Age and Individual Productivity:

A Literature Survey

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Abstract

This article surveys supervisors' ratings, analyzes of piece-rates and employer-employee datasets as well as other approaches used to estimate how individual productivity varies by age. The causes of productivity variations over the life cycle are addressed with an emphasis on how cognitive abilities affect labor market performance. Although wage profiles peak late in the working life, most of the evidence suggest that individual job performance tend to increase for the first years in the labor market, before stabilizing and eventually decreasing towards the end of ones career. Productivity reductions at older ages are particularly strong when problem solving, learning and speed are important, while older individuals' maintain a relatively high productivity level in work tasks where experience and verbal abilities matter more.

1. Introduction

Understanding age-productivity profiles is important to several areas of economic research. Given that older individuals are less productive, an aging workforce can reduce economic growth and decrease fiscal sustainability. If senior workers' wages exceed their productivity levels, older workers represent losses for the firms. Further, successful attempts to increase the retirement age may demand the removal of seniority-based wage systems.

The current article focuses on age differences in individual productivity and its causes. Figure 1 outlines how physical abilities, mental abilities, education and job experience form an individual's productivity potential. Combined with the firm's characteristics, these factors determine individual job performance. The weight of the different causal factors in determining individual productivity is steadily changing, where mental abilities and education have long been growing in importance, while physical abilities have become less important. Changing requirements on the workplace may imply that the ability to absorb new information is becoming increasingly important relative to having long work experience.

Investigations into how performance differs by age tend to come from several disciplines, such as social psychology, medical science and labor economics. The type of research approaches used typically differ according to the disciplines, where for instance psychologists often analyze manager's performance ratings while employer-employee datasets are mostly used by economists. Investigations from the various disciplines are considered, in order to get a broad perspective on why productivity varies by age.

This paper is organized as follows: Research on age-variation in mental abilities is presented in section 2, the role of experience and learning is discussed in section 3, while section 4 debates how mental abilities relate to productivity. Section 5 reviews the evidence on productivity variation between the age groups, section 6 presents data on age-earnings profiles, section 7 discusses the impact a wage profile that peaks at a later age than the productivity profile can have and section 8 concludes.

2. *Age, Cognitive Abilities and Interrelations with Training*

A large body of evidence supports the notion that cognitive abilities[2] decline from some stage in adulthood. Verhaegen and Salthouse (1997) present a meta-analysis of 91 studies that describe how mental abilities develop over the life span. These studies show that important cognitive abilities, such as reasoning, speed and episodic memory, decline significantly by the age of 50.

That mental abilities tend to decline in adulthood is a universal phenomenon. Age-induced changes to mental ability levels are similar for both men and women, and the same patterns are found across different countries (Maitland et al. 2000, Park et al. 1999). Furthermore, individuals with high ability levels are subject to the same changes in cognitive functioning as those with low ability levels (Deary et al. 2000). Age-reductions in memory and learning capabilities have been documented also

[2] "Cognitive" or "mental abilities" refer to broad aspects of intellectual functioning. These include reasoning, spatial orientation, numerical capabilities, verbal abilities and problem solving. The most commonly used measurement of cognitive abilities is the IQ score.

among many non-human species, ranging from fruit flies to primates, (Bunk 2000, Minois and Bourg 1997).

In spite of the seemingly unavoidable age-reductions in cognitive abilities, targeted training programs may provide a way of halting the decline. Schaie and Willis (1986a, 1986b) conclude that such programs can stabilize, or even reverse, age-specific declines in inductive reasoning and spatial orientation among many individuals. Similar evidence is presented by Ball et al. (2002), who find that those who exercise the use of abilities such as speed, reasoning and memory enhance the functional level of these abilities.

Different cognitive abilities tend to follow relatively independent slopes over the life cycle (Schaie 1994). A division can be drawn between the fluid abilities, mental abilities that are strongly reduced at older ages and crystallized abilities, which remain at a high functional level until a late age in life (Horn and Cattell 1966, 1967). Fluid abilities concern the performance and speed of solving tasks related to new material, and they include perceptual speed and reasoning. The second group, crystallized abilities, measures abilities that improve with accumulated knowledge, such as verbal meaning and word fluency.

The distinction between fluid and crystallized abilities is supported by empirical findings, such as Schwartzman et al. (1987). This study, which analyzes psychometric test results of men in different age groups, finds that verbal abilities remain virtually unchanged, while reasoning and speed abilities decline with age. Blum et al. (1970) provide similar findings, in a test-retest study of twins: vocabulary size is observed not to differ from young to old ages, despite a general reduction in other cognitive abilities.

Studies on age and mental functioning are either based on cross-sectional data, which describe the population's current abilities, or longitudinal data sets, which follow the ability levels of one or more cohorts. Cross-sectional analyzes typically find a younger ability peak, as shown in the "Seattle Longitudinal Study" where age-differences are examined both by longitudinal and cross sectional approaches (Schaie 1996). The longitudinal data suggest that for example verbal abilities peak as late as age 53, while according to the cross-sectional data, the ability peaks take place at younger ages.

Both cross-sectional and longitudinal approaches for measuring age-ability differences cause some problems, the latter one being non-random attrition. In the Seattle Longitudinal Study, more than half of the initial sample was lost by the time of the third wave (Schaie 1994). This loss of respondents is likely to create an upward bias in the age-ability estimates, since the remaining sample is likely to be positively selected. A second source of error stems from test practice, meaning that individuals in subsequent waves perform better simply because they have more exercise in taking these type of tests. Thus, ability decrements found in longitudinal data will most likely underestimate the true cognitive declines (Willis and Baltes 1980).

Cross-sectional data may also produce biased results, since ability levels can differ between cohorts. Willis and Schaie (1998), analyze primary mental ability test results for 1924, 1945, 1952 and 1959 cohorts, and find increasing test performance in reasoning and verbal memory, but decreasing results in tests of vocabulary and numerical ability. Tuddenham (1948) and Flynn (1987) find increases in military cognitive test results over time, though Rodgers (1999) argue that the findings of increasing mental abilities are at least partly due to methodological errors, and therefore exaggerated. Further, the fact that mental ability levels rise may be due to the schooling expansion, which is not explicitly controlled for in these studies, can be an important factor in explaining the rise in abilities. Another argument for this observation, is that such tests have become more commonplace in candidate-selection processes in recent years (Jenkins 2001), which means that individuals from more recent cohorts will prepare more and be more motivated at taking such tests.

3. *Experience and Learning*

The decreased cognitive abilities of older workers can lead to lower productivity, unless their longer experience and higher levels of job knowledge outweighs the declines in mental abilities. Warr (1994) suggest a categorization of professions according to whether age boosts or reduces performance. Here, jobs are distinguished according to whether reduced cognitive performance and/or long experience affects job performance. Salthouse (1984) uses typewriters as an example of a profession where experience alleviates the impact of cognitive reductions. He finds that older typewriters use more efficient work strategies and therefore work as effectively as their younger counterparts despite their reduced speed.

The productivity profile may change over time given structural changes in the labor market. Accelerating technological progress can increase the importance of being able to learn and to adjust to new ways of working, while a long work experience become less important. This is particularly problematic for older employees, due to age-related declines in the processing speed and in learning capacities (Baltes and Lindenberger 1997, Hoyer and Lincourt 1998).

Not only the ability to learn, but also the amount of training offered, is reduced with age. Older employees will have fewer remaining years before retirement, and the firms' decision on whether to invest in their workers' human capital will depend on the expected age at retirement. Senior workers will have a shorter duration to reap the rewards of increased human capital and productivity, and will therefore be offered fewer opportunities to participate in training programs. If the retirement age is assumed to take place at later ages, the firm's returns to human capital investments would be higher, which could increase the amount of training and productivity level that is offered to older individuals.

The elderly learn at a slower pace than younger individuals especially if what they learn is qualitatively different from what they already have mastered. Rybash et al. (1986) argue that as people grow older, they undergo an *encapsulation* of job know-how, implying that the individuals' skills are attached to certain work domains, and are increasingly less transferable. In some occupations, the cognitive abilities that remain stable are the ones most closely correlated with job success. Senior employees can remain highly productive within a field that they know well and where long experience is beneficial. An example of an age-robust ability is *tacit knowledge*, procedural knowledge used to solve everyday problems, which can explain why many older managers perform as good as younger ones (Colonia-Willner 1998). However, when they perform unfamiliar work, they have to rely on the ability to learn and to adjust, exactly those skills that decline most by age. Senior individuals are less able than young individuals to reorient themselves to new task requirements and to solve novel problems (Smith 1996) and age-induced productivity reductions may increase with the complexity of the work task (Myerson et al. 1990).

Job experience improves productivity for several years, but there does come a point at which further experience no longer has an effect. Ilmakunnas et al. (1999) assess a broad sample of Finnish manufacturing employees, and find that job duration improves job performance for only up to a length of 3.8 years. Ericsson and Lehmann (1996), however, argue that it takes roughly 10 years to achieve expert competence in games and situations where strategic and analytic competence is important, such as in chess. In summary, on-the-job-training increases productivity up until a point where additional experience no longer improves productivity.

4. Cognitive Abilities, Productivity and Wages

Age-variation in mental abilities are likely to affect productivity levels, because they are one of the most important determinants of education and work success (Barrett and Depinet 1991). Schmidt and Hunter (1998) investigate how different individual characteristics, such as education, work experience and general mental abilities, relate to job performance. They find that mental ability tests predict a person's job performance better than any other observable characteristic.

Currie and Thomas (1999) and Tyler et al. (2000) find that mental ability levels measured at young ages determine adult income levels, adjusting for socio-economic characteristics. Currie and Thomas examine scores from a general mental ability test at the age of 7, while Tyler et al. analyze the test results of high school drop-outs in math, writing, reading, science and social studies. A range of other studies give further weight to the notion that mental ability levels determine wage levels, including Bishop (1991), Boissiere et al. (1985), Dolton and Vignoles (2000), Grogger and Eide (1993) and Murnane et al. (2000).

Longitudinal studies find an increasingly strong correlation between test scores and wages over time. Murnane et al. (1995) study the relationship between mathematics test performance at the end of high school and hourly wages in the U.S and find that the relation is becoming stronger over time. Also Juhn et al. (1993) find empirical support for the increasing payoff to ability levels within narrowly defined school and occupational groups. Further, the increased demand for cognitive skills in the last few decades applies for the labor market as a whole, at least in the US (Autor et al. 2003).

5. Measuring Productivity of individuals at Different Ages

This section survey the main approaches used to measure job performance differences by age. These include supervisors' ratings, piece-rate samples, employer-employee matched data sets as well as age-specific employment structure and age-earnings profiles.

Studies based on supervisors' ratings typically do not find any clear systematic relationship between the employee's age and his/her productivity. A meta-analysis by Waldman and Avolio (1986) based on 18 supervisor assessment samples, found a slight negative impact of age on job performance and argue that only a small part of the productivity variation could be attributed to age. McEvoy and Cascio (1989) review 96 studies on the impact of the employee's age on supervisors' assessment and sales records and find no clear effect of age on productivity. Remery et al. (2003) analyze a survey of 1007 Dutch business leaders and personnel managers regarding their workers' age and their productivity. They find that older individuals are seen as less productive in particular in workplaces with more older employees, which is where knowledge about older individuals' work capacities is likely to be highest. Medoff and Abraham (1980, 1981) find that the length of the firm tenure is either unrelated or negatively associated to performance evaluations of white-collar American workers.

A general disadvantage with the use of supervisors' ratings' to rank individuals by age and productivity is that managers may wish to reward older employees for their loyalty and past achievements. This can inflate the evaluations of senior employees, and bias the results (Salthouse and Maurer 1996). Dalton and Thompson (1971) investigate performance evaluations not only from supervisors, but also employees, in 6 large firms undergoing rapid technological change. The ratings from the engineers and their managers suggest that employees in their 30s put in the most effort and perform the most sophisticated technical work, and that productivity falls as the engineers move into their 40s and beyond.

A second approach to measuring the impact of age on job performance is based on *piece-rates*, measuring the quantity and quality of a worker's output. Studies based on this approach tend to find that older employees have lower productivity levels. Mark (1957) and Kutscher and Walker (1960) provide some evidence that mail sorters and office workers kept productivity quite stable at higher ages, while factory workers' productivity fell after the age of 55. A study of a broad range of industries from the U.S. Department of Labor (1957) finds that job performance increases until the age of 35, before steadily declining thereafter. At the end of the career, productivity declines by 14% in the men's footwear industry, and 17% in the household furniture industry.

These task-quality/speed tests are potentially more objective as they rely less on managerial assessment, may suffer from the fact that the workers are selected in terms of age groups and occupational types (Rubin and Perloff 1993). Further, the time-limit in such samples may bias results, if older employees can only maintain a high work speed in the short time period that is studied (Salthouse and Maurer 1996).

The productivity of individuals doing “creative” jobs, such as researchers, authors and artists can also be measured by the quantity as well as the quality of their output. Stephan and Levin (1988) study researchers within the fields Physics, Geology, Physiology and Biochemistry. The number of publications and the standard of the journals they appear in are found to be negatively associated with the researchers’ age. Similar evidence is found in the field of economics, where Oster and Hamermesh (1998) conclude that older economists publish less than younger ones in leading journals, and that the rate of decline is the same for top researchers as among others. Further evidence suggesting that there is a negative association between either age or tenure and scientific output is found in Bayer (1977) and Bratsberg et al. (2003).

Miller (1999) describes how the output of artists varies across their life span. He analyzes the number of paintings, albums and books produced by 739 painters, 719 musicians and 229 writers and find that the peak ages for creative output seem to be in the 30s and 40s, the only exception being female authors who write most in their 50s.

A third way of measuring productivity by age is based on the analysis of *employer-employee matched data-sets*[3], where individual productivity is measured as the workers’ marginal impact on the firm’s value-added. These datasets gives information both on wages and productivity estimates, which allows one to compare whether productivity estimates differ from individual wages. These studies are likely

[3] A survey of analyzes based on matched employer-employee data is found in Abowd and Kramarz (1999).

to be less subjective than those based on supervisors' ratings, and there are fewer sample selection problems than studies based on piece-rates. However, the main challenge to this approach is to isolate the effect of the employees' age from the other influences on the firm's value-added, which leads to strong identifying assumptions. It also demands high quality longitudinal data on both firm and individual characteristics.

An overview over how employer-employee studies relate to age is presented in Table 1. For most of the employer-employee studies, an inverted U-shaped work performance profile is found (Andersson et al. 2002, Crépon et al. 2002, Ilmakunnas et al. 1999, Haltiwanger et al. 1999, Hægeland and Klette 1999). Here, individuals in their 30s and 40s have the highest productivity levels. Employees above the age of 50 are found to have lower productivity than younger individuals, in spite of their higher wage levels.

Exceptions to findings suggesting a productivity that decreases by age includes Hellerstein and Neumark et al. (1995), who find that productivity increases over the life span. However, the authors stress that no conclusions about age and productivity can be drawn, due to a high influx of young immigrants, and that their Israeli manufacturing firm dataset is of a relatively poor quality. Similarly, a study of American firms (Hellerstein et al. 1999), suggest that those above 55 contribute the most to output levels. However, Hellerstein et al. (1999) find that the peak productivity shifts to 35-54-year-olds workers when they use the firms' value-added instead of output levels as an indicator of productivity. Further, their previous analysis based on the same dataset studying the impact on the firm's output concluded that workers productivity dropped with age (Hellerstein et al. 1996).

A problem with the fact that most studies on age-productivity differences are based on cross-sectional evidence is that seniority leads to occupational shifts. Good workers get promoted, while inefficient workers lose their jobs or are demoted. This can cause estimation bias, since selectivity increases with age. Employer-employee datasets also have the problem that firms' success can increase the number of new employees and lead to a younger age-structure, which could lead to wrong estimates since a young age-structure could be the consequence rather than the cause of a firms' success. Using a lagged measure of the firm's age composition to estimate current productivity can overcome this problem, as worker influx or outflow to the firm will have less of an impact on the worker's productivity. Andersson et al. (2002) use such lagged measures of the worker's in their analysis of employer-employee data, and their analysis support the idea that older workers tend to be less productive than younger ones. However, they also find that tertiary non-technical workers tend to positively affect productivity until a later age.

Age-earnings profiles can provide information on productivity profiles in settings where wages reflect current productivity. One example is a study by Lazear and Moore (1984), who examine the difference between earnings profiles of the self-employed and salary workers. They find that the self-employed tend to have little wage variation over the life cycle, while salary workers have increasing wages throughout their career. This suggests that productivity remains stable over the life cycle. A study by Boot (1995), describe age-earnings profiles for British workers in the first half of the 19th century, when there were few regulations in the labor market. For the physically demanding work that is analyzed, men reach their peak earnings in the beginning of their 30s, and wages decrease substantially from around 40 years of age.

Changes in the labor market attachment could also provide information on the labor market attachments over time. If older workers cope worse with changes on the workplace, then rapid changes should affect them worse than younger age groups. Bartel and Sicherman (1993) put forward evidence that the risk of job loss is in fact higher among older workers when the rate of technological change is highest. This finding is also supported in studies based on inter-industry and international data (Ahituv and Zeira 2000, Clark et al. 1999).

Analyzes of the relation between changes to the age structure of the population and aggregate measures of performance, such as technical progress or economic growth can also provide insight about workers' productivity. Nishimura et al. (2002) investigate the impact of age structure on technical progress and value-added growth in Japanese industries for the years 1980-1998. They estimate the relation between technological progress and the employee's age structure and find that the relation between the share of educated workers older than 40 years and technological progress is positive in the 1980s, but turned negative in the 1990s. This may be due to a higher rate of technological change in the 1990s which shifted the productivity peak towards younger ages.

Lindh and Malmberg (1999) and Malmberg and Lindh (2002) find that the initial size of the share of 50-64 year old is positively correlated to economic growth in each subsequent 5-year period, by studying age structure and economic growth in the OECD for the period 1850-1990. No clear effect is found for younger age groups. Although the causal mechanism of this correlation is not identified, these investigations suggest that productivity peaks late in the working life. However, several other plausible reasons for why the proportion of 50-64 year olds is positively associated with economic growth. One possibility would be that there is an unobserved factor which affects both the level of economic growth as well as demographic indicators such as life expectancy, which influences age structure. Hence, the association between age structure and growth is not necessarily due to a late peak in life.

6. Age-Earnings Profiles

A wage analysis provided by the OECD shows that for 17 out of the 19 countries observed[4], gross wages peak for the 45-54 year old age group (OECD 1998). The age-earnings profile is characterized by a relatively steep increase in wage levels until the peak is reached followed by a mild reduction in earnings the last years before retirement. The 25-29-year-olds earn on average 0.72 of what the 45-54-year-olds earn, while the 55-64-year-olds earn 0.91 of what the 44-54-year-olds do[5].

Age-differences in wages increase with educational level (OECD 1998). For individuals with less than an upper secondary education, 25-29-year-olds earned 0.81 times of what the 45-54-year-olds earned, while for those with a university education, 25-29-year-olds earned only 0.53 times of what the 45-54-year-olds earned.

7. Age-Earnings and Age-Productivity Profiles

Based on the evidence presented in previous sections, the apparent late peak in the age-earnings profile contrasts the earlier peak in productivity level. This suggests that there exists a discrepancy between productivity and wages, where wages are lower than productivity levels at young ages, unless the productivity estimates are wrong[6].

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[4] The countries in the study were Australia, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Mexico, the Netherlands, New Zealand, Norway, Portugal, Sweden, Switzerland and the U.S. For the Czech Republic and the UK, the wages peak for the 35-44-year-olds.

[5] These percentages represent unweighted averages for the countries in the study.

[6] Alternatively, one could argue that wages and productivity levels match at all ages. Age-earnings profiles indisputably slope upwards, while there is uncertainty about the shape of the age-productivity curve. One could therefore argue that it is the productivity profile which is incorrectly estimated, and that the true productivity profile is identical to the age-earnings profile.

Figure 2 shows a stylized situation where it is assumed that younger workers are underpaid and older workers are overpaid relative to their productivity. Hence, firms can only profit from employing the young. The implications in the case of population aging is shown, where the firms' profits decrease as the share of unprofitable older workers increase. Therefore, as the share of older workers increase, the firms' incentive will be either to exclude them or to lower their wages.

Several theories have emerged to explain the rationality of why age earnings profiles peak later than age productivity profiles. One important reason is employers' initial uncertainty about new employees' productivity levels (Harris and Holmstrom 1982). Older workers are paid above their marginal productivity, since upwards sloping wage profiles strengthen the employees' work effort by raising their shirking costs, lower the firms' need to train new workers and decrease the risk of company secrets being shared if to competing firms because of low turnover. Further, when older workers receive higher wages as a reward for past productivity, junior workers' loyalty to the firm can rise since they will also want to reap the rewards of a bonus for long service. Hutchens (1989) argue that this type of incentive systems, *delayed payment contracts*, is most frequently used when the workers' performance is difficult to observe and measure.

An important reason why it is in the interest of firm owners to have a wage peak at relatively high ages, is that the average worker has been young, so that firms gain from having a delayed payment contract as long as most workers are paid below their marginal productivity. However, as Lazear (1988) contests, population aging challenges the financing of such systems, by increasing the firms' incentives to either decrease the wages of older individuals' or to lay them off.

Delayed payment contracts implicitly assume that individuals have either life long contracts in a firm or that any job switches are done between firms with similar wage systems. However, when a worker could choose whether to work in firm A, where the wages peak early in life and firm B, where the wages peak late in life this type of payment system can not be sustained. The rational worker could spend his/her younger years in firm A with high initial salaries, and then switch to firm B with high seniority-wages in the middle of his/her career. Consequently, firm B will lose young workers who otherwise would bear the costs of seniority wages. The frequency of job shifts has increased over time (Bergmann and Mertens 2002, Burgess and Rees 1996), and if this trend continues, and involves shifts between different types of job shifts, it means that age-earnings profiles of firms employing the same type of workers would need to harmonize, which most likely shift would involve putting wages toward younger ages.

8. Conclusion

Studies that estimate the influence of age on individual productivity are based on different indices, including supervisors' evaluations, piece-rate studies and analyzes of employer-employee datasets. Most piece-rate studies, measuring the quantity and quality of the workers' output, and analyzes of employer-employee datasets, where the firms' productivity is measured, suggest that productivity follows an inverted U-shaped profile where significant decreases are found after the age of 50. A problem with most estimates of how productivity varies by age is that older individuals who remain in the workforce are positively selected and have a higher productivity than that of those who leave the workforce, which can bias the estimates.

Further, although supervisor's evaluations do on average show little or no relationship between the assessment score and the age of the employee, subjective opinions may be biased, where for example managers opinions of older employees may be inflated due to loyalty reasons.

An important cause of these age-related productivity declines is likely to be age-related reductions in cognitive abilities. Some abilities, such as perceptual speed, show relatively large decrements from a young age, while others, like verbal abilities, show only small changes throughout the working life. Experience boosts productivity up to a point, and thereafter will additional tenure have little effect. Older individuals learn at a slower pace and have reductions in their memory and reasoning abilities. In particular, senior workers are likely to have difficulties in adjusting to new ways of working.

Older workers may possess characteristics that are important to the firms' success, but difficult to measure. Senior employees may have a wider professional network, give training and guidance, provide tacit knowledge, uphold norms that prevent shirking and opportunistic behavior, and know better how to deal with problems that arise with only low frequencies. Such factors are difficult to quantify, in particular in studies of quantity of output such as studies of piece-rate firms. However, other approaches, such the analysis of employer-employee datasets, could be in a better position to capture such effects.

Authorities in most aging economies encourage 'active aging' policies, intended at increasing labor market participation of older individuals. The productivity loss associated with early retirement indicates that this emphasis is entirely justified. However, active aging policy programs must take into account that older workers' current seniority-based compensation systems can create a disparity between earnings and productivity at senior ages, which could lower the employment opportunities of older workers.

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Table 1. Overview of Employer-Employee Datasets

Authors	Region/ Country	Sample Size	Individual Variables	Age Categories	Control Variables	Productivity Measurement. Individuals' influence on:	Age-Productivity Profile	Remarks
Ilmakunnas et al. (1999)	Finland	3,882> Firms, 279,181 Employees	Education, Experience, No. of hours worked	Average employee age at each firm examined	Firm's Age, Capital	Firm's Value-Added	Productivity peak around age of 40.	Manufacturing
Crépon et al. (2002)	France	77,868 Firms, 3,000,000< Employees	Gender, Occupation, No. of hours worked	<25, 25-34, 35-49, 49<	Firms' Age and Size, Industry Type, Capital	Output	Productivity peaks for 25-34 Year Olds. Lowest for those above the age of 50	Manufacturing and non-manufacturing
Hægeland and Klette (1999)	Norway	7,122 Firms, 270,636 Employees	Education, Experience, No. of hours worked	Dependent on Length of Education and Length of Experience	Firms' Age, Industry Type, Region, Public Ownership, Foreign Ownership	Firm's Value-Added	Productivity peaks in the 30s, declines for those with above 15 Years of experience (who are in their late 30s and older)	Manufacturing
Hellerstein et al. (1999)	U.S.	3,102 Firms, 128,460 Employees	Gender, Race, Occupation, Whether Married, Education	<35, 35-54, 54<	No. of Employees, Region, Type of Establishment, Industry Type	Firm's Output or Value-Added	Productivity peak 55 years and older if output is used as estimate. Productivity lowest for 55 years and older if value-added is used	Manufacturing

Table 1. Overview of Employer-Employee Datasets (Continued)

Authors	Region/ Country	Sample Size	Individual Variables	Age Categories	Control Variables	Productivity Measurement. Individuals' influence on:	Age-Productivity Profile	Remarks
Haltiwanger et al. (1999)	Maryland/ U.S.	Lacking Information (All firms in Maryland 1984-1997)	Gender, Education, Immigrant status	<30, 30-54, 54<	Firm s Age and Size, Industry Type, Period-Effects	Sales per employee	Workers above 55 have lowest productivity	All industries
Andersson et al. (2002)	Sweden	2,874 Firms	Education	16-29, 30-39, 40-49, 50-59, 60-64, 64<	Period-, Plant- and Industry-Effects	Firms' Value-Added	Workers above 50 with primary and secondary education have lower productivity, tertiary educated above 50 have higher productivity	Manufacturing and mining industries. Longitudinal analysis confirm findings.
Hellerstein and Neumark (1995)	Israel	933 Firms	Occupation	<35, 35-54, 54<	Industry Type No. of Employees, Firms's capital and Input factors R&D Spending	Firm's Output	Productivity Peaks for 55 years and older	Poor quality of data, and high inflow of young immigrants lower validity of the study

Figure 1.) Outline of key factors affecting job performance

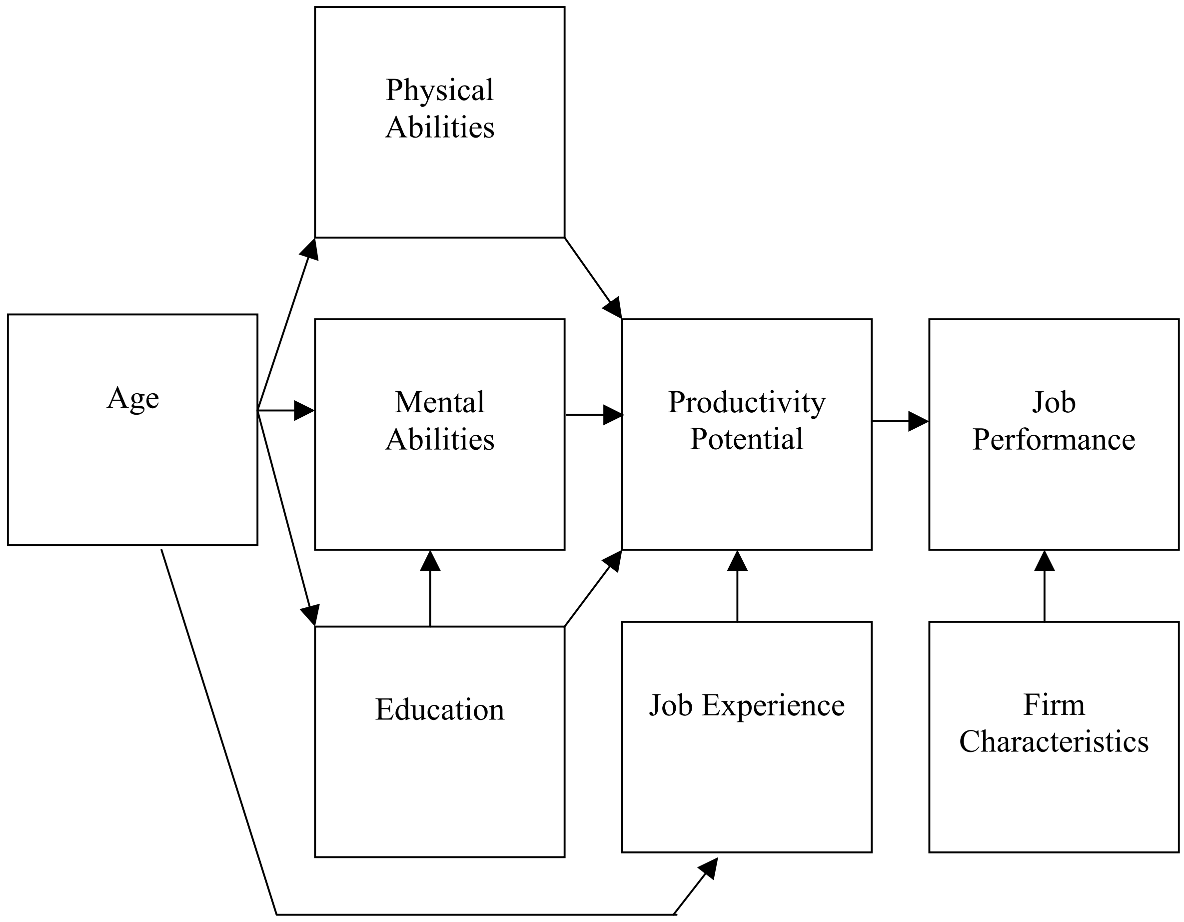

Figure 2.) Stylized Presentation of Productivity and Earnings across the life span. Based on Lazear (1979) and Jackson (1998).