the appendix illustrate the same approach, but distinguish between polarised and strongly polarised LLM. The main results remain unchanged. Magnitudes vary. Wages and wage growth are higher in strongly polarised regions. Strongly polarised labour markets, being structurally more equal in 1980, experience a larger rise in wage inequality than polarised labour markets. Again, composition effects mainly attribute to this shift. Differences in the workforce composition attribute to roughly 80 % of the rise in observed wage inequality. It remains a slightly larger rise in structural wage inequality. Notwithstanding, strongly polarised labour markets are structurally more equal than polarised labour markets. This holds both for upper and lower inequality.

5.4.5 The link between occupational and wage growth

Results from the decomposed wage structure hint at a small if existent link between job polarisation and wage inequality. The channels of wage growth, due to the interplay of supply and demand, or skill shifts within occupations, are further inconclusive. An alternative approach to assessing the link between occupational and wage shifts is to analyse their correlation. This approach directly follows Autor et al. (2008) for the U.S., and Dustmann et al. (2009) for the German labour market. They implement an OLS regression that assesses the relationship between shifts in employment shares and wage growth by wage percentile:

$$\Delta E_{p,t} = \alpha_t + \beta_t \Delta w_{p,t} + \epsilon_{p,t} \tag{5.8}$$

In this equation, $\Delta E_{p,t}$ denotes the percentage employment change, and $\Delta w_{p,t}$ denotes the percentage wage growth, at wage percentile p, and over time t. The change of the employment share thereby measures employment change. The change in relative mean wages at each percentile over time measure wage growth. For Germany, Dustmann et al. (2009) estimate a positive relationship solely above the median, but no correlation below the median.

I will carry out a similar analysis, though not only subdividing the data above and below the median, and decades, but also distinguishing between regions subject to different degrees of job polarisation. Negatively and weakly polarised LLM are pooled to increase the number of observations.

Table 5.4 illustrates regression results for four regions, periods, and segments of the wage distribution. Figure 5.10 in the appendix displays the corresponding scatter plots of the relationship. There is a positive and significant relationship for the full sample and above the median similar to Dustmann et al. (2009). A firm link above the median seems to spur this positive and significant relationship, while the relationship is zero below the median. Segmenting the estimation in decades, results for the total observation period appear to be fuelled by a strong link in the 1980s. The estimations for the remaining decades only yield insignificant coefficients. Explanatory power is overall low, besides estimations for the 1980s and estimations above the median.

The patterns of correlation change when studying each region separately: Besides a positive correlation above the mean in the 1980s, all coefficients are insignificant for weakly and negatively polarised LLM. Similarly, in polarised LLM, there is only a positive significant correlation for the 1980s, which a positive correlation above the median drives.

Interestingly, the pattern differs for strongly polarised labour markets. For the full sample period, there is a positive and significant correlation between employment and wage growth. There is a positive correlation for each decade individually, although this is mainly due to a strong correlation above the median. Only in the 2000s, there is a significant and positive correlation below the median. Further, the coefficient, though insignificant, below the median is always positive in strongly polarised LLM in each decade, while it is negative in the remaining LLM.

Overall, the link between occupational and wage growth is inconclusive: There are hints of rising wages with rising employment shares at the top, but not so at the bottom of the wage distribution. These results are further limited to the 1980s. These results are difficult to reconcile with a direct link between employment and wage growth. Strongly polarised LLM are peculiar: First, all coefficients are positive. Second, there are signif-

Table 5.4: OLS Regressions: Employment Change on Wage Growth

region	period	sample	Δ wage	R-squared
full sample	1980-2010	full	0.84*	0.03
		below median	−0.07	0.00
		above median	1.66**	0.10
	1980-1990	full	1.21***	0.10
		below median	−0.42	0.01
		above median	1.81***	0.24
	1990-2000	full	0.27	0.00
		below median	0.04	0.00
		above median	0.67	0.02
	2000-2010	full	0.14	0.00
		below median	0.07	0.00
		above median	0.2	0.00
weakly and negatively polarised	1980-2010	full	0.21	0.00
		below median	−0.64	0.02
		above median	0.84	0.02
	1980-1990	full	0.59	0.02
		below median	−0.42	0.01
		above median	1.22*	0.08
	1990-2000	full	−0.01	0.00
		below median	0.15	0.00
		above median	0.09	0.00
	2000-2010	full	−0.44	0.02
		below median	−0.72	0.04
		above median	−0.33	0.01
polarised	1980-2010	full	0.41	0.01
		below median	−0.55	0.02
		above median	1.34	0.06
	1980-1990	full	0.95**	0.06
		below median	−0.48	0.01
		above median	1.62***	0.20
	1990-2000	full	−0.15	0.00
		below median	−0.25	0.00
		above median	−0.14	0.00
	2000-2010	full	−0.02	0.00
		below median	−0.21	0.01
		above median	0.15	0.00
strongly polarised	1980-2010	full	1.4 ***	0.10
		below median	0.82*	0.06
		above median	1.95***	0.15
	1980-1990	full	1.47***	0.16
		below median	0.33	0.01
		above median	2.00***	0.26
	1990-2000	full	0.87*	0.04
		below median	0.45	0.02
		above median	1.51*	0.07
	2000-2010	full	0.54*	0.04
		below median	0.65*	0.07
		above median	0.41	0.02

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. (*|**|***) denote significance at the (10|5|1)% level of significance. N= 10,886,214.

icant coefficients outside the 1980s. Third, there are significant coefficients below the median, both in the 1980s and 2000s as well as for the total observation period.

From this perspective, a possible shortfall in the supply of skilled labour, if existent, seems limited to the 1980s. At the same time, eroding wages at the bottom due to displaced workers in medium-paying positions seem unlikely: The correlation between employment and wage growth below the median is insignificant, except for strongly polarised LLM, where the fall in employment shares is most pronounced. Only in strongly polarised LLM, the link is positive and significant. The results hint at within-occupation shifts in skills due to occupational upskilling. To account for initial skills and upskilling, I expand equation 5.8:

$$\Delta E_{p,t} = \alpha_t + \beta_t \Delta w_{p,t} + \gamma_t \Delta s_{p,t} + \delta_t educ_t + \epsilon_{p,t} \tag{5.9}$$

In this equation, $\Delta s_{p,t}$ denotes the skill change by percentile, measured by the change of mean years of education, and $educ_t$ denotes the initial mean years of education at the beginning of the period by percentile. This equation captures within-occupation shifts as well as the initial skills within occupations. Further, the link between occupational and wage growth can be estimated independently from the skills and skill shifts within occupations.

Table 5.5 displays regression results for the total sample and full period, various regions, above and below the median and each decade. Regression results are very distinct from table 5.4, where skills were not accounted for. First, explanatory power has increased markedly. Second, the coefficient for initial education is positive, and mostly strongly significant. Third, changes in skills within occupation play a major role in occupational growth. The correlation is positive and in most cases strongly significant – except for the 2000s. Fourth, the correlation between wage and occupational growth changes sign – it is negative for all regions, segments and decades. The significance is mainly limited to the 1990s and below the median. Accounting for skills entirely changes regression results – thereby strongly improving the explanatory power of the regression.

Regional subsample estimations are similar and resemble estimations for the full sample with minor exceptions. Estimating the link between occupational and wage shifts with and without the consideration of skills leads to contrasting results. The positive relationship between occupational and wage shifts in table 5.4 appears to spuriously explain differing skills and skill shifts. The coefficient becomes negative or insignificant after accounting for skills. At the same time, the explanatory power of the model rises

Table 5.5: OLS Regressions: Wage Change on Occupational Change

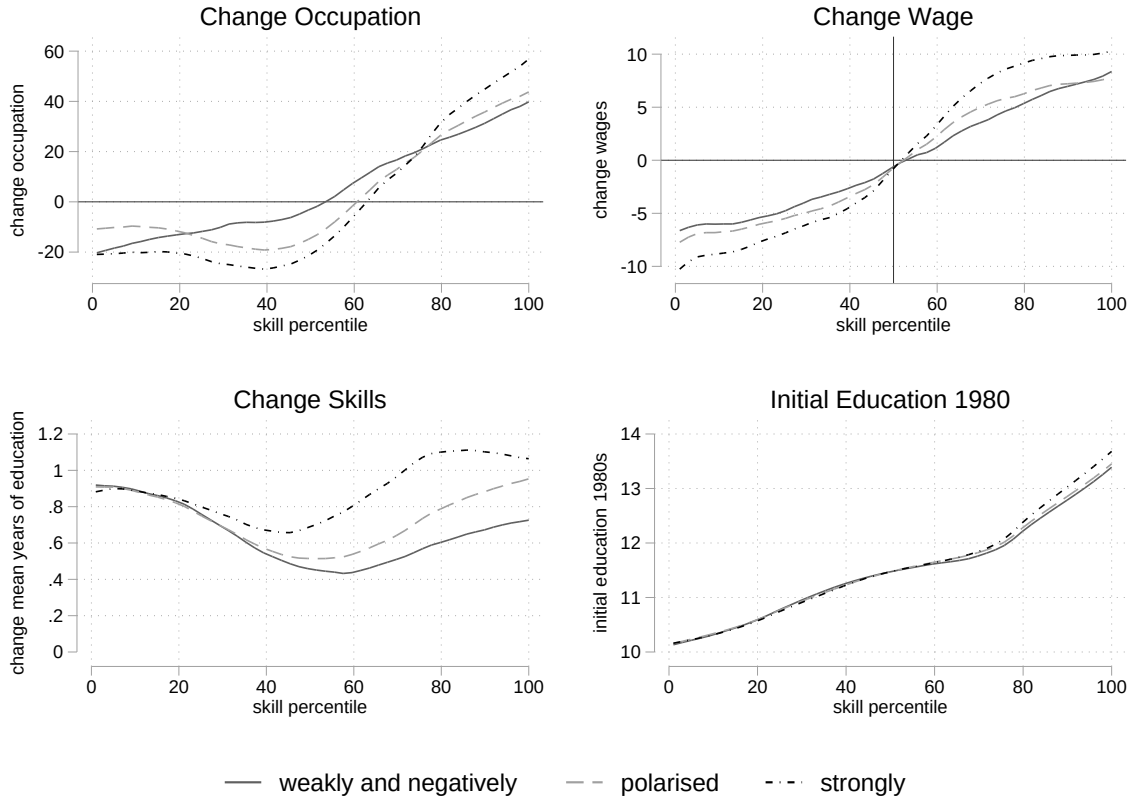
region	period	sample	Δ wage	Δ skills	initial educ	R-sq.
full sample	1980-2010	full	−1.64***	57.49***	30.16***	0.41
		below median	−2.13***	50.85***	47.41***	0.41
		above median	−2.21**	70.12***	35.5 ***	0.54
	1980-1990	full	−0.71	51.55***	7.57***	0.46
		below median	−0.92	41.49**	11.06***	0.35
		above median	−0.44	54.22***	7.44***	0.60
	1990-2000	full	−0.69*	31.5 ***	8.19***	0.34
		below median	−2.53***	46.96***	24.76***	0.54
		above median	−1.52**	44.86***	9.63***	0.57
	2000-2010	full	−0.82**	11.23	7.37***	0.28
		below median	−0.75	8.26	10.71***	0.19
		above median	−1.16**	6.96	8.67***	0.47
weakly and negatively polarised	1980-2010	full	−1.14**	41.89**	29.71***	0.30
		below median	−1.3	−24.41	22.6 *	0.21
		above median	−1.38	71.71***	31.53***	0.42
	1980-1990	full	−0.54	38.78***	8.1 ***	0.29
		below median	−0.62	19.95	10.31***	0.13
		above median	−0.53*	45.5 ***	8.1 ***	0.44
	1990-2000	full	−0.34	10.72	9.66***	0.32
		below median	−1.01*	12.05	20.06***	0.29
		above median	−0.42	19.93	8.88***	0.38
	2000-2010	full	−0.7 **	−16.65	5.96***	0.20
		below median	−0.8	−38.25**	7.37	0.19
		above median	−0.62	−7.79	5.96***	0.21
polarised	1980-2010	full	−1.68***	54.34***	28.41***	0.35
		below median	−2.27***	46.25*	45.62***	0.33
		above median	−2.05**	63.25***	32.6 ***	0.48
	1980-1990	full	−0.51	41.34***	6.31***	0.33
		below median	−0.78	46.43**	11.82***	0.31
		above median	−0.04	42.29***	5.75***	0.47
	1990-2000	full	−0.78	28.15**	7.4 ***	0.26
		below median	−2.88***	40.62*	26.6 ***	0.47
		above median	−1.82***	43.32***	8.75***	0.52
	2000-2010	full	−0.87***	7.25	7.78***	0.30
		below median	−0.65	−1.97	8.11**	0.12
		above median	−1.15**	4.52	9.33***	0.52
strongly polarised	1980-2010	full	−1.27**	51.35***	30.6 ***	0.46
		below median	−1.52***	46.93***	43.71***	0.51
		above median	−2.04**	65.01***	38.67***	0.57
	1980-1990	full	−0.51	50.04***	8.12***	0.56
		below median	−0.18	47.45***	8.21***	0.44
		above median	−0.66	50.27***	9.91***	0.66
	1990-2000	full	−0.36	26.1 ***	9 ***	0.38
		below median	−1.54*	28.56**	19.07***	0.48
		above median	−0.75	35.86***	11.17***	0.59
	2000-2010	full	−0.28	7.18	6.8 ***	0.25
		below median	−0.5	10.65	12.69***	0.35
		above median	−0.75	1.26	8.65***	0.40

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. (*|**|***) denote significance at the (10|5|1)% level of significance. N= 10,886,214.

firmly. The negative relationship rejects a scenario of demand-driven wage shifts due to job polarisation.

These results oppose a positive relationship between occupational and wage shifts. At the same time, they highlight that technological change raises skill requirements within occupations. Regional differentials vanish although they vary in their employment growth pattern. As described in section 5.3.3, these regions vary in the supply of high-skilled labour. In order to comprehend how job polarisation changes skill requirements, figure 5.8 plots these occupational shifts along the skill distribution, next to the remaining components of equation 5.9.

Figure 5.8: Occupational shifts, wage shifts, change of skills, and initial education by skill percentile – by Degree of Job Polarisation (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,886,214. Each line is smoothed using a local smoothing epanechnikov kernel function and a bandwith of 10.

Occupational changes are near-monotonic for negatively and weakly polarised LLM, and represent a j-function for polarised and strongly polarised LLM. Despite variances in occupational shifts, wages shifts are near-monotonic in each region with positive wage

growth above the median, negative wage growth below the median, and zero wage growth at the median. The steepness of the monotonic function increases with the degree of job polarisation. Although occupational shifts differ, the pattern of wage shifts is similar. The initial occupational skill distribution is equal between regions. Before emerging job polarisation in 1980, skills within occupations are equal.

Regions distinguish with respect to occupational skill shifts. In each region, skill shifts represent a u-form, with higher skill growth at the top and bottom than at the middle. Until the 20th percentile, each region is alike in skill growth. Beyond the 20th percentile, skill growth is higher the more a region is subject to job polarisation. There is a further increase in skills in occupations that already require a certain skill level. This forecloses a scenario of supply-driven wage shifts due to job polarisation. More specifically, it rules out a scenario, in which technological change replaces medium-skilled workers, which then work in jobs at the bottom of the skill distribution. If such a scenario would hold, skill shifts at the bottom tail were larger in polarised than in non-polarised LLM. Likewise, an oversupply of high-skilled workers seems unlikely. Although skill shifts are larger in polarised LLM, they are directly translated into larger wage growth.

By contrast, the results point at increasing skill requirements within occupations the more a region is subject to job polarisation. Arguably, one may assume that technological change in polarised regions led to upskilling and higher skill growth in top-paying positions. The upskilling then leads to wage growth. A possible shortfall in the supply of high-skilled labour seems implausible, since the relationship between wage and occupational growth is negative. Polarised and strongly polarised LLM attract high-skilled workers (see figure 5.5). Migration likely compensates the higher demand for high-skilled labour in polarised regions. At the same time, educational expansion seems to hold pace with increasing demand for high-skilled labour in Germany (see also Acemoğlu (2003); Beaudry and Green (2003); Katz and Autor (1999)).

5.5 Conclusion

This study contributes to the literature on the link between job polarisation and wage inequality. It contrasts the view that job polarisation attributes to rising wage inequality in the case of Germany, and thus conforms with Antonczyk et al. (2009); Beaudry and Green (2003); Dustmann et al. (2009); Freeman and Schettkat (2001). It further contributes to the literature that suggests distinct wage formation between Anglo-Saxon and Continental European countries, e.g. Acemoğlu and Autor (2011); Blau and Kahn

(1996, 2002). It adds to the view that technological change and employment polarisation affect the wage structure differently in Germany than in the U.S. (Beaudry and Green, 2003; Lee et al., 2013). Lastly, it confirms a balanced growth path between the increasing demand for higher education and educational expansion in Germany (Abraham and Houseman, 1995; Acemoğlu, 2003; Beaudry and Green, 2003; Katz and Autor, 1999).

Technological change and job polarisation leads to increasing employment shares of top-paying positions and high-skilled workers in Germany. This mechanically drives up wage inequality, but only scarcely moves the wage structure itself. Structural wage shifts in polarised regions relative to non-polarised regions are small and limited to wages at the top of the wage distribution. Regions, in which job polarisation occurs, do not differ in structural wage inequality from regions, in which job polarisation did not occur.

Moreover, employment shifts are not correlated to wage growth once accounting for skills. Employment growth is strongly positively correlated to initial skill levels and skill growth within jobs, but is not positively correlated to wage growth. Polarising regions face larger skill shifts within occupations, while they also attract a larger share of high-skilled workers. Due to a concurrent increase in both demand and supply there is no effect upon wages.

Job polarisation thus is an unlikely driver of rising wage inequality in Germany. Lower tail wage inequality, abruptly rising in the 1990s, can most likely be accounted for changes other than related to job polarisation, such as shifts in the institutional framework (Dustmann et al., 2009). The constant rise in upper inequality can mainly be attributed to rising wages at the top, which is directly associated with skill shifts. Technological change appears to generally raise skill requirements within occupations in Germany. The growth path of supply and demand of skilled workers is constant and seems balanced, creating neither a shortage nor an oversupply (Abraham and Houseman, 1995; Acemoğlu, 2003; Beaudry and Green, 2003).

Bibliography

Åberg, R. (2003). Unemployment Persistency, Over-education and the Employment Chances of the Less Educated. *European Sociological Review*, 19(2):199–216.

Abraham, K. G. and Houseman, S. (1995). Earnings inequality in Germany. In *Differences and changes in wage structures*, pages 371–404. University of Chicago Press.

Accetturo, A., Dalmazzo, A., and de Blasio, G. (2014). Skill Polarization in Local Labour Markets under Share-Altering Technical Change. *Journal of Regional Science*, 54(2):249–272.

Acemoğlu, D. (2002). Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, 40(1):7–72.

Acemoğlu, D. (2003). Cross-Country Inequality Trends. *The Economic Journal*, 113(485):F121–F149.

Acemoğlu, D. and Autor, D. (2011). *Skills, Tasks and Technologies: Implications for Employment and Earnings*, volume 4 of *Handbook of Labor Economics*, chapter 12, pages 1043–1171. Elsevier, Amsterdam.

Antonczyk, D., Fitzenberger, B., and Leuschner, U. (2009). Can a Task-Based Approach Explain the Recent Changes in the German Wage Structure? *Jahrbücher für Nationalökonomie und Statistik*, pages 214–238.

Autor, D. H. and Dorn, D. (2013). The Growth of Low-Skill Service Jobs and the Polarization of the US Labor Market. *American Economic Review*, 103(5):1553–97.

Autor, D. H., Katz, L. F., and Kearney, M. S. (2008). Trends in U.S. Wage Inequality: Revising the Revisionists. *The Review of Economics and Statistics*, 90(2):300–323.

Autor, D. H., Levy, F., and Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *The Quarterly Journal of Economics*, 118(4):1279–1333.

Beaudry, P., Doms, M., and Lewis, E. (2010). Should the Personal Computer Be Considered a Technological Revolution? Evidence from U.S. Metropolitan Areas. *Journal of Political Economy*, 118(5):988 – 1036.

Beaudry, P. and Green, D. A. (2003). Wages and Employment in the United States and Germany: What Explains the Differences? *American Economic Review*, 93(3):573–602.

Beaudry, P., Green, D. A., and Sand, B. (2012). Does Industrial Composition Matter for Wages? A Test of Search and Bargaining Theory. *Econometrica*, 80(3):1063–1104.

Beaudry, P., Green, D. A., and Sand, B. M. (2014). The Declining Fortunes of the Young since 2000. *American Economic Review*, 104(5):381–86.

Blau, F. D. and Kahn, L. M. (1996). International Differences in Male Wage Inequality: Institutions versus Market Forces. *Journal of Political Economy*, 104(4):791–836.

Blau, F. D. and Kahn, L. M. (2002). *At Home and Abroad: U.S. Labor Market. Performance in International Perspective*. Russell Sage Foundation, New York.

Card, D., Heining, J., and Kline, P. (2013). Workplace Heterogeneity and the Rise of West German Wage Inequality. *The Quarterly Journal of Economics*, 128(3):967–1015.

Consoli, D., Vona, F., and Saarivirta, T. (2013). Analysis of the Graduate Labour Market in Finland: Spatial Agglomeration and Skill–Job Match. *Regional Studies*, 47(10):1634–1652.

Crescenzi, R., Rodríguez-Pose, A., and Storper, M. (2007). The territorial dynamics of innovation: a Europe–United States comparative analysis. *Journal of Economic Geography*, pages 673–709.

Dauth, W. (2014). Job Polarization on Local Labor Markets. Technical Report 18, Institute for Employment Research.

DiNardo, J., Fortin, N. M., and Lemieux, T. (1996). Labor Market Institutions and the Distribution of Wages, 1973-1992: A Semiparametric Approach. *Econometrica*, 64(5):1001–44.

Dustmann, C., Fitzenberger, B., Schönberg, U., and Spitz-Oener, A. (2014). From Sick Man of Europe to Economic Superstar: Germany's Resurgent Economy. *Journal of Economic Perspectives*, 28(1):167–88.

Dustmann, C., Ludsteck, J., and Schönberg, U. (2009). Revisiting the German Wage Structure. *The Quarterly Journal of Economics*, 124(2):843–881.

Firpo, S., Fortin, N. M., and Lemieux, T. (2009). Unconditional Quantile Regressions. *Econometrica*, 77(3):953–973.

Florida, R. and Mellander, C. (2016). The Geography of Inequality: Difference and Determinants of Wage and Income Inequality across US Metros. *Regional Studies*, 50(1):79–92.

Freeman, R. and Schettkat, R. (2001). Skill Compression, Wage Differentials, and Employment: Germany vs the US. *Oxford Economic Papers*, 53(3):582–603.

Gaskell, G., Ten Eyck, T., Jackson, J., and Veltri, G. (2005). Imagining nanotechnology: cultural support for technological innovation in Europe and the United States. *Public Understanding of Science*, 14(1):81–90.

Goldin, C. D. and Katz, L. F. (2009). *The Race between Education and Technology*. Harvard University Press.

Goos, M. and Manning, A. (2007). Lousy and Lovely Jobs: The Rising Polarization of Work in Britain. *The Review of Economics and Statistics*, 89(1):118–133.

Goos, M., Manning, A., and Salomons, A. (2009). Job Polarization in Europe. *American Economic Review*, 99(2):58–63.

Goos, M., Manning, A., and Salomons, A. (2014). Explaining Job Polarization: Routine-Biased Technological Change and Offshoring. *American Economic Review*, 104(8):2509–26.

Green, D. A. and Sand, B. M. (2015). Has the Canadian labour market polarized? *Canadian Journal of Economics*, 48(2):612–646.

Katz, L. F. and Autor, D. H. (1999). Changes in the Wage Structure and Earnings Inequality. In Ashenfelter, O. and Card, D., editors, *Handbook of Labor Economics*, volume III of *Handbook of Labor Economics*, chapter 26, pages 1463–1555. Amsterdam: Elsevier.

Katz, L. F. and Murphy, K. M. (1992). Changes in Relative Wages, 1963-1987: Supply and Demand Factors. *The Quarterly Journal of Economics*, 107(1):35–78.

Kohn, K. (2006). Rising wage dispersion, after all! The German wage structure at the turn of the century. ZEW Discussion Papers 2098, Centre for European Economic Research.

Kropp, P. and Schwengler, B. (2011). Abgrenzung von Arbeitsmarktregionen–ein Methodenvorschlag. *Raumforschung und Raumordnung*, 69(1):45–62.

Lee, N. and Rodríguez-Pose, A. (2013). Innovation and spatial inequality in Europe and USA. *Journal of Economic Geography*, 13(1):1–22.

Lee, N., Sissons, P., and Jones, K. (2013). Wage inequality and employment polarisation in British cities. *London: The Work Foundation*.

Leonardi, M. (2015). The Effect of Product Demand on Inequality: Evidence from the United States and the United Kingdom. *American Economic Journal: Applied Economics*, 7(3):221–47.

Marinelli, E. (2013). Sub-national Graduate Mobility and Knowledge Flows: An Exploratory Analysis of Onward and Return-Migrants in Italy. *Regional Studies*, 47(10):1618–1633.

Michaels, G., Natraj, A., and Reenen, J. V. (2014). Has ICT Polarized Skill Demand? Evidence from Eleven Countries over Twenty-Five Years. *The Review of Economics and Statistics*, 96(1):60–77.

Moretti, E. (2010). Local Multipliers. *American Economic Review*, 100(2):373–777.

Moulton, B. R. (1996). Bias in the Consumer Price Index: What Is the Evidence? *The Journal of Economic Perspectives*, 10(4):159–177.

Oaxaca, R. (1973). Male-Female Wage Differentials in Urban Labor Markets. *International Economic Review*, 14(3):693–709.

OECD (2014). OECD Factbook 2014. *Economic, Environmental and Social Statistics*.

OECD (2015). Benefit Generosity – During the initial phase of unemployment, 2001-2013. Web: `http://www.oecd.org/els/soc/NRR_Initial_EN.xlsx`. Retrieved 04 March 2016.

Prasad, E. S. (2004). The Unbearable Stability of the German Wage Structure: Evidence and Interpretation. *IMF Staff Papers*, 51(2):354–385.

Spitz-Oener, A. (2006). Technical Change, Job Tasks, and Rising Educational Demands: Looking outside the Wage Structure. *Journal of Labor Economics*, 24(2):235–270.

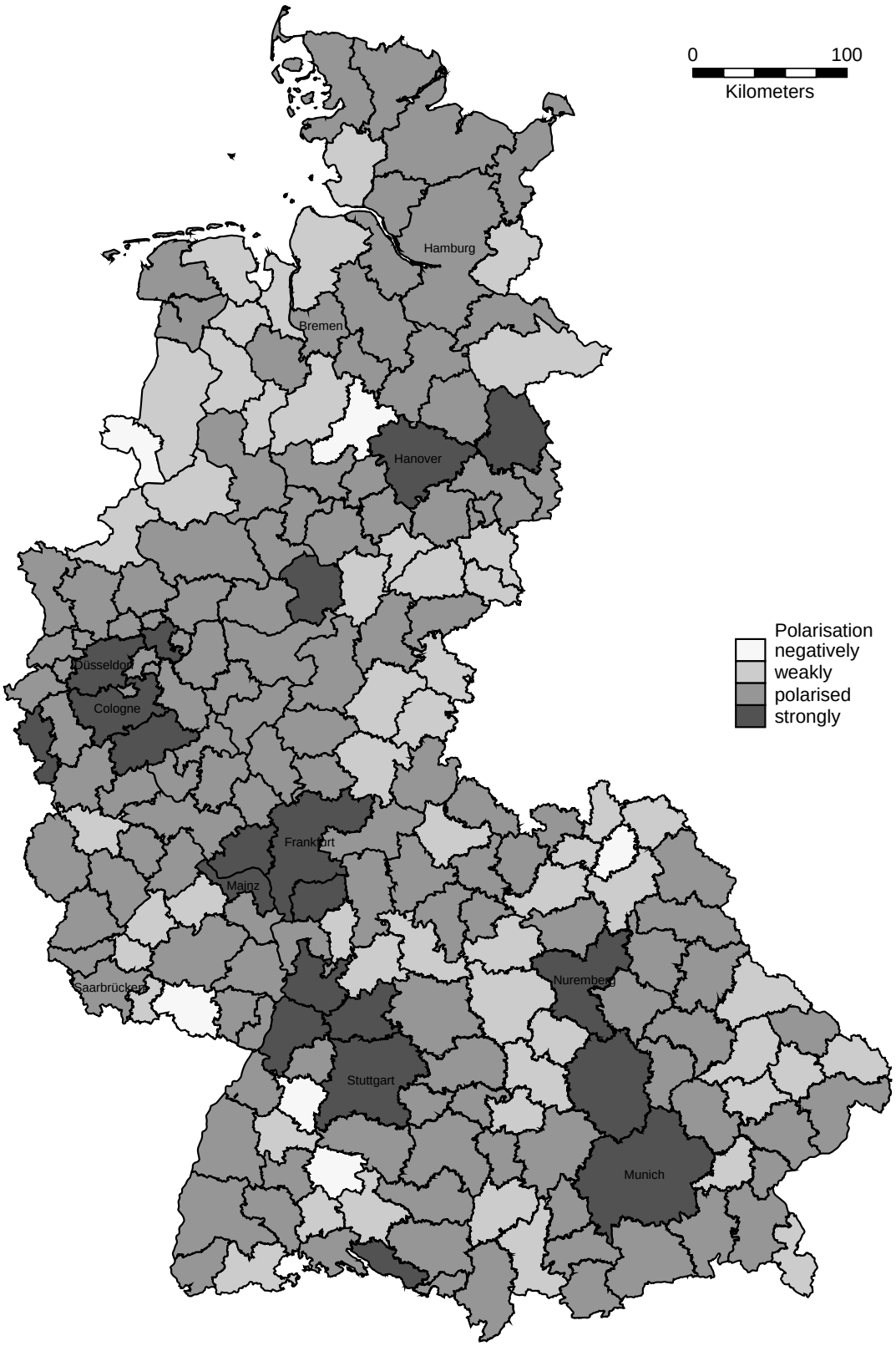
Statistisches Bundesamt (2016). Preise – Verbraucherpreisindicese für Deutschland – Lange Reihe ab 1948. Web: `https://www.destatis.de/DE/Publikationen/Thematisch/Preise/Verbraucherpreise/VerbraucherpreisindexLangeReihen.html`. Retrieved 24 September 2016.

Tinbergen, J. (1975). *Income Distribution: Analysis and Policies*. North-Holland Pub. Co., Amsterdam.

vom Berge, P., König, M., Seth, S., et al. (2013). Sample of Integrated Labour Market Biographies (SIAB) 1975-2010. Technical Report 01/2013, FDZ data report.

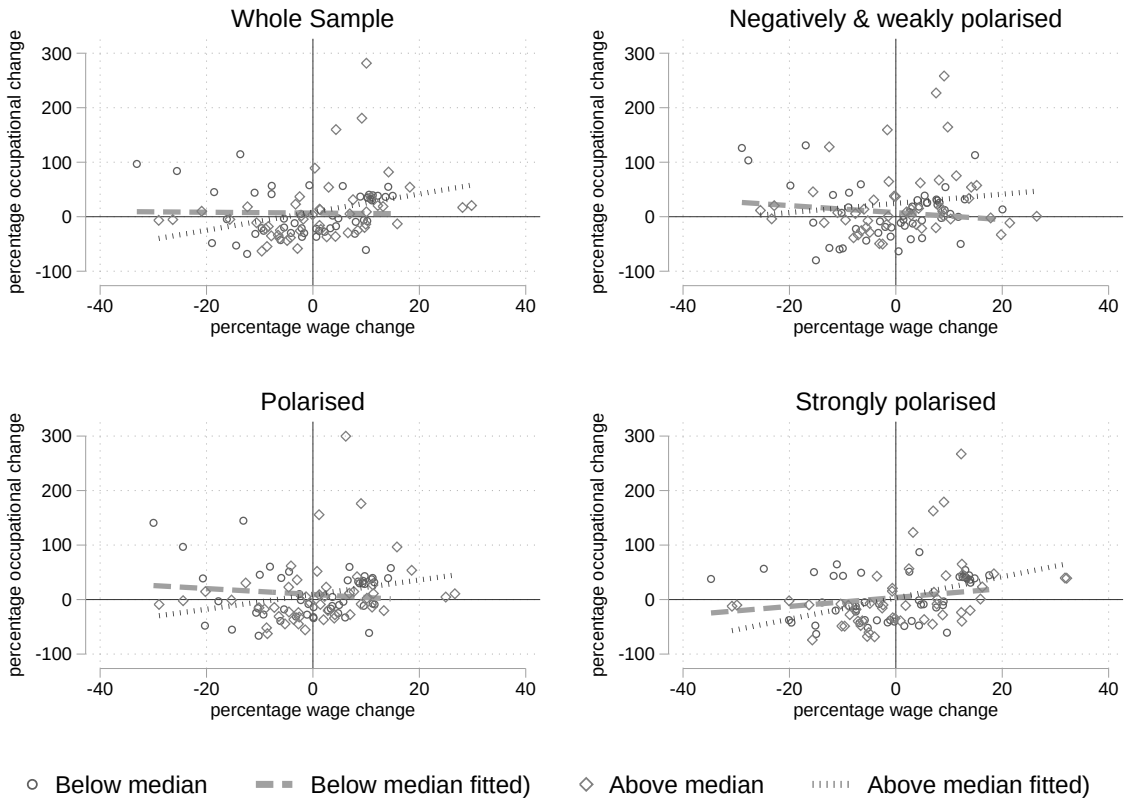
Appendix to Chapter 5

Figure 5.9: Map of Job Polarisation in Germany



Source: Own illustration based upon Dauth (2014).

Figure 5.10: Link between Wage and Occupational change (1980-2010)



Source: 2% IABS Sample for full-time workers between the age of 20 and 60 years of age in Germany. N=10,886,214.

Table 5.6: Wage Gap in 1980: Quantile Decomposition – Reference Group: Strongly Polarised LLM

wage	difference	composition	structural
85th percentile	7.3%	4.7%	2.6%
50th percentile	6.1%	2.0%	4.0%
15th percentile	7.9%	1.8%	6.1%
inequality measure	difference	composition	structural
total wage inequality	-0.7%	2.9%	-3.5%
upper tail wage inequality	1.2%	2.7%	-1.5%
lower tail wage inequality	-1.9%	0.2%	-2.0%

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N= 271,982, N= 171,815 for polarised LLM and N= 100,167 for strongly polarised LLM.

Table 5.7: Regional Wage Gap in 2010 – by Degree of Job Polarisation: Quantile Decomposition – Reference Group: Strongly Polarised LLM

wage	difference	composition	structural
85th percentile	19.1%	12.3%	6.7%
50th percentile	13.4%	5.7%	7.7%
15th percentile	10.5%	2.1%	8.5%
inequality measure	difference	composition	structural
total wage inequality	8.5%	10.3%	-1.7%
upper tail wage inequality	5.6%	6.6%	-0.9%
lower tail wage inequality	2.9%	3.7%	-0.8%

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N= 241,031, N= 149,302 for polarised LLM and N= 91,729 for strongly polarised LLM.

Table 5.8: Regional Growth Wage Gap in 2010: Quantile Decomposition – Reference Group: Strongly Polarised LLM

wage	difference	composition	structural
85th percentile	11.8 pp	7.6 pp	4.1 pp
50th percentile	7.3 pp	3.7 pp	3.6 pp
15th percentile	2.6 pp	0.2 pp	2.4 pp
inequality measure	difference	composition	structural
upper tail wage inequality	9.2 pp	7.4 pp	1.8 pp
lower tail wage inequality	4.5 pp	3.9 pp	0.5 pp
upper tail wage inequality	4.7 pp	3.5 pp	1.2 pp

Source: 2% IABS Sample for full-time workers between 20 and 60 years of age. N= 513,013.

6

Concluding Remarks

The dissertation at hand sheds light upon various aspects of demography and labour market outcomes in Germany, and how they are linked to one another. Demographic aspects are crucial, and should be accounted for, when analysing labour market outcomes, such as shifts in the wage and occupational structure. The dissertation shows that demographic shifts are directly linked to wage shifts (chapter 3), changes in the cohort size alters supply of labour and may affect wages and occupational patterns (chapter 4), and linkages between occupational and wage shifts vanish once accounting for shifts that occur within the labour force (chapter 5). These results are enriched by an innovative method of small-scale population projection (chapter 2).

Each chapter contributes to the state of knowledge: Chapter 2 extends a proposed method of averaging various population projection methods. It illustrates how averaging over various projection techniques, base periods, and age groups further increases projection accuracy. In particular, it shows how averaging mitigates the projection error, when yearly fluctuations in migration are high – a situation where common population techniques are subject to relatively high inaccuracy. Chapter 3 demonstrates how demographic shifts barely affect wage inequality, although it does affect wages. It implicitly shows how wage inequality measurements are an appropriate means to draw conclusion upon lifetime wage inequality. Chapter 4 challenges the view that a declining demand for higher skills attributes to falling wages for young labour market entrants. In a situation, where the demand for high-skilled labour market entrants shrinks, wages and wage premia for higher education are stable seem when the absolute number of high-skilled labour market entrants falls. Chapter 5 controverts the view that employment polarisation is linked to a reshaping wage structure. It emphasises the changing skill formation and the educational expansion within occupations due to technological change. Once accounting for skill shifts within, employment polarisation and rising wage inequality are not related to one another.

The empirical results presented in this thesis reflect outcomes limited to Germany. Thus, they reflect peculiarities of the German labour market and of German demographic change. Still, many of the empirical applications in this thesis extend existing models

that were discussed in the economic literature. These applications illustrate the necessity of a sophisticated view on the demographic composition and the transition of the workforce when analysing labour market outcomes. In order to draw more general conclusions, international labour market outcomes in the light of demographic transitions need assessment in further labour markets than the German.