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THE INFLUENCE OF THE USE OF THE MORE PREVALENT TECHNOLOGY ON THE WAGES OF OLDER EMPLOYEES IN GERMANY†

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Abstract

The labor market of tomorrow will be determined by the transition from an industrial to a knowledge society. In this process, the accumulation of human capital becomes increasingly important whilst opportunities for low qualified staff steadily diminish. Globalization and technological advancement results in enhanced economic participation of highly qualified staff in the form of higher wages and better employment opportunities. In the literature, this is attributed to the "Skill-Biased Technological Change" (SBTC) (Nikutowski, 2007). According to the "task approach" (Autor *et al.* 2003), the technological change due to falling computer prices (computerization) leads to changes in task structures which favor a trend towards routinization ("routinization hypothesis").Alongside these developments Germany faces the challenge of demographic change, which is reflected primarily in the shrinking and ageing of the population (Siegrist *et al.* 2005). Consequently, Germany anticipates a distinct decline in the number of economically active persons in the next few decades (Federal Statistical Office, 2009). With the objective of securing adequate labor force potential the pension age was raised to 67 years, although statistics confirm that the average retirement age in Germany is a long way off the present age limit of 65 years (German Statutory Pension Insurance, 2012; Stößel, 2008). From this starting point, the question derived concerns the influence of technological change on occupational success, as measured by the gross wages of older working persons. The study examines whether the increasing use of computers in workplaces is leading to a shift towards non-routine tasks among older workers to the same extent as younger workers in accordance with the routinization hypothesis. Moreover, it is analyzed if among older workers it is also primarily the highly qualified persons who benefit from this trend in the form of higher gross wages. The analyses are based on data from the BIBB/IAB and BIBB/BAuA Employment Survey from the years 1979 to 2012, which enable the precise measurement of task profiles over time (Tiemann and Zopf, 2010). The work tasks carried out by older employees (aged 50-65) are investigated on the basis of the "task approach" model (Autor *et al.* 2003).

Keywords: Technological Change, Older Workers, Tasks, Wages

1. Introduction

The world of work is undergoing extensive change. Globalization, economization, technical developments and structural alterations are all exerting an effect as we move towards a service and knowledge society characterized by a high degree of complexity and dynamism. These developments have been accompanied by an increasing wage differential which has been

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observed in western industrialized countries since the 1980's (Danziger and Gottschalk, 1994; Katz and Murphy, 1992; Levy and Murnane, 1992; Machin and Van Reenen, 2008). This rise in income disparity especially applies to the United States (Weins, 2005). Although developments in continental Europe and in Germany in particular initially appeared to display a relative level of stability (Prasad, 2004), increasing wage inequality has been identified since the 1990's (Bergmann, 2004; Dustmann *et al.* 2007; Fitzenberger, 1999; Fitzenberger *et al.* 2001; Gernandt and Pfeiffer, 2006; Kohn, 2006; Möller, 2005; Schäfer, 2007). Up until the beginning of the 1990's, the increasing wage differential was restricted to the upper wage distribution segment and has continued within the upper and lower segment since (Dustmann *et al.* 2009; Fitzenberger, 2012; Gernandt and Pfeiffer, 2006; Kohn, 2006). The interpretation of the increase in the wage differential is significant compared with other western industrialized countries (Card *et al.* 2012), and the increase is associated with wages which are falling in real terms (Antonczyk *et al.* 2012). Various approaches towards the explanation of this development have been adopted in literature. In terms of explanation approaches, the present paper will consider only the theory of skill-biased technological change (STBC) (Katz and Autor, 1999) and the theory of the task-based approach (a further development of the SBTC approach) (Acemoglu and Autor, 2011; Spitz Oener, 2006).

The group of older persons in active employment represents a relevant problem group within the context of the changing world of work. Because of the demographic trend, a distinct decline in the number of economically active persons is anticipated in the next few decades. Therefore, for economies to address the needs of a larger number of older people, they must promote full and productive employment of the working age population. In Germany, the probability of being in employment declines with rising age. With the objective of securing adequate labor force potential the pension age was raised to 67 years, although statistics confirm that the average retirement age in Germany is a long way off the present age limit of 65 years (employment rates among 60 - 65 years- olds are slightly above 40%) (Suga, 2012). Continuous adaptation of skills and lifelong learning is required in order to be able to retain the employability of older workers up to retirement age (Schmidt, 2009). Numerous studies provide evidence that older employees find it more difficult to apply new technologies in the workplace. Goldin and Margo (1992) show that it is highly likely that jobs performed by older persons will be replaced by new technologies. This could exert a considerable influence on both their job opportunities and on their career success (e.g. measured in terms of wage).

The present paper examines the technology explanation for the wage shift by investigating the relationship between computers, tasks, qualification and wages of older employees compared to younger age groups. Taking the tasks approach (Autor *et al.* 1998) as a starting point, an initial analysis will be undertaken of how the task profiles of older persons in active employment have moved towards an increasing exercise of non-routine activities during the course of technological change. The second stage will involve a consideration of skills development in older and younger employees over the course of time. A multivariate analysis will be conducted to investigate whether the increasing technologization as well as the trend towards higher qualification levels impacts the resulting gross income among older workers in the same way as it does for younger workers.

2. Facts of Wage Development in Germany

The following remarks will address the latest status of research regarding the development of wage inequality in Germany.

According to the employment statistics of the Federal Employment Agency (Bundesagentur für Arbeit, 2013 a) gross income of the 35-to-49-year-olds as well as of the 50-to-64-year-olds have risen drastically in the last few years.[1] While, in 1999, the median of the gross salary of the 35-to-45-year-olds amounted to 2455 Euros and that of the 50-to-64-year-olds to 2590 Euros, the numbers increased to 2916 Euros for the 35-to-49-year-olds and 2919 Euros for the 50-to-64-year-olds in 2010. However, while the 50-to-64-year-olds were gaining more on average compared to the 35-to-49-year-olds, the gross income of the two groups aligned over time (c.f. Figure 1).

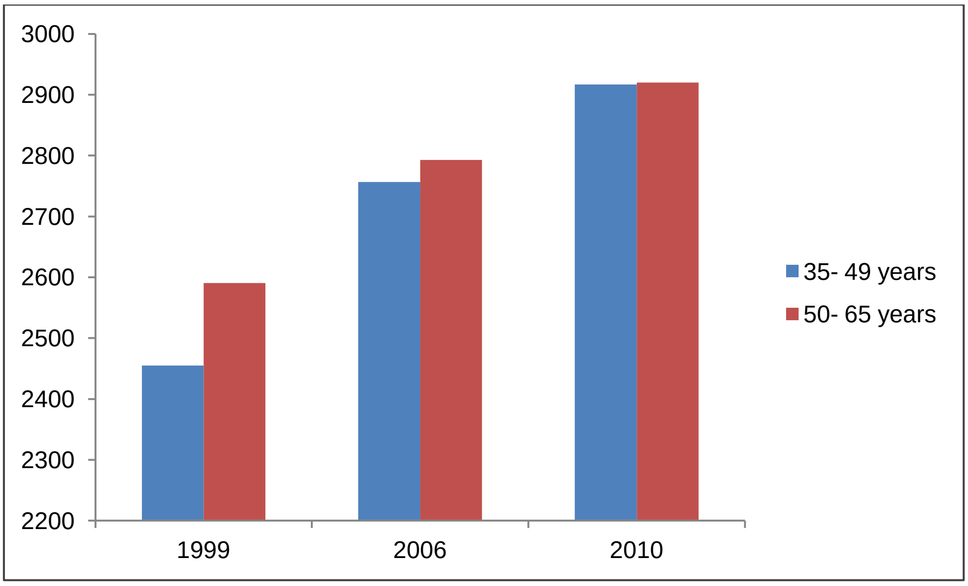

Figure 1. Development of the monthly gross income of younger and older workers over time

Source: Federal Employment Agency (2013), Employment statistic, own graph

On top of that, a growing wage differential can be observed since the 1990's (Figure 2).

[1] The employment statistics is missing data for the years 1979, 1986, as well as 2012. It contains information about monthly gross salary of employees subject to social security contribution in Germany. Employees who are subject to social security contribution are all employees who are obligated to hold health, old age and long-term care insurance or have to contribute to these insurances according to the Employment Promotion Act. This also includes in particular apprentices, workers in part-time positions for older employees, interns, student trainees, and people who have been drafted for obligatory military service or community service from an employment that is subject to social security contributions. The same holds for military personnel who are contracted for just up to two years. Not included, however, are self-employed, unpaid family workers, military professionals and military personnel contracted for more than two years, drafted men without former employment, and officials. For more information please see: Bundesagentur für Arbeit, 2013 (b).

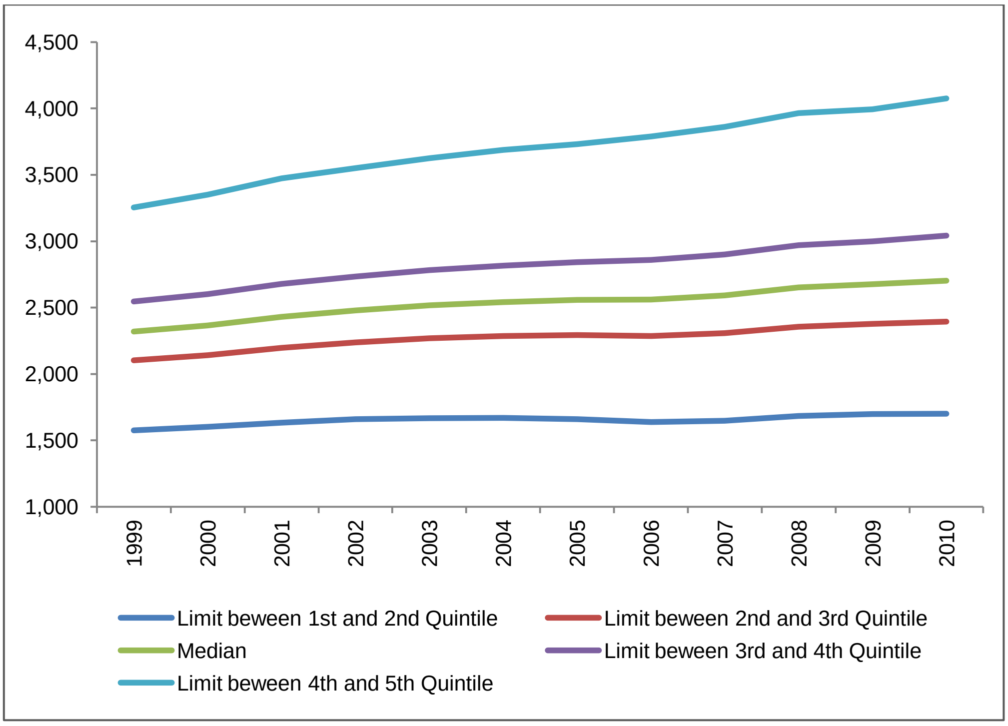

Figure 2. Development of the monthly gross income in Germany
Source: Federal Employment Agency (2013), Employment statistic, own graph

Gernandt and Pfeiffer (2006) arrive at the result that the increase in wage inequality between 1994 and 2005 in West Germany was concentrated on the lower segment of wage distribution. In East Germany, this was more likely to take place within the upper distribution segment. In his analyses, Fitzenberger (1999) shows that wage inequality in West Germany has increased in the upper segment of wage distribution. Kohn (2006) demonstrates a rise in wage inequality for those in full-time active employment in West and East Germany in the upper and lower segment of distribution. Antonczyk, DeLeire and Fitzenberger (2012) undertake a comparison of wage developments in West Germany and the USA. Their investigations show that a continuous increase in wage inequality in the lower segment of distribution has been recorded since the 1990's. This trend has been accelerating since the end of the 1990's. The increasing wage inequality has been affecting all skills groups since the beginning of the 1990's, whereby the more highly qualified in particular are benefiting from higher wages. No wage gains in real terms are ensuing for employees with low or medium levels of qualification, who are experiencing losses in some cases. The study conducted by Dustmann, Ludsteck and Schönberg (2009) also provides evidence for the identification of increasing wage inequality in Germany. Riphahn and Schnitzlein's (2011) results are in line with those of Antonczyk, DeLeire and Fitzenberger (2012) and Dustmann, Ludsteck and Schönberg (2009) and identify an increasing wage differential in the upper and lower segment of wage distribution in East and West Germany. Card, Heining and Kline (2012) find an accelerating trend towards a higher wage inequality in the upper and lower section of wage distribution and show that a large part of this shift involves employees with a given level of training and occupational experience. Antonczyk, Fitzenberger and Sommerfeld (2010) are also able to demonstrate an increase in wage inequality, although this occurs in the lower segment of distribution. The work carried out by Antonczyk, Fitzenberger and Leuschner (2009) shows that wage inequality has increased over the course of the last few decades and is somewhat more pronounced in the lower segment of wage distribution than in the upper. In overall terms, the results of the relevant literature suggest that a marked wage shift has been occurring in Germany since the 1990's and that the increase is taking place in the upper and lower segment of wage distribution. This development is concomitant with wage losses in real terms in the medium and lower segment of distribution, and there is an increase in skills-related wage differentials between the highly and low qualified. Most studies assume that wage inequality in the 1980's exclusively took place within the lower segment of wage distribution.

3. Theoretical Framework

In most theoretical explanatory approaches, technological change is viewed as a main reason for the increasing wage differential (Bound and Johnson, 1992; Juhn *et al.* 1992; Katz and Murphy, 1992). Card *et al.* (1996) show that the rise in wages in the 1980's is connected to the increasing deployment of computers. Mincer's (1991) analyses demonstrate that the relative wages of college and high school graduates increase in line with R&D intensity at an aggregate level. Krueger (1993) comes to the conclusion that the use of computers in the workplace leads to a relative increase in wages. Autor *et al.* (1998) also state increasing computerization as the reason for 30-50% of the rising demand for highly qualified workers since 1970. Notwithstanding this, some studies using company data from the manufacturing sector come to the conclusion that the increase use of computers cannot explain the increasing wage differential (Chennells and Van Reenen, 1997; Doms *et al.* 1997; Entorf and Kramarz, 1997). Various approaches towards the explanation of wage inequality are detailed in the relevant literature. The aim of the present paper is to highlight skill-biased technological change and the task-based approach due to the fact that these explicitly incorporate the influence of technological change.

3.1. The Thesis of "Skill-Biased Technological Change" – Skills Distortion in Work Demand

Changes in skills requirements, workplace tasks, the use of technologies and their impact on wages are intensively debated in the literature on the labor market (Antonczyk *et al.* 2009; Autor *et al.* 2006; Autor *et al.* 2003; Card and DiNardo, 2002; Dustmann *et al.* 2009; Goos and Manning, 2007; Green, 2007; Machin and Van Reenen, 2008). One widespread explanatory approach for increasing wage inequality is "skill-biased technological change" (SBTC) (Acemoglu, 2002; Katz and Murphy, 1992; Manchin and Van Reenen, 2008). According to this approach, the main reason for increasing wage disparities is the development of technological change. The argument is that the increasing dissemination of new technologies (such as computers) in the workplace leads to an increased demand for more highly qualified workers (a summary of the SBTC debate is provided by Acemoglu (2002), Katz and Autor (1999). This increase in demand causes a widening of the wage differences between highly qualified and low qualified workers (Petit and Soete, 2001; Spenner, 1979). It is further argued that more highly qualified workers are able to adapt to the increasing dissemination of new technologies in the workplace more readily than low qualified staff and thus also find it easier to assert themselves on the labor market (Autor *et al.* 1997; Berman *et al.* 1994). This trend towards a higher level of qualification can be observed in all sectors over the course of time (Musyken and Ter Weel, 2000). The increased inequality of income is thus understood as a shift of human capital requirements and of the adjustment of supply and demand. Some studies that apply this approach to Germany are able to demonstrate that a case of skills-distorted technical progress which implies an increased demand for more highly qualified workers may be capable of explaining the increasing wage inequality in the upper wage distribution segment (Dustmann *et al.* 2009; Fitzenberger, 1999; Antonczyk *et al.* 2012). Both Dustmann *et al.* (2009) and Antonczyk, DeLeire and Fitzenberger (2012) undertake comparative analyses between wage developments in Germany and the USA. The result that wage distributions in both countries differ widely leads them to come to the conclusion that the trend towards higher qualification and the parallel skills distortion of work demand cannot be the sole cause of this development. Institutional approaches are often used in order to explain the lower segment of the distribution (Giesecke and Verwiebe, 2009; Groß, 2009). Although empirical studies carried out by Kaiser (2000) and Falk and Koebel (2001; 2004) show that technological change in West Germany is skill-biased, German wage differences prove to be relatively slight in international comparative terms (Abraham and Houseman, 1995; Prasad, 2004). Spitz Oener (2006) shows that wages of employees at a medium qualification level decreased compared to employees with a high and low level of education. The relative wage position of highly qualified workers in the lower section of the wage distribution has also decreased slightly over the course of time (Spitz Oener, 2006). The main difference between West Germany and other countries is to be found in the wage situation of low qualified workers. Whereas the wages of this group of persons have decreased in other countries, they have slightly risen in Germany. Wage distribution within this employment group has also remained stable over time. Since, however, the unemployment rate amongst low qualified workers has risen sharply since 1980, the assumption may be made that Germany is experiencing the same set of inequality problems as the USA (Freeman, 1995; Krugman, 1994) (two sides of the same coin hypothesis). A number of dissenting voices speak out against the comparability of the German and American situations (Card *et al.* 1999; Krueger and Pischke, 1998; Nickell and Bell, 1996). The absence of a shift in the wages of low qualified workers in Germany is often explained by the presence of union wages. Other approaches assume that the explanation for the different wage developments in Germany and the USA is the presence of 'social norms' (Krueger and Pischke, 1998; Piketty and Saez, 2003; Saez and Vaell, 2005).

3.2. The Task Based Approach – Routinization Hypothesis and Polarization

During the 1990's, the main argument put forward in literature relating to the STBC approach was that wage dispersion could consist exclusively of non-observed knowledge and skills. The theory was that such knowledge and skills were in greater demand and thus attracted higher wages (Green, 2007). More recent studies assume that technological change has increased the demand for specific skills as well as the demand for general human capital (Friedberg, 2001). This leads in turn to a change in the structures in the labor market (Autor *et al.* 2006; Goos and Manning, 2007).

The idea that human capital has a complementary relationship with physical capital, whereby both represent substitutes for unskilled workers, goes back to Griliches (1969). This approach found widespread empirical support in the factor demand literature (Hamermesh, 1993). The correlation between human capital and technological change is based on the argumentation that highly qualified workers are more capable to adapt to changing economic conditions (Bartel and Lichtenberg, 1987; Nelson and Phelps, 1966; Schultz, 1975; Welch, 1970).

Taking the thesis of skill biased technological change as a starting point, a transmission mechanism is operationalized within the so-called task approach via which the increasing technologization at the workplace changes the activities exercised in the workplace (Acemoglu and Autor, 2011; Spitz- Oener, 2006). Virtually all analyses conclude that a significant shift in task profiles has taken place with an increasing computerization in the workplace. This suggests that technological change is accompanied by increased demand for technical skills (information technology and processing) and specific skills (management, consultancy) (Giesecke and Verwiebe, 2009).

Whereas the thesis of STBC takes a parallel technological distortion in all segments of wage development as its starting point, the task approach may indicate a polarization of employment (Dustmann *et al.* 2009; Spitz- Oener, 2006,). Within this context, the term polarization refers to a U-shaped wage development in which the wages of highly and low qualified workers rise relative to the wages of persons at a medium qualification level (Fitzenberger, 2012).

The merit of ALM, among other things, consists of the micro-theoretical foundation it provides for the complementarities of human manpower and computers in relation to possible substitutes, and the associated possibilities for empirical analysis.

The starting point for the task approach originated by Autor *et al.* (2003) is the observation that firms, faced with rapid technological development, have to decide whether to substitute human manpower with technology and/or which employees with which qualifications they require. The core hypothesis of the approach states that subsidiarities and complementarities exist between human manpower and workplace technology use, which can be represented by means of the employees' task structures.

Under the ALM approach, technological change is equated with “computerization” and the substitution of work tasks. The resulting polarization theory is based on the idea that falling computer prices act as the main driver of changes in task structures over the course of time (Acemoglu, 1998; Goos and Manning, 2007).

In the ALM paper a total of four categories of work tasks are delineated: routine manual tasks, routine cognitive tasks, non-routine manual tasks and non-routine cognitive tasks (Autor *et al.* 2003). Non-routine cognitive tasks are subdivided into analytical tasks and interactive tasks. The authors give the following description of routine tasks: “a task is routine if it can be accomplished by machines following explicit programmed rules” (Autor *et al.* 2003). This is in contrast to “non-routine tasks” which are defined as tasks “for which the rules are not sufficiently well understood to be specified in computer code and executed by machines” (Autor *et al*. 2003).

In line with the “routinization hypothesis” the introduction of computers results in the substitution of those tasks which are classified as routine (Goos *et al.* 2009). As a result there is falling demand for workers to carry out routine tasks (Autor *et al.* 2003). At the same time there is rising demand for workers who can carry out non-routine tasks (e.g. in the form of servicing newly introduced computer technologies).The widespread use of computers provides employees who carry out non-routine tasks with a form of technological support (Autor and Handel, 2009).

As a result of this development, in the cases of both cognitively demanding work tasks and less demanding computer tasks (e.g. among academics and unskilled staff), there is increasing demand for non-routine tasks, whereas demand drops in the intermediate segment of occupational tasks since there are fewer routine tasks to be carried out at each qualification level. This polarization is expressed primarily in salary levels (Autor *et al.* 2006).

Spitz-Oener (2006) was the first to apply the task approach to Germany. She comes to the conclusion that a shift of cognitive and manual routines towards the increasing exercising of analytical and interactive activities has taken place in recent decades. She also shows that there is a substitutive relationship between the use of computers in the workplace and manual and cognitive routine activities and a complementary relationship between such computer use and analytical and interactive work contents. Following her lead, important papers contributing to the debate on task-biased technological change in Germany were published (Antonczyk *et al.* 2009; Black and Spitz-Oener, 2010; Dustmann *et al.* 2007; Gathmann and Schönberg, 2010; Giesecke and Verwiebe, 2008; Spitz-Oener, 2008,), although the analyses have never previously been focused on older employees. In their analyses, Dustmann, Ludsteck and Schönberg (2009) demonstrate the U-shaped correlation between the wage level in individual occupations and the development of employment in these occupations. In contrast, Antonczyk *et al.* (2009) come to the conclusion that the task-based approach cannot explain wage development in Germany. Their results show that the tasks approach is solely capable of explaining wage inequality in the lower segment.

4. Technological Change and Older Employees

A small number of studies deal with the direct correlation between increased use of computers and the wage differential in the group of older employees. Katz and Murphy (1992) come to the conclusion that the relative wages of older low qualified workers decrease less than the wages of low qualified workers who are middle-aged. Their results show that the wages of highly qualified persons rise less. This asymmetry between skills and age indicates an interaction between task requirements (skill requirements) or outdated skills (Friedberg, 2001). In their investigations, Bartel and Sicherman (1993) come to the conclusion that additional continuing training costs caused by technological change lead older employees to enter early retirement. Analyses conducted by Juhn *et al.* (1992) also indicate increasing dispersion of wages towards premature retirement of older low qualified persons (compared to highly qualified workers).

Various factors provide a basis for assuming that older employees react differently to increasing computerization compared to younger age groups. On average, older workers have a lower level of qualification than younger workers.[2] For this reason, this age group exhibits a higher risk of having their jobs replaced by new technologies (Goldin and Margo, 1992). Because older workers tend to have outdated skills, it is also more likely that their skills are obsolete (Friedberg, 2001). Older workers are also less likely to decide to learn new technologies due to the fact that their impending retirement means that they do not expect to receive a high output for such an investment (Behringer, 1999). This provides a basis for assuming that computerization exerts a negative influence on the wages of older workers. If there is a complementary relationship between increased computer use and non-routine activities or training, then we may assume that older employees benefit less from this development.

The aim of the present paper is to address the issue of to what extend technological change influences the wage structure of older workers compared to younger age groups measured in terms of the increasing deployment of computers as a work tool. Since the Routinization Hypothesis (Autor *et al.* 2003) states that the increased use of computers on the labor market has led to a shift of task profiles towards the increasing exercising of non-routine tasks, the objective will be to investigate whether this trend has also resulted in a relative wage increase for older workers. The paper will also examine whether higher qualified workers are the primary beneficiaries of technological change in the form of higher wages.

5. Methodology

5.1. Sample

The study is based on data from the representative BIBB/IAB Qualification and Occupational Career Survey[3] and BIBB/BAuA working population survey[4] from the years 1979, 1986, 1992, 1999, 2006 and 2012.The data include population weightings which permit representative investigations to be undertaken of all persons in active employment in Germany. The advantage of the BIBB/IAB – BIBB/BAuA Employment Surveys is that they contain information about the work tasks done at individual level.

The analysis only takes account of men between 35 and 65 years of age who live in West Germany and are in full-time employment (cf. Table 1). Full-time employment is defined as at least 25 hours of working time per week. Persons who state that they work for over 71 hours per week are excluded from the surveys for reasons of implausibility. The data set contains both salaried employees and self-employed persons.

Table 1. Frequency distributions of age groups in the survey years analyzed

Age groups	1979	1986	1992	1999	2006	2012
35 - 50 years	7238	6004	5629	6474	4039	3815
50 - 65 years	3807	4419	4419	3946	1699	2701

Notes: In 2012 there is no restriction on the weekly working hours, since there are too few observations.
Source: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 2012, own calculations, only men in full-time employment living in West Germany

[2] The share of persons aged 50- 65 with high qualification (i.e. university degree) amounted in the year 1976: 7,36%, 1985: 9,04%, 1985: 9,04%, 1999: 15,91%, 2011: 18,2%, own calculations on the basis of the microcensus.
[3] In German: Qualifikation und Berufsverlauf. This survey is conducted by the German Federal Institute for Vocational Training (In German: Bundesinstitut fur Berufsbildung, BIBB) and the Research Institute of the Federal Employment Agency (In German: Institut für Arbeitsmarkt- und Berufsforschung).
[4] In German: Erwerbstätigenbefragung. This survey is conducted by the German Federal Institute for Vocational Training (In German: Bundesinstitut für Berufsbildung, BIBB) and the Federal Institute for Occupational Safety and Health (In German: Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA).

5.2. Instrumentation

The measurement of wage development over the course of time takes place on the basis of the (open) information provided by respondents of their monthly gross wage. Since this involves a categorical variable, a transformation needs to take place to make it possible to include this as a criterion in a multivariate model. This transformation is performed by determining a mean value for the individual income classes, which are collated in a constant variable.[5]

The measurement of technologization was undertaken by referring to the main work tool used, where a value of 0 represents a low level of technologization (use of simple work devices, tools, simple and semiautomatic machines) and a value of 1 represents a high degree of technologization (use of IT computers and programme-controlled work tools).

Since the data set was not collected with reference to the ALM categories of "routine" and "non-routine tasks", the operationalization of the task areas was undertaken on the basis of an approach developed by Rohrbach-Schmidt and Tiemann (2012). By running a factor analysis on the basis of a tetrachoric correlation matrix, the total of 17 task items are aggregated into the five categories: analytic, routine, cognitive, interactive, routine manual and non-routine manual (cf. Table 2).[6]

Table 2. Summary of tasks on the basis of the BIBB/IAB/ BIBB/BAuA Employment Surveys 1979 – 2012

	Classification	Tasks
Routine tasks	Routine cognitive	Programming; storing; writing; calculating; applying law
	Routine manual	measuring; operating; repairing; manufacturing; protecting
Non-routine tasks	Interactive	Buying; negotiating; promoting
	Analytic	teaching; consulting; investigating; organising; researching; managing
	Non-routine manual	Accommodating; caring; cleaning

Notes: Own representation based on Rohrbach- Schmidt and Tiemann (2012)

The influence of the degree of formal qualification is measured by the three skill categories (1) Low skilled: without a vocational training degree, (2) Medium skilled: with a vocational training degree ("Berufsausbildung") and (3) High skilled: with a degree from a University ("Hochschule") or a University of the Applied Sciences ("Fachhochschule").

6. Finding & Discussion

We analyze the impact of the more prevalent technology use on the change in the distribution of hourly wages for full time working males living in West Germany between 1979 and 2012. The focus of the analysis is on the comparison of the development of older (aged 50-65) and younger workers (aged 35-50). Consideration is also accorded to the effect exerted on wage shift by the task exercised and by the qualification level. To present our empirical results, we proceed in two steps. The first step is a descriptive representation of technological change, of the shift of task characteristics and of the qualification trends of older workers compared to younger workers over the course of time. The second stage involves using an OLS regression as a basis for investigating the size of the explanatory content of these control variables on wage development (increasing use of computers, higher qualification, task exercised). Our regression results are of descriptive nature as we only control for observable characteristics, i.e. we do not claim to estimate causal effects.

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[5] Gross income was surveyed in the following categories: up to DM/€ 1000, DM/€ 1000- 2000, DM/€ 2000-3000, DM/€ 3000- 4000, DM/€ 4000-5000, DM/€ 5000 and more.

[6] Since the task items are binary coded, it is not appropriate to carry out a factor analysis on the basis of simple Pearson correlations. Instead the factor analysis is applied on the basis of a tetrachoric correlation matrix (Kubinger, 2003).

6.1. Descriptive Statistics & Analysis

6.1.1. The Income of Older Workers Observed over Time

Table 3 shows the categorial monthly gross income from 1979 to 2012 for each age group. For 1979 it can be seen that older employees are more often found in lower income categories of up to 2000 DM compared to younger employees. Consequently, they were also found less often in higher income categories than younger workers.

Table 3. Monthly gross income in the years 1979 and 2012 differentiated according to age groups

Gross income 1979						
	Under 1000 DM	1000- 2000 DM	2000- 3000 DM	3000- 4000 DM	4000- 5000 DM	over 5000 DM
35-49 years	1.3%	26.0%	46.7%	15.6%	6.2%	4.2%
50-65 years	1.8%	32.1%	41.9%	13.6%	5.9%	4.7%
	1.5%	28.1%	45.1%	14.9%	6.1%	4.4%
Gross income 2012						
	Under 1000 €	1000- 2000 €	2000- 3000 €	3000- 4000 €	4000- 5000 €	over 5000 €
35-49 years	4.7%	15.4%	32.5%	24.9%	9.5%	13.0%
50-65 years	5.4%	17.1%	20.9%	20.9%	12.4%	23.3%
	5.0%	16.1%	27.5%	23.2%	10.7%	17.4%

Notes: BIBB/IAB – BIBB/BAuA Employment Surveys 1979 and 2012, own calculations, only men in full-time employment living in West Germany, N (1979) = 10202 , N (2012) = 298

In comparison, in 2012 older workers can be found mostly in the lower (of up to 2000 Euros) and the higher income category (4000 to over 5000 Euros).

6.1.2. Degree of Technologization over the Course of Time

An observation of the use of computers in the workplace over the course of time (1979- 2012) shows that a strong increase in the deployment of this tool has taken place during the period forming the object of investigation. Whereas in 1979 the proportion of men in full-time employment who stated that they used a computer as a working tool was 9%, it amounted to 53.2% in year 2012. If a differentiation is made between older (50-65 years) and younger workers (35-50 years), we see that a significant trend towards increasing technologization has taken place in respect of both age groups (cf. Figure 3). Up to 1999 younger employees proclaimed more often than older employees that they use a computer at work (35-50: 1979- 5.5%, 1986- 7.7%, 1992- 18.3%, 1999- 39.8%, 50-65: 1979- 4.9%, 1986- 5.4%, 1992- 11.1%, 1999- 34.6%). In 2006, older employees indicated more often to use a computer as their main working tool (35-50: 2006– 50.4%, 50- 65: 54.3%). In 2012, however, both age groups show identical numbers in computer usage (53.2%).

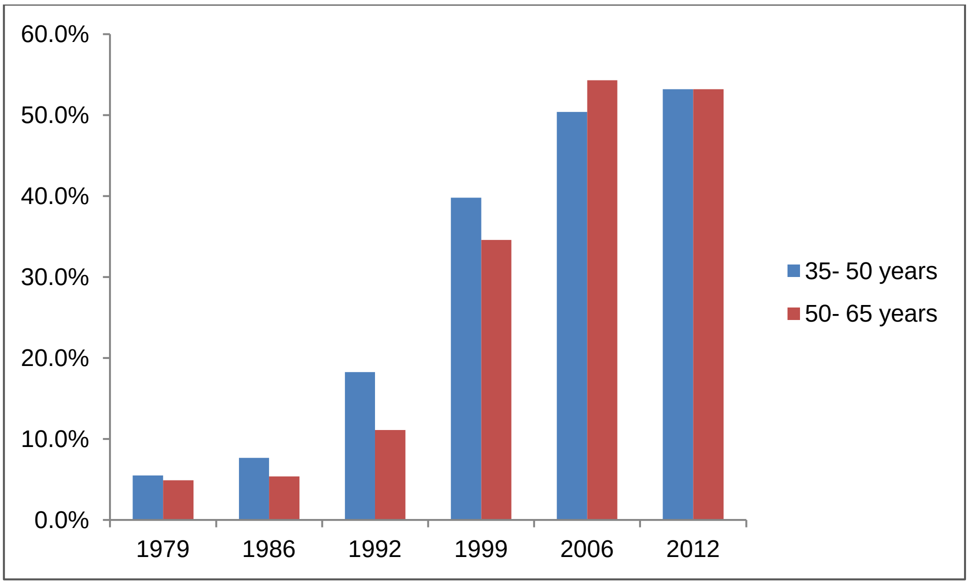

Figure 3. Technological change differentiated according to age
Notes: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 2012, own calculations, only men in full-time employment living in West Germany, N= 41.539

6.1.3. Changing Tasks

In line with the assumptions of the task approach, a significant shift of task characteristics towards increasing non-routine (analytical, interactive and non-routine manual) tasks took place during the period forming the object of observation. In contrast, the proportion of routine manual tasks exercised by all persons surveyed decreased. If a differentiation according to age groups is made, we observe that the trend towards increasing routinization has occurred in the case of younger and older workers alike. The percentage differences in distribution within the individual task categories of the 35-50 and 50-65 age groups are less than 2 percentage points in most cases. This means that no significant difference between the age categories can be assumed.

Figure 4 shows the proportions of frequently exercised tasks of older employees over time. In 1979, 50.3% of older workers frequently exercised routine manual, 23.4% routine cognitive, 20.3% interactive, 12.0% analytical and 2.8% nonroutine manual tasks. In comparison, in 2012, 31.9.3% of the 50-to-65-year-olds indicated to frequently exercise routine manual, 74.5% routine cognitive, 64.5% interactive, 14.2% analytical and 74.5% nonroutine manual tasks. Therefore, it can be seen that there is a decreasing trend in exercising routine manual tasks in this age group. However, the opposite is true for routine cognitive tasks. Nonroutine tasks are being exercised much more frequently compared to 2012, while the trend in analytical tasks is smallest in magnitude.

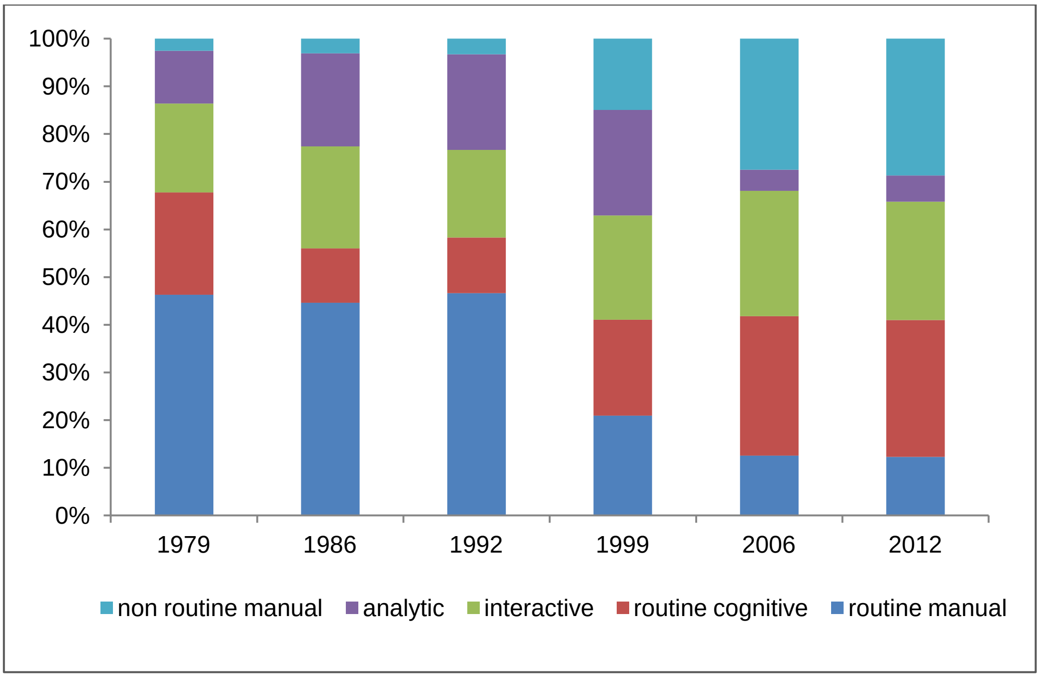

Figure 4. Shift in task contents of older employees

Notes: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 2012, own calculations, only men in full-time employment living in West Germany, N=122.567

6.1.4. Higher Qualification over the Course of Time

Table 4 shows the development of the level of qualification distinguished by older and younger workers. While in 1979, there were many much older employees did not have any form of formal qualification (33.5%), this share was reduced to 7.0% in 2012. In total the share of older workers with a medium skill level has decreased over time. In 1979, 57.4% of the 50-to-65-year-olds had completed an apprenticeship. In 2012, it was 61.9%. The share of older employees with a university diploma increased in the last few years dramatically: compared to 9.1% in 1979, in 2012 31.2% indicated to have had completed a university program.

Table 4. Higher qualification differentiated according to age

		Low skilled	Medium skilled	High skilled
1979	35-49 years	25.6%	63.2%	11.2%
	50-65 years	33.5%	57.4%	9.1%
1986	35-49 years	14.0%	63.8%	22.2%
	50-65 years	20.6%	64.4%	15.0%
1992	35-49 years	14.0%	62.4%	23.6%
	50-65 years	20.9%	61.6%	17.5%
1999	35-49 years	14.9%	62.6%	22.5%
	50-65 years	14.4%	59.5%	26.0%
2006	35-49 years	5.3%	63.7%	31.0%
	50-65 years	5.4%	55.3%	39.3%
2012	35-49 years	8.9%	63.0%	28.0%
	50-65 years	7.0%	61.9%	31.2%

Notes: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 2012, own calculations, only men in full-time employment living in West Germany

6.2. Multivariate Analysis

In order to measure the influence of increasing technologization, of changing task profiles and of the trend towards higher qualification on gross income over the course of time, six multilevel multiple regressions for the younger and older age group were specified in each case (Table 5). Both unstandardized (Comparison across samples) and standardized (comparison of several effects within one sample) regression coefficients are represented.

Table 5. OLS Regression analysis of monthly income (Differentiated according to age groups)

SECTION A

	1979				**1986**			
	35- 50 years		**50- 65 years**		**35- 50 years**		**50- 65 years**	
	β (se)	**B***	**β (se)**	**B***	**β (se)**	**B***	**β (se)**	**B***
Analytic	663.247*** (41.849)	0.212	825.661*** (64.376)	0.226	452.431*** (44.054)	0.159	740.936*** (56.211)	0.234
Routine cognitive	-55.071*** (29.727)	-0.022	-87.309*** (42.406)	-0.033	293.496*** (46.058)	0.090	168.795** (61.570)	0.045
Interactive	356.913* (32.247)	0.140	375.297* (49.104)	0.131	404.008*** (38.334)	0.142	397.498*** (48.707)	0.131
Routine manual	-301.305*** (24.267)	-0.147	-311.673*** (35.726)	-0.143	-291.956*** (34.401)	-0.122	-403.092*** (41.679)	-0.161
Non routine manual	-156.412*** (65.813)	-0.027	-79.873* (102.854)	-0.012	187.130** (72.601)	0.034	97.016 (107.047)	0.014
Technologisation	266.251*** (53.958)	0.057	160.430* (76.667)	0.033	283.111*** (60.952)	0.061	491.159*** (88.637)	0.086
Qualification	524.636*** (21.077)	0.307	535.026*** (29.621)	0.298	642.649*** (30.970)	0.319	698.371*** (36.968)	0.328
Constant	2109.140*** (27.231)		2099.065*** (37.324)		2514.837*** (44.242)		2500.025*** (50.191)	
R^2	0.279		0.276		0.319		0.371	
Adj. R^2	0.279		0.274		0.318		0.370	

SECTION B

	1992				**1999**			
	35- 50 years		**50- 65 years**		**35- 50 years**		**50- 65 years**	
	β (se)	**B***	**β (se)**	**B***	**β (se)**	**B***	**β (se)**	**B***
Analytic	381.620*** (44.825)	0.143	519.681*** (56.137)	0.168	434.274*** (35.980)	0.192	531.267*** (45.480)	0.241
Routine cognitive	262.407*** (48.068)	0.085	250.014*** (62.845)	0.066	181.518*** (31.448)	0.082	70.495*** (41.432)	0.031
Interactive	314.517*** (40.921)	0.107	385.478*** (49.933)	0.118	86.296*** (35.592)	0.037	147.657* (42.786)	0.066
Routine manual	-351.923*** (32.813)	-0.157	-418.284*** (37.401)	-0.176	-50.568* (32.801)	-0.023	-256.468*** (42.905)	-0.112
Non routine manual	-239.287*** (69.825)	-0.046	48.514 (98.111)	0.007	-0.540 (32.910)	0.000	-50.613 (43.102)	-0.021
Technologisation	347.311*** (41.195)	0.115	255.633*** (58.631)	0.065	413.348*** (32.260)	0.182	373.743*** (41.589)	0.161
Qualification	558.560*** (28.884)	0.301	676.179*** (32.862)	0.348	439.066*** (26.124)	0.242	345.534*** (32.732)	0.199
Constant	3290.272*** (40.914)		3194.085*** (42.825)		3534.521*** (36.806)		3854.908*** (47.141)	
R^2	0.317		0.370		0.246		0.263	
Adj. R^2	0.315		0.369		0.245		0.261	

SECTION C

	2006				2012			
	35- 50 years		50- 65 years		35- 50 years		50- 65 years	
	β (se)	B*	β (se)	B*	β (se)	B*	β (se)	B*
Analytic	-0.477 *** (0.078)	-0.111	-0.520*** (0.134)	-0.106	-0.700*** (0.064)	0.215	-0.550*** (0.060)	-0.177
Routine cognitive	0.277*** (0.046)	0.109	0.429*** (0.077)	0.155	0.403*** (0.056)	0.142	0.343*** (0.049)	0.137
Interactive	-0.064 (0.042)	-0.026	0.003 (0.067)	0..001	-0.081 (-0.081)	-0.027	-0.005 (0.051)	-0.002
Routine manual	0.014 (0.043)	0.006	0.179 *** (0.063)	0.076	-0.015 (0.053)	-0.005	-0.078 (0.050)	-0.030
Non routine manual	0.149*** (0.046)	0.059	0.112 (0.073)	0.042	0.213* (0.213)	0.052	0.222*** (0.068)	0.061
Technologisation	0.004*** (0.001)	0.107	0.003*** (0.001)	0.072	0.061 (0.049)	-0.024	0.14 (0.043)	0.006
Qualification	0.441*** (0.037)	0.214	0.440*** (0.053)	0.223	-0.061 (0.662)	0.265	0.558 (0.045)	0.240
Constant	2.855*** (0.091)		2.782*** (0.144)		2.383*** (0.142)		2.225*** (0.124)	
R²	0.138		0.152		0.190		0.138	
Adj. R²	0.136		0.147		0.188		0.135	

Notes: Source: BIBB/ IAB – BIBB/BAuA Employment Surveys 1979- 2012. Own calculations. Only men in full-time employment living in West Germany

Explanations and Definitions: Dependent variable: amount of monthly gross salary (DM/€), measured metric Reference categories: non analytic task, non routine cognitive task, non interactive task, non routine manual task, non non routine manual task, low degree of technologization, Qualificational degree: 0- low skilled, 1- medium skilled, 2- high skilled (treated as continuous variable), β: unstandardized regression coefficient, the magnitude of its value is relative to the means and standard deviations of the independent and dependent variables in the equation, refer to the slopes of the regression lines and are interpreted as the amount of change in the dependent variable (Y) that is associated with a change in one unit of the independent variable (X). B*: standardized regression coefficient, through z transformation a new variable results having a mean of 0 and a standard deviation of 1, measures the standard deviation change in the dependent variable given a one standard deviation increase in an independent variable Significance levels: *: p ≤ 0.1, **: p ≤ 0.01, ***: p ≤ 0.001, the probability of Type I error in hypothesis testing, Model fit: R²: equals the squared correlation coefficient and is interpreted as the proportion of the sample variation in yi that is explained by the OLS regression line. By definition, R² is a number between 0 and 1, each additional independent variable increases R², the complexity of the model is not considered. Adj. R²: A goodness- of- fit measure that penalizes additional explanatory variables by using a degrees of freedom adjustment in estimating the error variance, cannot be interpreted as a percentage of explained variance. (See also: Wooldridge, 2008).

Throughout the considered time series exercising an analytical task is connected to a higher gross income. Notably, this effect is higher for the 50-to-65-year-olds compared to younger workers. In total, the magnitude of the impact for both age groups declined from 1979 (younger workers: β 663,247 older workers: 825,661) to 1999 (younger workers: β 434,274, older workers: β 531,267). A sole exception can be seen in 2012 for the older workers: Here, exercising an analytical task has a negative impact on gross income.

While in 1979 exercising a routine cognitive task was still linked to a low income (in both age groups), it can be observed that since 1986 such tasks lead to a higher income. For the younger age cohorts this effect was stronger than for older workers most points in time of the series (e.g. 1999 younger workers: β 181,518, older workers: β 70,494). In 2012, the younger employees are an exception: Here, exercising a routine cognitive task leads to a lower gross income (β -0.198).

Up to 1999, there is a link between exercising interactive tasks and higher income for both age groups. In 2006, the effect for both age groups is quite weak. In 2012, exercising an interactive task leads to a higher gross income for younger employees (β 0.448) and to a lower gross income for older employees (β 0.335).

Routine manual tasks are connected to low income throughout time, while older workers tend to have lower wages than the younger. Here, as well, impacts are marginal.

Unlike in 1986, where non-routine manual tasks lead to a higher income, this trend diminishes with time. In 2006, exercising manual tasks is connected to higher income in both age groups (35- 50: β 0.149; 60- 65: β 0.112), in 2012 this is only true for the older employees (β 1.052).

The influence of technologization on income is stronger for the older age cohorts than for the younger throughout the time series. The magnitude of the effect on income increases over the observed time frame (1979: 35- 50: β 0.057, 50- 65: 0.033; 50- 65: β 0.332). The sole exception is the 50-to-65-year-olds in 2012: Here, there is nearly no impact of the usage of technical devices at the workplace on the amount of gross income (β -0.004).

Furthermore, the impact of the level of qualification is positive throughout the time series, while it is (in most cases) stronger for the 50-to-65-year-olds compared to the younger workers.

In (mostly) every cohort, it can be seen that the influence of the level of qualification is always the strongest effect (c.f. B* coefficients). The second strongest effect is the exercise of an analytical task. These two effects are valid in both age groups.

7. Conclusion and Future Recommendation

This paper provides an empirical analysis of the influence of the changes in wage structure of older employees in comparison to younger ones for the time period 1979 to 2012.

Two theoretical assumptions form the starting point for the explanation of wage developments over the course of time – skill-biased technological change (trend towards higher qualification) and the Routinization Hypothesis. The object of investigation is to discover whether similar trends in development can be observed for the group of older workers as for younger workers and whether the two theoretical assumptions have the same explanatory content for wage development.

The descriptive results show that a significant change in the direction of increasing computerization took place for both older and younger workers during the period forming the object of investigation. Up to 1999, younger workers indicated more often to use a computer as the main tool of work for their job compared to older workers. In 2006, older workers proclaimed to use a computer-based main tool of work in their job more often. In 2012, the computer usage of both age groups align. The data investigated supports the Routinization Hypothesis for both the older and younger age group. More non-routine and fewer routine tasks are performed over the course of time. No significant difference between the group of older workers and the group of younger workers can be identified. The level of qualification rose for both younger and older workers over the course of time. While in the first observation years younger workers were higher qualified, the proportion of older workers with a university degree has increased dramatically since 1999.

Multilevel specified multiple regressions were conducted in order to investigate the influence of technologization in conjunction with the shift in task profiles and the trend towards higher qualification on the wage structure of older and younger workers.

The multivariate results show that the effect of the cause variables measured on the income of the older and younger workers are very similar and that the coefficients differ only slightly.

Contrary to expectations, the Routinization Hypothesis could not be directly confirmed. Although increasing technologization has had a relatively large influence on the level of income for younger workers compared to older workers, the results show that not all non routine tasks explain a significantly higher income. However, the trend cannot be observed especially for nonroutine manual tasks. Exercising such a task is even connected to a lower gross income sometimes. Analytical and interactive tasks, on the other hand, are overall a positive influence on gross income. Exercising of routine tasks is only associated with a lower gross income in the case of manual tasks in most cases. For routine congnitive tasks there is no clearly identifiable trend. The mulitvariate analysis reveals a positive impact of the skill level on gross income.

Generally speaking, the Routinization Hypothesis was confirmed on the basis of the data, to that effect that exercising non-routine tasks are connected to a higher income. The effect of the distinct tasks on income seems to be stronger for the 50-to-65-year-olds compared to younger workers. The multivariate results show, similar to the theoretical assumptions, that exercising routine manual tasks are is linked to a lower income. Again, this effect is stronger for older workers. In contrast to the assumptions, exercising routine cognitive tasks leads to a higher income. This effect is stronger for the younger workers. The technologization same as the level of qualification is connected to a higher level of income. Here, the effect is stronger for older workers for both components. Overall, the multivariate results show that the influence of qualification on income is strong in both age groups.

Especially, the results from 2006 seem to be problematic because of some conflicting outcomes with regards to the results from the other years of the time frame. On top of that, the outcomes sometimes are completely in conflict with the assumptions made in the theory.

One possible way of explaining these results is that the task characteristics contained within the data which was used were not collected in line with the ALM approach (Rohrbach-Schmidt and Tiemann, 2012). This operationalization problem could be a cause of the fact that the results deviate from theory. It should also be mentioned that, in the definition of the task areas, other possibilities exist alongside the statistical (factor analysis) approach selected (theory/research practice, criterion validation), which lead to significantly different results (Rohrbach-Schmidt and Tiemann, 2012). It is appropriate to conduct the analyses using the other categorization possibilities. Additionally, new task items, which have only limited possibilities to be compared to the task items from the years before, were included in the survey in 2012.

One major disadvantage of the multiple regression analysis procedure which was used is that this process does not provide any information as to in which segment of wage distribution a wage differential has taken place. For this reason, it is appropriate to conduct analyses using other procedures which permit the increasing wage inequality to be measured and replicated over the course of time (e.g. the Tobit model).

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