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

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ABSTRACT

The labour 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. Globalisation and technological advancement result in enhanced economic participation of highly qualified staff in the form of higher incomes 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, Levy and Murnane, 2003) technological change due to falling computer prices (computerisation) leads to changes in task structures which favour a trend towards routinisation ("routinisation hypothesis"). Alongside these developments Germany faces the challenge of demographic change, which is reflected primarily in the shrinking and ageing of the population (Siegrist, Dragano and Wahrendorf, 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 labour 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 2009; Stößel 2008). From this starting point, the question derived concerns the influence of technological change on occupational success, as measured by the gross incomes of older working persons. The study examines whether the increasing use of computers in the workplace is leading to a shift towards non-routine tasks among older workers to the same extent as younger workers in accordance with the routinisation hypothesis. Moreover it is analyzed if among the older workers, it is also primarily the highly qualified persons who benefit from this trend in the form of higher gross incomes.The analyses are based on data from the BIBB/IAB and BIBB/BAuA Employment Survey from the years 1979 to 2006, 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, Levy and Murnane, 2003).

Field of Research: *Technological change, older workers, tasks, income, demographic change.*

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1. Introduction

The world of work is undergoing extensive change. Globalisation, economisation, technical developments and structural alterations are all exerting an effect as we move towards a service and knowledge society characterised by a high degree of complexity and dynamism. These developments have been accompanied by an increasing wage differential which has been observed in western industrialised 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 wage disparity especially applied 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, Ludsteck and Schönberg. 2007; Fitzenberger 1999; Fitzenberger, Hujer, McCurdy and Schnabel 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 this time (Dustmann, Ludsteck and Schönberg 2009; Fitzenberger 2012; Gernandt and Pfeiffer 2007; Kohn 2006). The interpretation of the increase in the wage differential is significant compared with other western industrialised countries (Card, Heining and Kline, 2012), and the increase is associated with wages which are falling in real terms (Antonczyk, DeLeire and Fitzenberger, 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 labour 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, 2010). 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 (Schmid, 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). If older persons earn less because of their lower level of qualification or lack of ability to apply new technologies, this may represent an incentive for entering early retirement or a risk factor for successful positioning on the labour market.

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, Levy and Murnane, 1998) as a starting point, an initial analysis will be undertaken of how the activity 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 technologisation has led to the same wage shifts for older workers as for younger workers. This process will control whether the trend towards routinisation and higher levels of qualification on the part of older and younger employees has the same explanatory content for the wage differential.

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. Gernandt and Pfeiffer (2007) 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 increasing increase in 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, Murphy and Pierce 1992; Katz and Murphy 1992). Card,Kramarz and Lemieux (1996) show that the rise in wages in the 1980's is connected with 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, Katz and Kruger (1998) also state increasing computerisation 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 (Chennels and Van Reenen 1997; Doms, Dunne and Troske 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 labour market (Antonczyk, Fitzenberger and Leuschner 2009; Autor, Katz and Kearney 2006; Autor, Levy and Murnane 2003; Card and DiNardo 2002; Dustmann, Ludsteck and Schönberg 2009; Goos and Manning 2007; Green 2007; Machin 2008). One widespread explanatory approach for increasing wage inequality is "skill-biased technological change" (SBTC) (Acemoglu 2002; Katz and Murphy 1992; Machin 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 (such as computers) more readily than low qualified staff and thus also find it easier to assert themselves on the labour market (Autor, Katz and Kruger 1997; Berman, Bound and Giliches 1994). This trend towards a higher level of qualification can be observed in all sectors over the course of time (Musyken and Ter Weel, 1998). The increased inequality of wage 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, Ludsteck and Schönberg (2009); Fitzenberger 1999; Antonczyk, DeLeire and Fitzenberger 2012). Both Dustmann, Ludsteck and Schönberg (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 the 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 the wages of employees at a medium qualification level reduced compared to employees with a high and low level of education. The relative wage position of highly qualified workers in the lower section of 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 order countries, they have risen slightly 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 German and American conditions (Card et al. 1999; Krueger and Pishke 1998; Nickell and Bell 1996). The non-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 Saetz; Saetz and Vaell 2005).

3.2 The task based approach – routinisation hypothesis and polarisation

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 on the labour market (Autor, Katz and Kearney 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 has met with 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 better able 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 operationalised within the so-called task approach via which the increasing technologisation 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 activity profiles has taken place in the wake of increasing computerisation 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 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 polarisation of employment (Dustmann, Ludsteck and Schönberg 2009; Spitz- Oener 2006,). Within this context, the term polarisation 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, Levy and Murnane (Autor, Levy and Murnane, 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 "computerisation" and the substitution of work tasks. The resulting polarisation 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, Levy and Murnane,

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, Levy and Murnane, 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, Levy and Munrane, 2003).

In line with the “routinisation hypothesis” the introduction of computers results in the substitution of those tasks which are classified as routine (Goos, Manning, and Salomons, 2009). As a result there is falling demand for workers to carry out routine tasks (Autor, Levy and Murnane, 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 polarisation is expressed primarily in salary levels (Autor, Katz and Kearney 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, Fitzenberger and Leuschner 2009; Black and Spitz-Oener 2010; Dustmann, Ludsteck and Schönberg 2007; Gathmann and Schoenberg 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. By way of contrast, Antonczyk, Fitzenberger and Leuschner (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 activity 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 (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 computerisation compared to younger age groups. On average, older workers have a lower level of qualification than younger age groups.[1] 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 such these 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 computerisation 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 which influence technological change has on 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 Routinisation Hypothesis (Autor, Levy and Murnane, 2003) states that the increased use of computers on the labour market has led to a shift of activity 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[2] and BIBB/BAuA working population survey[3] from the years 1979, 1986, 1992 and 1999.

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.

[1] 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.

[2] 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).

[3] 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).

Table 1: Frequency distributions of age groups in the survey years analysed

Age groups	1979	1986	1992	1999
35 - 50 years	7238	6004	5629	6474
50 - 65 years	3807	4419	4419	3946

Source: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 1999, own calculations, only men in full-time employment living in West Germany.

5.2 Instrumentation

The measurement of income development over the course of time takes place on the basis of the (open) information provided by respondents as to their monthly gross income. Since this involves a categorial variable, a transformation needs to take place which makes it possible to include this as a criterion in a multivariate model[4]. This transformation is performed by determining a mean value for the individual income classes, which are collated in a constant variable.[5]

Since the data set was not collected with reference to the ALM categories of "routine" and "non-routine tasks", the operationalisation 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.[6]

Table 2: Summary of tasks on the basis of the BIBB/IAB/ BIBB/BAuA Employment Surveys 1979 - 1999

	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

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

[4] 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. The mode of grouped income distribution is DM 3140.75.

[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. The mode of grouped income distribution is DM 3140.75.
Statistical indicators of the metric variables: N = DM 55,951, minimum = DM 500.00, maximum = DM 5500.00, mean value = DM 3325.66, Std = DM 1338.63. Differentiation according to age group produces the following: 35-50 age group: N = 22,170, mean value = 3558.65, Std = 1314.39; 50-65 age group: N = 13,833, mean value: 3593.19, Std = 1379.81.

[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].

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").

The degree of routinisation is based on the response stating to what extent the processes of the task are programmable (measured in terms of the question about whether the task follows precise rules) and the degree of repetitiveness involved. The higher the index value (max. 1), the higher the degree of routinisation.

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

6. Finding & Discussion

We analyse the impact of the more prevalent technology use on the change in the distribution of hourly incomes for full time working males living in West Germany between 1979 and 1999. The focus of the analysis is on the comparison of the development of older workers (aged 50-65) and younger workers (aged 35-50). Consideration is also accorded to the effect exerted on income 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 income 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.

6.1 Descriptive statistics & analysis

Degree of technologisation over the course of time

An observation of the use of computers in the workplace over the course of time (1979- 1999) 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 work tool was 9%, the percentage rose to 55,9% in 1999. If a differentiation is made between older (50-65) and younger workers (35-50), we see that a significant trend towards increasing technologisation has taken place in respect of both age groups (cf. Figure 1). Notwithstanding this, over the course of time lower proportions of older employees compared to younger workers state that they use a computer as a main work tool (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%).

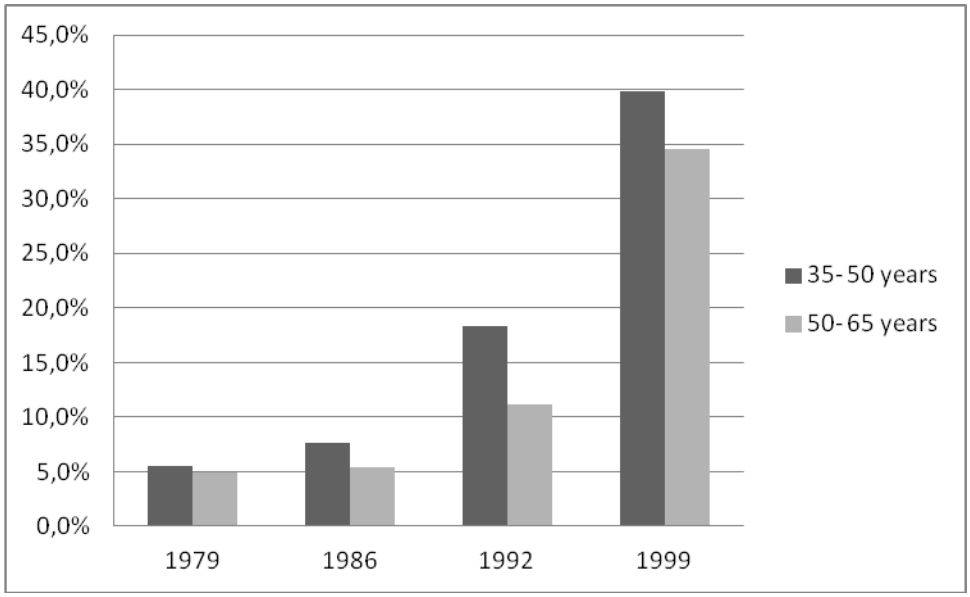

Figure 1: Technological change differentiated according to age

Source: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 1999, own calculations, only men in full-time employment living in West Germany, N= 41.539.

Changing tasks

In line with the assumptions of the task approach, a significant shift of activity characteristics towards increasing non-routine (analytical, interactive and non-routine manual) tasks took place during the period forming the object of observation (cf. Figure). By way of contrast, the proportion of routine (manual and cognitive) tasks exercised by all persons surveyed decreased. If a differentiation according to age groups is made, we observe that the trend towards increasing routinisation 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.

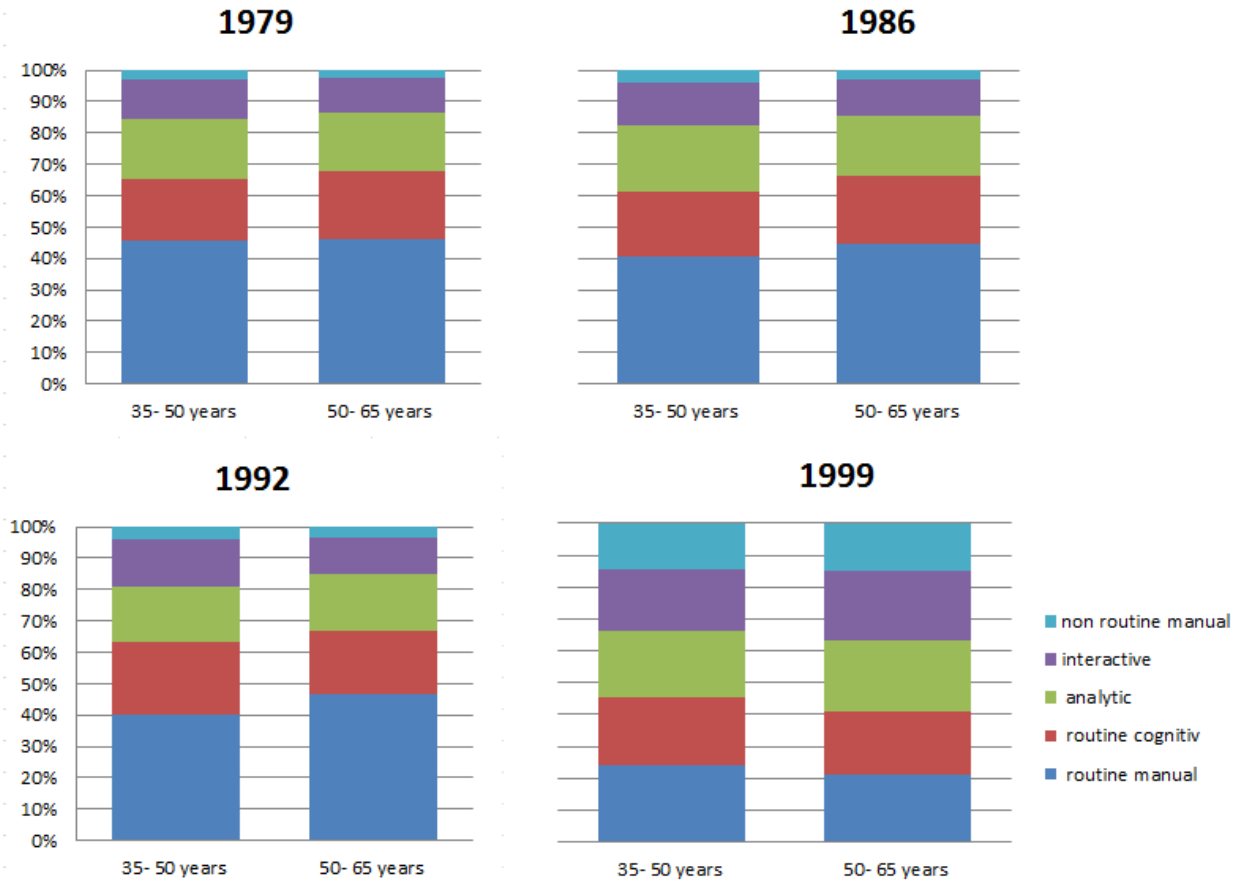

Figure 2: Shift in task contents differentiated according to age groups

Source: BIBB/IAB – BIBB/BAuA Employment Surveys 1979- 1999, own calculations, only men in full-time employment living in West Germany, N=122.567

Higher qualification over the course of time

Whereas there has been a reduction in the proportion of non-formally qualified persons (low skilled) (1979: 36.5%, 1999: 21.2%) and of persons with a medium level of qualification (medium skilled (1979: 27.0%, 1999: 24.6%), the proportion of more highly qualified workers increased (1979: 17.9%, 1999: 31.1%).

An observation of the development of qualification differentiated according to age groups shows that, compared to younger workers, older workers are more likely to be low skilled and less likely to be highly qualified. (This tendency is exhibited for all cohorts investigated with the exception of the year 1999, which revealed a higher proportion of highly qualified persons amongst older workers (26.0%) than was the case amongst younger workers (22.5%).

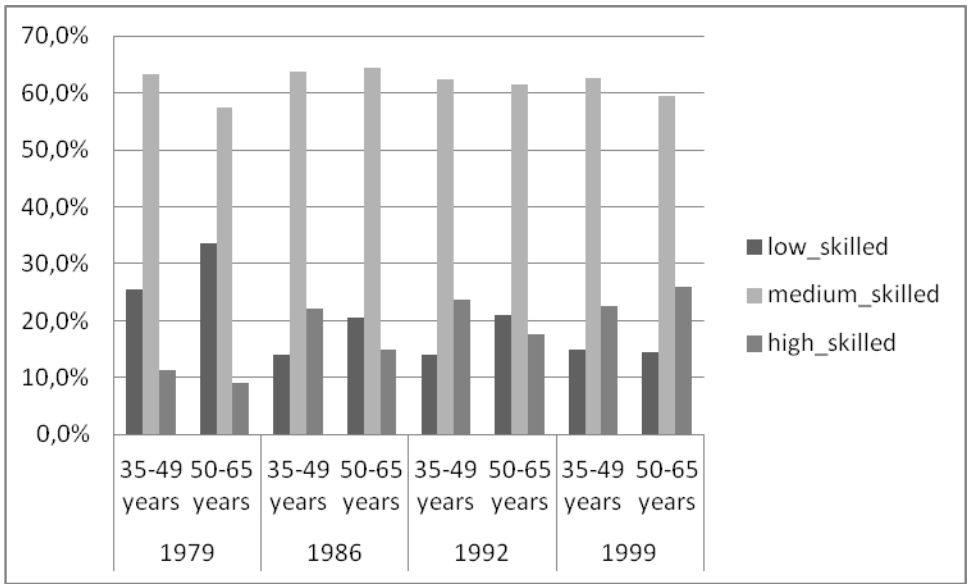

Figure 3: Higher qualification differentiated according to age

Source: BIBB/ IAB – BIBB/BAuA Employment Surveys 1979- 2006, own calculations, only men in full-time employment living in West Germany, N= 33707.

Differences in the gross income of older and younger workers

In order to be able to identify differences in the two age groups forming the object of investigation, a test for normal distribution (Kolmogorov-Smirnov)[7] and a test for homogeneity of variance (Levene's test)[8] were conducted. These lead to significant results which indicate that the values are not normally distributed and that the variances are not homogeneous. A comparison of median value using the Mann-Whitney test[9] produces a significance level of 0.05. This indicates that there are no significant differences between older and younger workers in income distribution.

6.2 Multivariate analysis

In order to measure the influence of the trend towards higher qualification and the technologisation on gross income, multiple regressions were specified for the younger and older age group and each survey year (cp. Table 3). Both unstandardised (for comparison across samples) and standardised (for

[7] Normal distribution test: significance corresponds to the likelihood of error with which the null hypothesis of normal distribution can be rejected. The higher the value, the more likely it is that a normal distribution can be assumed. Notwithstanding this, H_1 (inhomogeneity) should be assumed in the case of significances under = 0.05.

[8] Levene Test: significance of the Levene statistic is the likelihood of error for the rejection of H_0 (variances in the statistical population are equal). The greater this significant, the more likely it is that H_1 can be assumed (variances are unequal sigma_1 NE sigma_2). Homogeneity or heterogeneity should be assumed if the statistic, which is virtually t-distributed, takes on a relevant level of significance. The aim here is to assume H_0 and not, as is usually otherwise the case, H_1.

[9] Mann Whitney test: a test for two independent samples which requires an interval scale level. The two totals produced are used as a basis for testing the hypothesis that both samples originate from the same statistical population. If the hypothesis is true, the values of both groups should be approximately equally distributed in the series formed at the start, i.e. the average ranks of both groups should have about the same value.

comparison of several effects within one sample) regression coefficients are presented. Exercising a non routine analytical task has a positive effect on income over the course of time.

The effect is slightly larger for the older age group. The intensity of the effect decreases in both age groups from 1979 (younger age group: β 663,247; older age group: 825,661) to 1999 (younger age group: β 434,274; older age group: β 531,267). Exercising a routine cognitive task was associated to a lower income in the year 1979 in both age groups. However, it has a positive effect on income since 1986. This effect is in all analyzed survey years higher for younger employees (e.g. 1999: younger age group: β 181,518, older age group: β 70,495).Exercising an interactive task has a positive effect on income. The influence is stronger for the 50-65 age group, but the strength of the effect decreases over the course of time. Exercising routine manual tasks have a negative effect on income over the course of time. For the older age group the effect is more negative than for the younger ones. There is a break in the development in the year 1999 as the income losses decrease clearly for younger employees (β -50,568) whereas they are still strong for the 50-65 age group (β -256,468).Exercising non routine manual tasks was associated to higher income in 1979. This effect decreases over the course of time.

The positive effect on income is higher for the older age group. For the older age, the influence of technologization on income is higher over the course of time. The level of qualification has a positive effect on the income over the course of time, too. For the 50-65 age group the influence is stronger than for younger employees. Within the analyzed years, the level of qualification has the strongest effect on income (cp. B* coefficients).The exercising of an analytical task has the second strongest effect. These influences apply for both age groups. The only exception is in the year 1999, when the effect of exercising an analytical task is stronger than the qualification degree for the 50-65 age group. In all models there is a positive influence of technologization. The strength of the effect is clearly lower than the level of qualification.

Table 3: OLS Regression analysis of monthly income (differentiated according to age groups)

	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***	0,30	535,026***	0,29	642,649***	0,31	698,371***	0,32

	(21,077)	7	(29,621)	8	(30,970)	9	(36,968)	8
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	

Table 3 continued

	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	

Source: BIBB/ IAB – BIBB/BAuA Employment Surveys 1979- 2006, 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 technologisation, 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**: *: $p \leq 0.1$, **: $p \leq 0.01$, ***: $p \leq 0.001$, the probability of Type I error in hypothesis testing, **Model fit**: R^2: 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, R^2 is a number between 0 and 1, each additional independent variable increases R^2, the complexity of the model are not considered. Adj. R^2: 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).

7. Conclusion and future recommendation

This paper provides an empirical analysis of the influence of the changes in income structure of older employees in comparison to younger ones for the time period 1979 to 1999.

Two theoretical assumptions form the starting point for the explanation of income developments over the course of time – Skill-biased technological change (trend towards higher qualification) and the Routinisation Hypothesis. The object of investigation is to discover whether similar development trends 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 income development.

The descriptive results show that a significant change in the direction of increasing computerisation took place for both older and younger workers during the period forming the object of investigation, although older employees are less likely than younger employees to use PC's in all survey years investigated. The data investigated supports the Routinisation 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, although older workers are more likely to be low skilled and less likely to be highly qualified.

Multilevel specified multiple regressions were conducted in order to investigate the influence of technologisation in conjunction with the shift in activity profiles and the trend towards higher qualification on the income 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. An increase in gross incomes could be demonstrated during the period of time forming the object of investigation.

Multivariate results show that the determining factors on income move in the same direction for both age groups. The Routinisation Hypothesis could be confirmed as it is shown that the exercising of non routine tasks has a positive effect on income. The effects of the tasks categories on income are stronger for the 50-65 age group.In accordance with the theoretical expectations the multivariate results show that the exercising of routine manual tasks leads to a lower income, especially for the older age group. Contrary to expectations, performing routine cognitive tasks has a positive effect on income. This effect is stronger for younger employees. Both technologization and level of qualification lead to a higher income. The effect of those two components is stronger for the older age group. In sum, the multivariate analyzes show, that the degree of qualification has a stronger influence on the income than technologization. This effect is applies for both age groups. Thus, it seems that both the task based approach and the thesis of skill biased technological change find empirical evidence for both age groups, whereby the effect in the case of latter is slightly larger.

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

The results provide the information that older workers are affected by the change to the labour market in just the same way as younger employment groups. The fact that such older workers are less likely to use technological work tools and are more likely to be lower qualified than young workers represents a disadvantage for the former. In order to maintain the employability and attractiveness of older workers in the workplace it is, within the scope of the concept of lifelong learning, appropriate to invest in continuing training opportunities, particularly in the field of new technologies. Nevertheless, employees should receive incentives to encourage willingness to acquire higher qualifications throughout the whole of the phase of their active working life.

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