The Speed of Obsolescence: Evidence from the Dutch Public Sector

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HRD is extensively concerned with human capital investment, but only focuses on how skills and knowledge become obsolete to a limited extent. In this paper we look at the speed of obsolescence. Using data from a survey among Dutch public sector employees, we find that the yearly rate of skills obsolescence is 2.6%. Subsequent analyses show that the skill obsolescence rate is impacted by educational attainment level, occupation, and sector of employment.

Keywords: Skills obsolescence, Yearly rate, Public sector

Human capital plays a crucial role in the knowledge economy. In most western countries, economic activity is becoming more knowledge-intensive. This may be caused by the increasing complexity of production processes and a migration of capital intensive production to low-wage regions. These developments are reflected in a changing composition of employment. Some types of low-skilled jobs disappear completely while the skill requirements of other jobs shift. This implies that today's labor market demands more intermediate and highly skilled people, while the demand for low-skilled labor decreases, compared to a few decades ago (Groot & de Grip, 1991).

Knowledge intensive production of products and services requires a well-educated labor force. But it is equally important that the skills and knowledge of the workforce remain up-to-date, as various developments render human capital obsolete (van Loo & Rocco, 2006). Examples of these developments are technological innovations (Bartel et al., 2002; Watkins and Marsick, 1993), organizational change (Bresnahan et al, 2001; Pillay, 1998) and increasing competition (Ghosal, 2002).

In the past years, there has been a growing realization that investment in skills and knowledge of the workforce is essential. Both governments and the corporate world are engaged in developing initiatives geared towards increasing the educational attainment and are aware that skills obsolescence requires continuous investment in human capital. Investment in human capital has become a key priority evidenced by a surge in both HRD research and practice. Far less, however is known about the obsolescence of skills and knowledge and which factors play a role here.

Problem Statement and Research Questions

In this paper, we look at the speed of skills obsolescence and the factors that contribute to it. Our problem statement is: How are fast do skills depreciate, what is the impact of personal characteristics (age and gender), and to what extent do the educational attainment level, the occupation and the sector of employment contribute to skills obsolescence? In order to address this problem statement, we propose the following two research questions:

1. How fast do skills and knowledge depreciate and what is the relationship with age and gender?
2. Is educational attainment, occupation and sector of employment related to the speed of skills obsolescence?

Before we address these research questions by analyzing skills obsolescence empirically, we first discuss the theoretical framework and review different types of skills obsolescence and measurement methods in the next two sections.

Theoretical Framework

The theoretical framework for this study is human capital theory. Human capital may be defined as an individual's capacity to produce goods and services (Carnevale, 1983). Human capital theory has a rich history in economic science. Since the pioneering work of Becker (1962) and Mincer (1974), numerous theoretical and empirical contributions have been published. Notwithstanding the enormous amount of publications available, the basic idea of the human capital model is simple. Analogously to the theory on physical capital goods, the investments in

humans are considered to represent a stock of capital that can be used at the workplace. The key element in human capital theory is that there is an assumed equilibrium between the investments in expertise that people acquire through different means (education, training, experience etc) and the returns to expertise in terms of labor productivity or income. Human capital theory is based on the following assumptions: Product and labor markets are competitive; firms attempt to maximize profits; workers seek to maximize life-time earnings; and the labor force has both knowledge and mobility to take advantage of the best opportunities available (Swanson & Holton, 2001).

In essence, the human capital model is concerned with the relation between an individual's investment in human capital (education, training participation, experience etc.) and the results from human capital investment in terms of compensation or productivity. Human capital theory also concerns itself with the impact from different types of human capital (general, specific, transferable) and acquisition modes (initial or during the career, formal vs. informal, intentional vs. incidental, on-the-job vs. off-the-job) on labor market outcomes.

Skills obsolescence is an integral part of human capital theory as investments in human capital only indicate *gross* investments in skills and knowledge. *Net* human capital investment can only be determined when the decay of human capital over time is taken into account. Skills obsolescence, which relates to the process of individual skill decay or the decrease in the value of certain skills, should therefore be considered when analyzing the relationship between human capital investments and labor market outcomes. Skills obsolescence caught the attention form human capital theory when it became apparent that the obsolescence of worker skills may be regarded as the main reason for why individual workers need continuous updating of their skills throughout the career in order to remain sufficiently productive.

Skills Obsolescence: Types and Measurement

Types of skills obsolescence

Skills obsolescence is a complex phenomenon. In the economic literature on the subject (Neumann & Weiss, 1995; De Grip and van Loo, 2002) usually a distinction is made between technical and economic skills obsolescence. Technical skills obsolescence occurs when skills and knowledge depreciate due to overuse ('wear') or when skills and knowledge are not used for extended periods of time ('atrophy'). A typical example of technical skills obsolescence is the physical wear that occurs with physically demanding work conditions. On the other hand, skills obsolescence can be economic. In that case not the actual stock of human capital depreciates, but the value of them in the labor market decreases, as a result from less demand for some skills or because workers do not need certain skills and knowledge when they change jobs. The decreasing value of classic typewriter skills with the introduction of personal computers is a typical example of economic skills obsolescence (Van Loo, 2005).

Skills obsolescence has also been discussed in other research areas. In organizational psychology, skills obsolescence theory is heavily influenced by Kaufmans work on the obsolescence of technical professionals (engineers). Kaufman defines obsolescence as: The degree to which organizational professionals lack the up-to-date knowledge or skills necessary to maintain effective performance in either current or future work roles (Kaufman, 1989, p. 74). Kaufman (1978, 1979) distinguishes between two types of obsolescence: job obsolescence with deals with the ability to perform one's current job or work role and professional obsolescence, which can be described as the capability to be effective in future work roles. By applying a systems model approach, Kaufman relates the development of job obsolescence among engineers to four factors (Kaufman, 1989, p. 77): 1) Environmental change: rapidly changing technology such as the introduction of computers, the information explosion and the exponential increase in technical knowledge; 2) Organizational climate: determined to a large extent by management policies and practices, especially those related to how the reward system values keeping knowledge and skills up-to-date; 3) The nature of work: job assignment requirements, especially the degree to which knowledge and skills are used; and 4) Individual characteristics: cognitive, motivational and personality factors related to staying up-to-date. In Kaufman's model, these four factors all have an impact on obsolescence. Organizational climate affects obsolescence directly as well as indirectly through the nature of work. Individual characteristics are affected by the nature of work and in turn impact obsolescence. Kaufman's empirical work shows that organizational climate and the nature of work are more important contributing factors to obsolescence than individual characteristics. But these individual characteristics do still impact obsolescence significantly. Development activities, both formal and informal, have a negative impact on obsolescence (Kaufman, 1982).

Pazy (1996) notes that the point of view of individuals in explaining obsolescence and training behavior has not been of much interest in the literature on obsolescence and updating behavior. Her research (Pazy, 1996, 1997) aims to address this issue by explicitly considering the rationale behind participating in training activities to combat skills obsolescence.

Measurement of skills obsolescence

In human capital theory, skills obsolescence is usually measured in an indirect manner, by using wages or earnings profiles. The idea behind this is that ultimately, skills obsolescence will reflect itself in the wage. Empirical work on the relation between skills obsolescence has focused on examining the effects of career interruptions (Mincer & Ofek, 1982), the loss of human capital due to worker displacement (Jacobson, LaLonde, & Sullivan, 1993) and the obsolescence of skill due to technological development (Neuman & Weiss, 1995). The main problem in using wages or wage profiles in measuring skills obsolescence is that it is difficult to isolate the true obsolescence effects. For example, large wages losses for workers who change industries may reflect the loss of sector-specific human capital (i.e. obsolescence), but may also be due to efficiency wages, union rents, incentive pay schemes or internal labor markets (Kletzer, 1998).

Skill obsolescence can also be approached and measured in a more direct manner. It can be seen as the value loss of the entire skill set of workers, but it can also be approached by looking at separate competences (Van Loo & Semeijn, 2004). The chosen approach clearly impacts the measurement method. When skills obsolescence is seen as the loss of the entire skill set of employees it can be measured by calculating the total decrease in the skills and knowledge between two consecutive skill measurements. When skills obsolescence is approached by looking at a number of competences, a number of potential measurement problems arise: What are the relevant competences? How should they be measured? And how should we find evidence for the depreciation of certain competences?

In this paper, we approach skills obsolescence by defining it as the decrease in value of the total of someone's skills and knowledge. This implies that we apply a broad definition of the skills obsolescence concept, which encompasses various causes for skills obsolescence. In the way we measure it, skills obsolescence can occur when some skills and knowledge becomes less relevant over time. On the other hand, it can also be caused by job mobility, which make some skills less usable or even completely obsolete. The advantage to our approach to skills obsolescence is that it is relatively easily measured. The disadvantage is that it is a rather rude measure, as it implicitly considers all decreases in skills and knowledge to be evidence for skills obsolescence. This implies that the non-use of skills and knowledge that typically occurs when workers work outside of the profession they were trained for during their education (e.g. a teacher becoming a car mechanic) is also seen as skills obsolescence. In addition, our skills obsolescence measure can be impacted by the discrepancies between what workers learned during education and on-the-job and what is expected from them in a job.

Method

In order to measure skills obsolescence we use a quantitative approach. We calculate the yearly rate of skills obsolescence by using two types of information:

1. The self-assessed percentage of skills and knowledge acquired during education and on-the job that is still useful today (KB);
2. The length of the active working career (T).

The complement of the percentage of skills that is still useful today (100-KB) can be seen as the total amount of skills obsolescence that has occurred during someone's active life. This skills obsolescence can be expressed as a yearly rate (YSO) by using the following equation:

$$YSO\% = 100 \times \left(\left(1 + \frac{(100 - KB)}{100} \right)^{\frac{1}{T}} - 1 \right)$$

Data

We use data from a large-scale survey among employees employed in the Dutch public sector. We surveyed workers from all 12 subsectors in the public domain, but excluded active military employees. The survey was commissioned by the Netherlands public sector retirement fund. In a first step, using telephone numbers from the customer data base, about 10.000 active public sector employees, stratified by sector of employment and age group, were contacted with the request to participate in a survey. The target group was distributed equally among sector of employment and age. Half of the employees were younger than 45 at the time of the survey, while the other half was 45 years of age or older. About half of the employees initially contacted agreed to participate and they were asked to state their e-mail address. The group willing to participate received an e-mail with an embedded web-link to the online survey.

Of the 5.000 employees willing to participate initially, 2.533 eventually completed the survey (response rate of 51%).

The survey included a number of items on labor conditions, job satisfaction, HRD policies and the skills and knowledge needed to perform effectively. There were also a number of items on retirement and opinions on the retirement policies of the public sector organizations. The survey data was merged with administrative data from the pension fund's customer data base. This data included pension entitlements, the current wage, age, the length of the career, gender and sector of employment. For this paper, a question on the percentage of skills and knowledge acquired during education and work that is still useful today (KB) was central. The length of the active working career (T) was taken from the administrative data, which has the advantage that measurement errors in determining the number of years of service are avoided.

Results

Table 1 provides an overview of the average yearly percentages of skills obsolescence for all workers combined, for males and females separately and for a number of age clusters. The main result is that employees in the Dutch public sector lose 2.6% of their skills and knowledge on a yearly basis. On average, males have a lower rate of skills obsolescence (2.3%) than females (3.2%). The difference is statistically significant ($F=39.2$, $p=0.00$). Differing rates of skills obsolescence between gender can be explained by the phenomenon that women often interrupt their careers to raise their children, which implies that they are not employed for a number of years in their career. In those years, they may lose skills and knowledge because they do not use them, while they are generally unable to acquire new skills that are required for work.

Table 1. *Skills obsolescence of Dutch public sector employees*

Group	Average yearly % during careeer
Gender	
Male	2.3
Female	3.2
Age	
- 25	8.6
26-30	7.4
31-35	4.3
36-40	2.7
41-45	2.1
46-50	1.7
51-55	1.3
56-60	1.1
61 +	1.2
Total	2.6

The table also shows that young workers are more affected by skills obsolescence than older workers. Workers under 30 lose 7-8% of their skills and knowledge a year. The rate of skills obsolescence for older workers (56+) is only around 1%. ANOVA showed that the differences between the age groups are statistically significant ($F=180.8$, $p=0.00$). The substantial difference in skills obsolescence rates between age groups can be explained in various ways. Firstly, younger workers change jobs faster than older employees, which implies that part of the skills obsolescence we measure for younger workers is caused by the fact that what young people learned during their education is no longer useful in their job. In addition, young workers have generally acquired less knowledge during their career than older workers. Therefore, the total amount of skills and knowledge available will be less for younger, which implies that a larger share of skills and knowledge will depreciate each year. Finally, when young people work in more dynamic jobs than older workers, they will be confronted with more changes, which implies that their skills and knowledge will depreciate faster.

Skills Obsolescence by Educational Attainment Level, Occupation and Sector of Employment

Is the degree of skills obsolescence related to the educational attainment level of workers, the occupation they have and their sector of employment? Figure 1 shows that the yearly rate of obsolescence is higher as the educational attainment level rises. The differences between the educational levels are statistically significant (ANOVA, F=18.2, p=0.00). Workers that have only completed elementary education face a skills obsolescence rate of 1,4% a year, while university graduates lose close to 4% of they skills and knowledge on a yearly basis. We found earlier that skills obsolescence is lower for older workers. The fact that we find higher obsolescence rates for highly educated workers could therefore be the result of the fact that highly educated workers are younger on average. From background analyses on our data, this is, however, only the case to a very limited extent. Only workers with primary or lower intermediate education are a little older on average. For the other educational attainment levels, there are no significant age differentials.

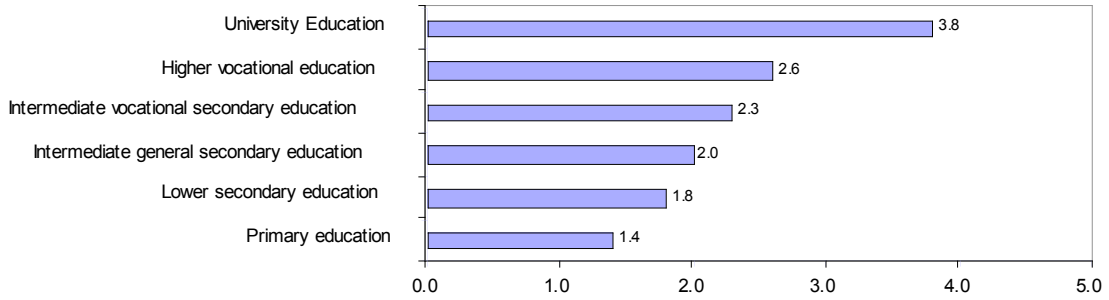

Figure 1. Skills Obsolescence by Educational Attainment Level, Yearly % During Entire Career

Figure 2 presents the yearly skills obsolescence rates for 14 occupational groups. ANOVA revealed that the differences between groups are statistically significant (F=4.4, p=0.00). In four occupations, the yearly rate is higher than 3%: Researchers/scientists (4%), ICT professionals (3,6%), Public administration and law officials (3,4%) and medical and care professionals (3,2%). Again, the influence of age is very limited. Only ICT professionals are slightly younger than average. The four high skills obsolescence occupations are intuitively attractive. These are all occupations that are highly susceptible to the effects of technological advance, organizational change and other

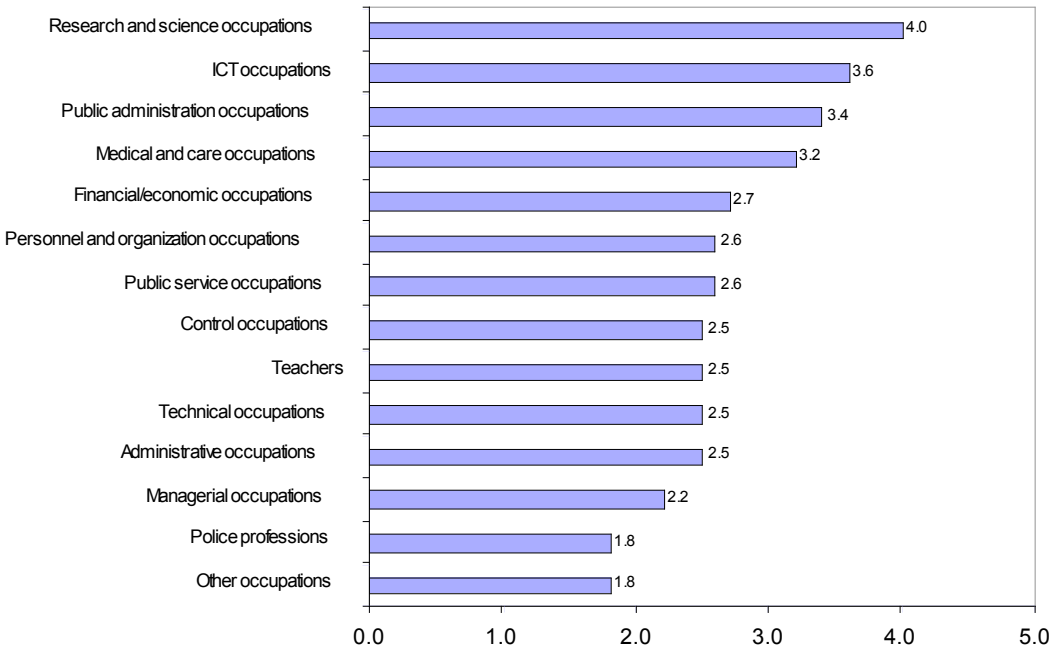

Figure 2. Skills obsolescence by occupational group, yearly % during entire career

innovations. Occupations with average skill obsolescence rates (between 2.5% and 3% per year) are: financial/economic occupations (2.7%), personnel and organization occupations, public service occupations (both 2.6%), control occupations, teachers, technical occupations and administrative occupations (all 2.5%). For managers, police professions and other occupations, the degree of skills obsolescence is lower (2.2%, 1.8% and 1.8% respectively).

In figure 3 we look at skills obsolescence rates in various public sectors. The differences between the sectors are statistically significant (ANOVA, F=3.2, p=0.00) and the rate of skills obsolescence is highest in academic hospitals (3.2%) and universities (3.1%). The rate is somewhat lower in the public utility sectors and in the provincial governments (both 2.9%). There is relatively little skills obsolescence in the civilian defense sector (2.2%), primary and secondary education (2.1%) and the police (1.8%). The sectoral pattern we find reflects the skills obsolescence rates by occupational group, but the differences between sectors are smaller than the differences between occupational groups. This can be explained by the fact that occupational clusters are more homogeneous than sectors. Sectors generally employ a mix of people, both in high and in low skills obsolescence occupations. For instance: hospitals employ both medical and care professionals (with high rates of skills obsolescence) and administrative personnel (with low rates of skills obsolescence).

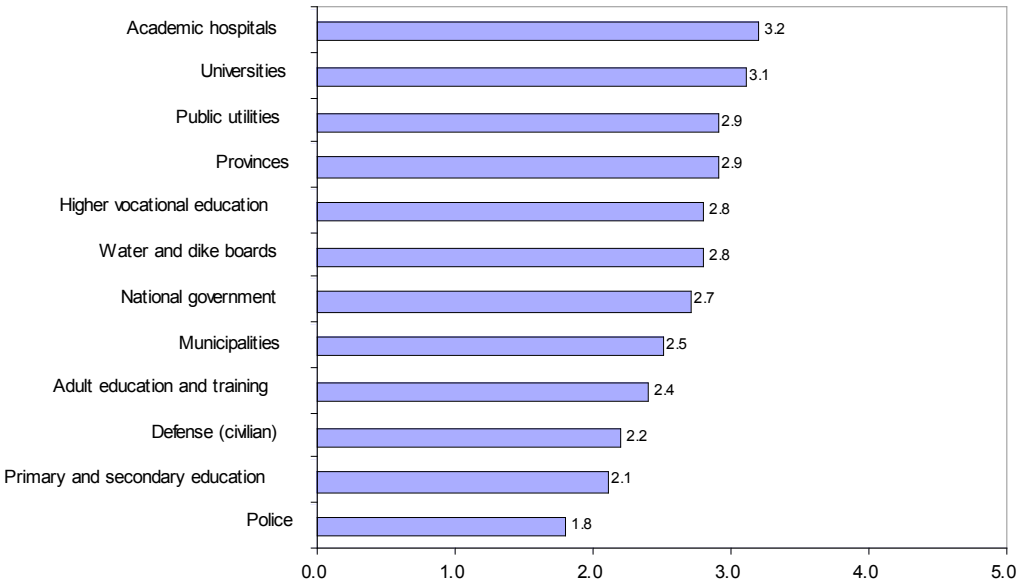

Figure 3. Skills obsolescence by sector of employment, yearly % during entire career

Towards a comprehensive model

The analyses show that skills obsolescence is impacted by the educational attainment level, the type of occupation and the sector of employment. This raises the question whether the combination of these employment characteristics has a significant impact on skills obsolescence. We therefore investigate to what extent these labor market characteristics impact the speed of skills obsolescence in a multivariate framework. In addition to the three labor market variables, we include a number of important controls. We include gender and two job tenure measures: the number of jobs held in the public sector and the number of jobs in the public sector. The number of job changes can impact the degree to which employees are confronted with skills obsolescence. On the one hand, many job changes during ones' career can lead to a loss of job specific skills and knowledge, when workers in new jobs are not able to use the human capital from previous jobs. On the other hand, job changes can lead to less skills obsolescence, when they contribute to the acquisition of skills and knowledge.

Figure 4 gives an overview of the variables that have a significant impact on the yearly rate of skills obsolescence. The figure displays all regression coefficients that have a significant impact on skills obsolescence. The impact of these coefficients is measured by the percentage points skills obsolescence changes as a result of the various factors.

Eleven of the factors have a significant impact on the rate of skills obsolescence. Firstly, the educational attainment level has a large impact. Skills obsolescence is higher for workers with higher vocational or university education than for intermediate or lower educated workers. The average difference between these two groups is about two percent. There are also a number of occupational groups that have a positive impact on skills obsolescence. These are: public policy and legal occupations, technical occupations, ICT occupations and scientific or research occupations. Especially ICT occupations are susceptible to skills obsolesce. The yearly rate of skills obsolescence for ICT professional is 1,6% higher on average than workers employed in other occupations. Sector of employment also has an impact on skills obsolescence. Workers employed in the public utility sector are confronted with higher rates of skills obsolescence, while employees in the primary and secondary education sector experience less skills obsolescence.

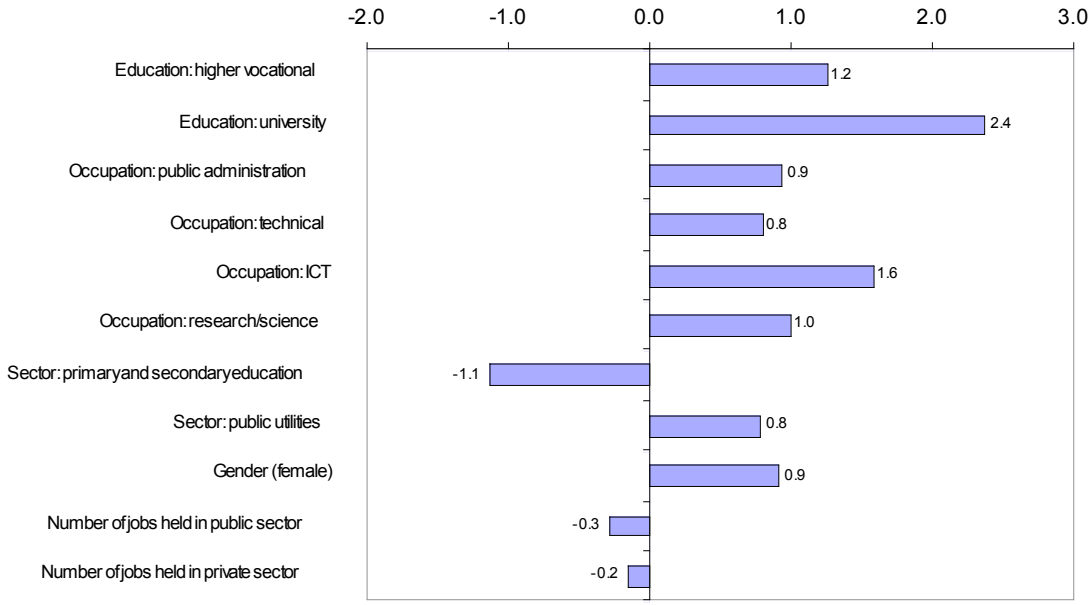

Figure 4. Factors with a significant impact on skills obsolescence, impact on yearly skills obsolescence rate in percentage points.

Gender has a significant impact on skills obsolescence as well. Female workers face, irrespective of their educational background, occupation and sector of employment almost 1% more skills obsolescence than male workers. In addition, the number of jobs held appears to play a role. More jobs, either within or outside of the public sector implies a lower rate of skills obsolescence.

Limitations and conclusions

The method we used to analyze skills obsolescence in this paper should be seen as a starting point for further research into how and why skills and knowledge depreciates. The method features a number of limitations. Firstly, the measurement of skills obsolescence does not distinguish between knowledge and skills acquired during education and skills and knowledge acquired during the working career. This implies that the possible impact of training and education during the career on the usefulness of the skills and knowledge acquired before the career is not addressed. Secondly, we measure skills obsolescence by investigating the decrease in the whole set of skills and knowledge someone possesses. It may be expected, however, that some skills are a lot more susceptible to skills obsolescence than others, while some knowledge may not depreciate at all or even increases during the career. These differences could be addressed by extending the analysis to include a number of different competences. Finally, the results presented here are based on the analysis of public sector workers in the Netherlands. Future research could focus on extending the analysis to market sector workers and to workers in other countries.

Despite the limitations, the method to analyze skills obsolescence yields interesting and intuitively appealing results. We found that the educational attainment level, the occupation and the sector of employment has a clear and significant impact on the degree to which an employee is faced with skills obsolescence. The fact that some groups

of workers are more affected by skills obsolescence than others offers possibilities to improve existing training and employability policies. Both governments and market organizations could use this type of information to better focus their HRD efforts.

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