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**KNOWLEDGE TRANSMISSION IN THE  
SECOND PART OF CAREERS: DOES  
FORMAL TRAINING MATTER?**

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# **Knowledge transmission in the second part of careers: does formal training matter?**

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## **Purpose**

This paper examines to what extent formal training targeted to workers aged 45 and over could enhance their knowledge transmission activities and specifically in changing work environments.

This is a key issue for Human Resources practitioners. Allowing older workers to keep on interacting with their colleagues and transmitting their knowledge acquired through experience reduces the risk for firms of losing critical knowledge assets.

## **Design/methodology approach**

We use French matched employer-employee data to estimate the effect of participation in training sessions intended to support change on the probability for workers aged 45-59 of frequently showing work practices to their co-workers.

To account for selection bias into training, we reduce the group of untrained workers to those who wanted to attend to training session but had to cancel their participation for exogenous reasons. Leuven and Oosterbeek (2008) show that this is a valid approximation of a random assignment to training.

## **Findings**

Training with the intention to support change for workers aged 45 and more significantly increases knowledge transmission for training participants. This effect is not strictly related to a supervising role as it is significant for workers without subordinate; it holds when we address the selection bias into training by narrowing down the comparison group.

When training comes as a response to mitigate the potential negative effects of technological or organizational changes in the work environment, it helps workers aged 45-59 maintain their contribution to the knowledge base of the production.

## **Originality**

This study sheds a new light on the effectiveness of older workers' training. Some contributions argue that training for older worker is not very effective because it has no significant effect on employment duration, earnings or on relative productivity.

We show that specific types of training to update skills after a technological or organizational change allow older workers to keep interacting with their co-workers and pass their knowledge gained through experience, thereby reducing the risk for firms of losing critical knowledge assets.

## **Research implications**

Our findings suggest that two main aspects have to be borne in mind when assessing the effectiveness of training for older workers. First, the reasons for training must be carefully considered, especially if it occurs in response to technological or organizational change in the workplace. Second, the continuation of interactions between older workers and their co-workers must be factored.

If the public debate acknowledges that employee learning and development is critical in times of structural change and crisis, the outcomes of knowledge transmission within workplaces in terms of job satisfaction, turnover intentions, productivity or innovation, which we do not cover in this paper, deserve further investigations. In particular, we believe that studying how the training that supports technological and organizational change influences the relationship between age diversity and firm productivity is a promising avenue for future research.

## **Practical implications**

The implication of this article for human resource managers is that there may be a substantial cost to not updating the skills of older workers after technological or organizational change.

Indeed, it is likely that a large proportion of jobs will only be partially automated, which implies that while some tasks will disappear, rendering the corresponding skills obsolete, others will persist and the skills associated with them will remain useful to organisations.

If older workers are excluded from their work collectives after these changes, because their skills have not been updated through training, the knowledge from their accumulated experience that remains valuable will be irrevocably lost when they retire.

**JEL Classification:** J14, J24

**Keywords:** Older workers, knowledge transmission, skill obsolescence, technological and organizational change, training

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## 1 Introduction

The rapid ageing of the workforce is a major challenge for human resource practitioners. They have to maintain older workers' employability to encourage them to stay longer in their jobs. In addition, they have to cultivate greater intergenerational knowledge sharing to deal with increasingly age-diverse teams and organizations. In this setting, European Union employers and trade unions have negotiated in March 2017 a framework agreement on active ageing as well as an inter-generational approach. This agreement has two main goals: improving the ability of workers of all ages to remain healthy and active in work until the legal retirement age and facilitating transfers of knowledge and experience between generations.

However, recent studies that have examined the effective transmission of knowledge from experienced employees point out a strong decline of knowledge transmitters over age 45, i.e. in their second part of careers (Masingue, 2009; Molinié and Volkoff, 2013; Greenan and Messe, 2018). This suggests that the knowledge accumulated by employees approaching retirement age is no longer passed on, which can lead to inefficiencies if younger employees have to relearn on their own instead of drawing on the experience of older employees. To explain this phenomenon, Greenan and Messe (2018) put forward the role of technological change and specifically the introduction of Information and Communication Technologies (ICTs) in organizations. Some empirical evidence show that these innovations accelerate the obsolescence of specific skills acquired by senior workers (De Grip and Van Loo, 2002) and affect them negatively through adaptability requirements (Aubert et al., 2006; Bartel and Sicherman, 1993). Consequently, workers aged 45 and over have progressively lost their role of knowledge transmitters in the dynamic work environment of the most technology advanced firms.

Building on these insights, this paper examines to what extent formal training targeted to workers aged 45 and over could enhance their knowledge transmission activities and specifically in changing work environments. We start from the assumption that when an important change in the techniques used in the production process is implemented, part of the skills accumulated by experienced workers become obsolete while others remain valuable for the organization. Backes-Gellner and Janssen (2009) distinguish two kinds of tasks and required skills: those based on technical knowledge (e.g. programming software) and those based on experience (selling or negotiating contracts). From German data, they show that workers performing knowledge-based tasks face greater skill obsolescence than those performing experience-based ones. More generally, Green (2012) notes that the frontier between tasks and skills affected by the development of ICTs and those that are not remains difficult to draw. This strongly relies on the decisions that companies make to capitalize on the knowledge-based resources held by their employees when the new technology is implemented and its uses defined. In any case, offering training opportunities to workers in the second part of their careers to update their obsolete skills is a way to maintain access to those skills that still contribute to the knowledge base of production. In doing so, these workers remain integrated to the process of knowledge transmission within the organization. Of course, we are not suggesting here that this is the only role of training, nor that it has no potential impact on productivity. We recognize that training is also likely to maintain the employability of workers through the renewal of their skill set. Nevertheless, our empirical strategy does not aim to provide evidence in this respect. We focus on the knowledge transmission effect of training, an indirect effect that the literature has scarcely studied.

The sharp decline with age of participation in training is widely acknowledged (Becker, 1962; Behaghel and Greenan, 2010; D'Addio et al., 2010). This can be partly explained by the shorter period when this training investment will be valorized (Cheron and Terriau, 2018), by a lack of motivation of older workers for improving their human capital (Warr and Fay, 2001) or by employers' perceptions about

their lower adaptability (Taylor and Walker, 1994; Loretto and White, 2006; Van Dalen, Henkens and Schippers, 2010; Wang, Olson and Shultz, 2012). Some specific policies to combat this decline have been pioneered, such as an age-dependent tax deduction on training expenses in the Netherlands (Leuven and Oosterbeek, 2004). Hence workers aged 45 and over that participate in training are likely to be highly selected. To address this selection bias, we follow the approach suggested by Leuven and Oosterbeek (2008). We narrow down the group of untrained workers to those who wanted to attend to a training session but had to cancel their participation on the basis of exogenous reasons. Leuven and Oosterbeek (2008) show that this is a valid approximation of a random assignment to training. This method allows us to come closer to the causal effect of training for workers aged 45 and over on their probability of passing on their knowledge to other colleagues.

We use data from a French matched employer-employee survey on training and workers' trajectories (DEFIS) conducted in 2015. Respondents declare how frequently they show some work practices to other colleagues, so we can identify the workers who are integrated to knowledge transfer process of their firm. In addition, the DEFIS survey provides a detailed description of employees' training participation and training characteristics and goals. The employee level survey is linked to a firm level that provides information on workplace characteristics and firms' specific Human Resources Management practices. We can control for a large set of reliable company, job and work environment's characteristics that may influence both the access to training at 45 and over and the probability of showing frequently work practices to colleagues. To help us carry out our identification strategy, we rely on specific questions indicating whether there was a training session that respondents wanted to attend but were unable to do so and for what reasons.

We find that participation in training has a positive effect on the probability of transmitting knowledge and skills after age 45. More interestingly, this effect is only significant and substantial when training aims at accompanying a change occurred in the work environment. Other types of training, such as to become more effective at work or to take on responsibilities, do not have a significant impact on the participation of older people in the knowledge transmission process. This suggests that promoting access to training for seniors aged 45 and over to support a change in the working environment is a good human resource practice to keep these employees integrated into the knowledge transmission process. Beyond skills' updating, it favors the retention of valuable knowledge from experienced employees, such as knowledge about subject matter expertise, business relationships and social networks, organizational knowledge and institutional memory or knowledge of governance (Joe et al., 2013).

The remainder of our paper is organized as follows. Section 2 presents a short overview of the literature on knowledge transmission. Section 3 describes the data set and some descriptive statistics. In section 4, we explain our empirical strategy and we show our empirical results. Section 5 concludes.

## **2 Background**

Knowledge transfers between colleagues have been thoroughly studied in the management literature, particularly in terms of mentor-protégé relationships. Starting from the traditional model in which one senior assists with the protégé's personal and professional development (Ragins, 1997), it has been shown that setting mentor-protégé relationships may help professionals learn technical knowledge and organizational ropes as well as improve managerial talent (Kram, 1988). Furthermore, mentorship is an efficient training and development tool for protégés (Roche, 1979) and it improves mentors' satisfaction (Hunt and Michael, 1983). Management literature on mentorship has also introduced social networks theory to go beyond the single dyadic relationship and studied developmental networks (Higgins and Kram, 2001).

In economics, while the relevance of learning by doing was recognized in the seminal papers about human capital accumulation (Mincer, 1961; Arrow, 1962; Becker, 1962; Rosen, 1972), early human capital theory has not paid much attention to the role of knowledge transmission on skills' development or productivity and focuses more on education and formal training. Until recently, only a few empirical studies point out the importance of learning from co-workers for human capital development. Bishop (1991) shows that informal training by co-workers or training by watching others have positive and significant effects on new hires' productivity. Loewenstein and Spletzer (1999) report that informal training for new hires, provided by coworkers or supervisors, explains a sizeable amount of within job wage growth. Liu and Batt (2007) show that returns to informal training depend on whether trainers are supervisors or co-workers.

Recent empirical studies emphasize the importance of knowledge transfers in skills' development of new hires but most of them are controlled laboratory experiments or case studies of one specific firm or occupation. Empirical studies on call-center agents show that new hires benefit from knowledge spillovers from experienced co-workers (De Grip, Sauermann Sieben, 2011; Lindquist et al., 2015). De Grip and Sauermann, (2012) extend this result to the whole workforce by showing through a field experiment that call-center agents productivity increase when peers have participated in training, due to likely knowledge spillover from trained to untrained workers. De Grip and Smits (2012) show that scientists or engineers who face a skill gap try to upgrade their skills learning from their colleagues. Among science researchers or teachers, Waldinger (2012) finds little evidence of knowledge spillovers while Jackson and Brugeman (2009) find empirical support of learning from coworkers. Investigating large labor markets, other empirical studies obtain mixed evidence. Muehlemann and Leiser (2018) estimate that informal instruction of a new hire by supervisors and co-workers, a prerequisite for him or her to reach full productivity, amounts to about 20% of the total hiring cost. Cornelissen et al. (2017) find small peer effects in wages for high-skilled occupations and large peer effects in wages of low-skilled occupations. They attribute it to peer pressure rather than knowledge spillovers as comparison with co-workers' productivity may encourage an increase in own effort (Falk and Ichino, 2006; Mas and Moretti, 2009; Bandiera et al., 2010; Cornelissen, 2016).

In addition, the interest for knowledge transfers among economists has also been renewed by the development of new internationally comparable data on informal learning at work through the OECD Programme for International Assessment of Adult Competences (PIAAC). Informal learning is defined as the acquisition of skills through learning by doing or learning from supervisors or co-workers (OECD, 2013). A high percentage of workers perceive that informal learning is relevant for them on a daily basis (De Grip, 2015). More precisely, the share of workers who learn new things by doing tasks ranges from 12% in Korea to 53% in Spain and the share of workers who learn new things from supervisors or co-workers ranges from 10% in Korea to 36% in Spain<sup>1</sup>. This is consistent with country-specific studies conducted in Netherlands or in France that show that workers learn particularly well from engaging in challenging activities or from cooperating with more experienced colleagues (Borghans et al., 2014; Fournier et al., 2017).

Despite the new interest in informal learning, the effect of age is not well documented and has been studied only from the perspective of trainees, i.e. workers who upgrade their skills through learning from others. Using PIAAC, De Grip et al. (2018) exhibit a quadratic relationship between involvement in informal learning and age suggesting that older workers engage in informal learning activities until a turning point at the end of the employee's working life. However, little is known about the characteristics of knowledge transmitters, i.e. workers who transmit their knowledge to their colleagues. Since organizational productivity benefits to a large extent from knowledge transmission, the relationship

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<sup>1</sup> For France, these two shares are respectively 45% and 25%.

between age and the ability to transmit knowledge deserves further investigation as well as the mediating role of human resources practices, e.g. provision of formal training.

### 3 Data and descriptive statistics

We use a French matched employer-employee survey on training and workers' trajectories (DEFIS) carried out in 2015 by the CEREQ at the request of the National Council for Professional Training Assessments (CNEFP), DEFIS is funded by the Joint Fund for Ensuring Career Paths (FPSPP), currently "France Competences". This survey has been first conducted in March-April 2015 on a representative sample of 3700 firms with 10 employees or more in all market activity sectors excluding agriculture and public administration and on a non-representative one of about 800 companies below this size threshold. In a second stage, around 16000 workers employed in the responding firms in December 2013 were interviewed first in 2015 and then re-interviewed each fall until 2019.

This employer-employee matched survey adopts a two-stage sampling design where enterprises are sampled first. The sample of enterprises is randomly drawn from the SIRENE file and the sample of employees from the Déclarations Annuelles de Données Sociales (DADS) of 2013. To take into account the probability that employees that are drawn in the sample respond to the survey, the weighting of the first wave of DEFIS uses a double inference method. A further step is to weight the responding companies in which selected employees provided a response. A final weighting step is carried out using a calibration on the DADS data.

For this study, we restrict our sample to employees aged 30-59. According to the sampling frame, we know that selected employees had been in employment in the responding company for the 18 months before their interview. Since we are interested in knowledge transmission, we exclude from our sample the workers who report having no colleagues. This leads to a working sample of 9684 individuals.

To measure knowledge transmission, we exploit information about the interactions that respondents have with their colleagues. More precisely, the survey asks workers the following question: "Do you often have to show your colleagues how to do part of their work?". answers being "often", "sometimes" or "never". We create a binary indicator equal to one if the respondent answers "Often". Indeed, only 10.9% of respondents answer "never" to this question. In our sample, 35.8%<sup>2</sup> of the respondents report that they often show some work practices to their colleagues. Hereafter, we will refer to these individuals as knowledge transmitters.

This question is self-reported, which can be seen as a limitation. In particular, the fact of having participated in a training session could bias the individual perception of knowledge transmission. However, the structure of the questionnaire mitigates this problem since the question on knowledge transmission is located in a section devoted to the organization and working conditions (section C) which precedes the description of the training courses attended (section F). In section C, respondents describe work organization at the date of the survey when in section F they describe the training sessions attended over the past twelve months. Moreover, subjectivity plays a role knowledge transmission as one needs to be confident in one's abilities to effectively transfer. It thus seems difficult not to be aware of showing some work practice to co-workers.

The main limitation of the question is that it is coarse in the sense that it captures a threshold identifying a higher frequency of knowledge transmission. This may be problematic for measuring a higher level of

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<sup>2</sup> All the statistics and estimates are weighted to account for unequal sampling rates.

knowledge transfer when employees have a structural role in the information dissemination network. This is the case for supervisors who are often called upon to show the work because of their hierarchical position. For this reason, we also consider a subsample of 5910 individuals who report having no subordinates. More objective measures of the intensity of knowledge transmission would thus be interesting complements to the subjective measures, but they would probably require another survey framework, such as time use surveys.

Our data allows us to control for a rich set of characteristics, regarding the workers, their work practices and their organizational environment. We have information on the standard socio-demographic characteristics (gender, age, marital status, educational and occupational level), on workers' seniority and daily wage. To control for a potential effect of health, we introduce a dummy for the presence of health limitations. Regarding jobs, we control for full time or part-time work as well as for a set of variables regarding the respondents' self-reported working conditions. Fournier et al. (2017) show from the same data set that informal learning is more frequent when the job implies frequent exchanges with colleagues, when the tasks to perform are complex and when the workers are autonomous. We introduce additional controls for teamwork, repetitive tasks, learning from colleagues and frequent meetings.

In addition, DEFIS provides firm level information that captures the organizational environment. In their analysis, Fournier et al. (2017) have identified different human resources practices that promote knowledge transmission letting workers autonomous in their daily activities, sharing information about training opportunities or developing workers' ability to transmit their knowledge. In this respect, we construct binary indicators for the presence in the firm of autonomous workgroups, apprentices and a department dedicated to workers training

We finally control for the economic situation of the firm, with size dummies, and other binary variables indicating respectively whether the firm is a subsidiary, whether its workforce has been growing and whether it has experienced some recruitment difficulties. This last variable echoes the results of Van Dalen et al. (2015) who show that firms with recruitment difficulties tend to adopt workplace accommodation measures and develop more practices towards their senior workers.

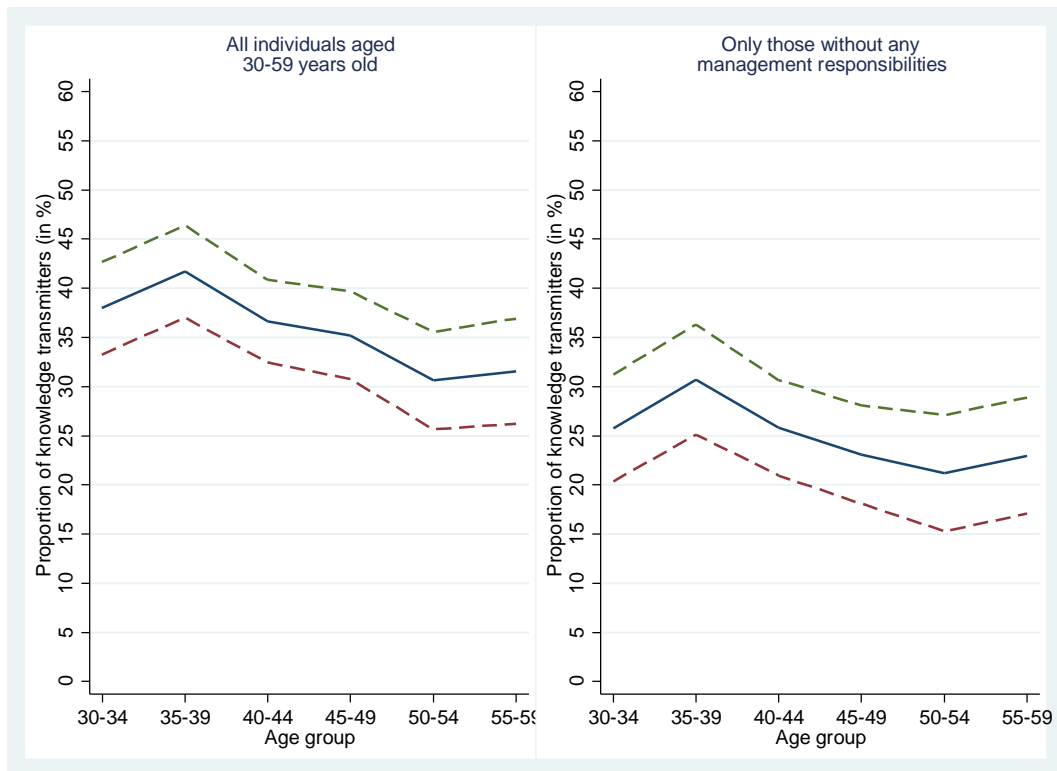
Figure 1 shows the proportion of knowledge transmitters by age group with their confidence intervals at a 5% significance level. We plot the left graph from the whole sample of 9684 individuals while the right graph is built from the subsample of 5910 individuals who have no subordinates. This figure shows that the proportion of knowledge transmitters falls sharply after age 45<sup>3</sup>.

Figure 1: Proportion of knowledge transmitters by age group

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<sup>3</sup> Running a simple Probit model and controlling for age and occupation dummies, we find that for workers without any management responsibilities, being aged 45-49 years old reduces by 9.4% the probability of being a knowledge transmitter. This negative effect is significant at a 5% level.





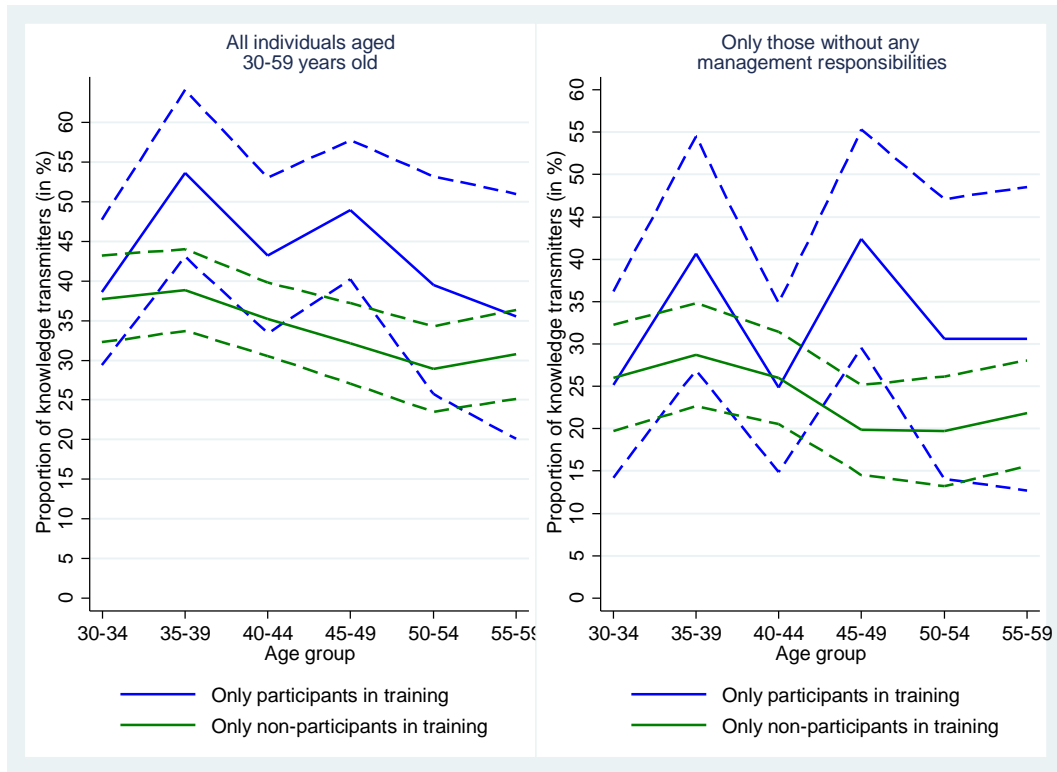
Comments: knowledge transmitters are workers who report that they frequently show their colleagues how to do part of their work.

Source : CNEFP-France compétences-Céreq, DEFIS 2015

We then examine to what extent participation in training would mitigate the fall in the proportion of knowledge transmitters after age 45. Given our baseline hypothesis, we consider a specific type of training aiming to update workers' skills after a change that occurred in the work environment. DEFIS allows distinguishing these types of training sessions from other types. Indeed, the survey asks respondents: "Since January 2014, have you participated in training sessions to support a change in the work environment?". In Section 4, we show the incidence of other types of training on the probability of being a knowledge transmitter. Figure 2 shows the proportion of knowledge transmitters by age distinguishing two categories of workers: those having participated in training sessions aiming to support a change in the work environment and those who have not. As in Figure 1, we present the results for the whole sample of 9684 workers in the left graph and those obtained from the subsample of workers without any subordinates in the right graph. This figure suggests that the fall in the proportion of knowledge transmitters after age 45 is less pronounced among workers who have received training to support change.<sup>4</sup>

<sup>4</sup> In the graph, the effect seems to be only significant for individuals aged 45-49 years old. However, running a simple Probit model and controlling for age and occupation dummies, we find that for workers without any management responsibilities, being aged 50-54 years old reduces by 11.9 percentage points the probability of being a knowledge transmitter for non-participants to a training session aiming at supporting a change. In contrast, for workers who participate in such a training session, this negative effect is clearly lower (-6.6 p.p.) and becomes non-significant.

Figure 2 Proportion of knowledge transmitters and participation in training to support change by age group



Source : CNEFP-France compétences-Céreq, DEFIS 2015

For the remainder of the paper, we restrict our sample to the workers aged 45-59. Table 1 provides descriptive statistics to compare the characteristics of knowledge transmitters with those of workers who do not take up such a role. We do so for the sample of all workers aged 45-59 (N=4731) and for the subsample of workers aged 45-59 who have no management responsibilities (N=2927). These statistics are consistent with the literature related to knowledge transmission and informal learning. Females are under-represented among knowledge transmitters as well as workers with low educational or skill level and seniority, employed in low-paid or part-time jobs. Working conditions also have an influence on workers' participation in knowledge transmission after age 45. Working in teams, learning things from other co-workers and having frequent meetings are positively associated with the probability of showing work practices to other colleagues. In addition, some firms' characteristics and human resources practices favors knowledge transmission after age 45. The probability of showing work practices to other colleagues is higher in large firms, that have set autonomous workgroups and that have encountered recruitment difficulties. Regarding industry-specific correlations, we note an under-representation of workers employed in the transport industry among knowledge transmitters.

Our main variable of interest is the participation in training to support change over the last twelve months. Table 1 shows a strong positive correlation between this variable and the probability of frequently showing work practices to colleagues after age 45. In the sample of all workers aged 45-59, the proportion of participants in such training is 8 percentage points (pp) higher among knowledge transmitters than among other workers. When disentangling knowledge transmission from management responsibilities by restricting this sample to workers without any subordinate, the proportion of participants in training is 10.6 pp higher among knowledge transmitters than among other workers.

The simple descriptive statistics show that participation in training to support change is positively associated with the probability of being a knowledge transmitter after age 45 especially when the activity of transmission is not related to management responsibilities. However, participation in training could be influenced by a set of observable and unobservable characteristics that could also influence the probability of being a knowledge transmitter. To come closer to the estimation of a causal effect we have to correct for this selection bias.

Table 1 Descriptive statistics of the sample

	All workers aged 45-59		Workers aged 45-59 without any subordinate	
	Knowledge transmitter		Knowledge transmitter	
	YES	NO	YES	NO
<b>Characteristics of the worker</b>				
Female	0.263	0.361***	0.311	0.390*
Aged 45-49	0.461	0.414	0.415	0.398
Aged 50-54	0.331	0.366	0.360	0.385
Aged 55-59	0.209	0.221	0.225	0.217
Single	0.193	0.247*	0.224	0.275
Primary education	0.102	0.129	0.138	0.136
Vocational education	0.450	0.531**	0.452	0.549***
High-school education	0.088	0.103	0.085	0.099
Undergraduate education	0.200	0.165	0.238	0.159***
Graduate/Post-graduate education	0.160	0.072***	0.088	0.058
Blue-collar workers	0.299	0.395***	0.380	0.431
Clerks	0.320	0.423***	0.377	0.449*
Engineers/managers	0.381	0.182***	0.242	0.120***
Health limitations	0.146	0.164	0.200	0.174
Part-time job	0.046	0.155**	0.071	0.177***
Log of hourly wage	2.816	2.580***	2.724	2.520***
<b>Seniority</b>				
< 10 years	0.270	0.348***	0.264	0.368***
11-20 years	0.297	0.280	0.271	0.276
21-30 years	0.261	0.237	0.268	0.231
> 30 years	0.172	0.135*	0.197	0.124**
<b>Working conditions</b>				
Works in teams	0.715	0.594***	0.659	0.548***
Has learned from other colleagues	0.477	0.395**	0.516	0.405***
Has frequent meetings	0.712	0.486***	0.592	0.428***
Carries out repetitive tasks	0.451	0.569***	0.486	0.420
Has participated in training to support change	0.226	0.146***	0.221	0.115***
<b>The employing firm</b>				
Is a subsidiary	0.645	0.559***	0.664	0.565
<b>Size</b>				
1-19 employees	0.215	0.268	0.202	0.264
20-49 employees	0.126	0.131	0.087	0.130*
50-249 employees	0.167	0.203	0.166	0.201
250-1999 employees	0.200	0.201	0.200	0.21
2000 employees and more	0.292	0.196***	0.344	0.194***

Manufacturing	0.294	0.250	0.313	0.249
Building	0.096	0.088	0.050	0.076
Retail trade	0.180	0.191	0.192	0.197
Transports	0.076	0.126**	0.081	0.148**
Hostels/restaurants	0.053	0.035	0.065	0.023
Information/communication	0.039	0.048	0.044	0.046
Housing/finance/insurance	0.107	0.068**	0.104	0.065
Services to firms	0.115	0.144	0.104	0.145
Has set autonomous workgroups	0.580	0.504**	0.622	0.506***
Has apprenticeships	0.626	0.569	0.620	0.557
Has a growing workforce since 3 years	0.291	0.245	0.310	0.256
Has a department dedicated to training	0.505	0.462**	0.526	0.468
Has experienced recruitment difficulties	0.702	0.624**	0.732	0.639***
<b>Number of observations</b>	1757	2974	746	2181

Statistical significance for difference in means of characteristics between knowledge transmitters and other workers: \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Source : CNEFP-France compétences-Céreq, DEFIS 2015

## 4 Empirical strategy and results

### 4.1 Correcting for the selection bias

There is evidence that older workers suffer from reduced access to training (Behaghel and Greenan, 2010). In our sample, the proportion of participants who undertook training sessions to support change is 26.5% for workers aged 30-34 but only 16.6% for workers aged 45 and over. Hence, older workers who participate in these training sessions may have specific characteristics. We need to control them to assess the effect of training on knowledge transmission.

To tackle this issue, we follow the approach suggested by Leuven and Oosterbeek (2008). Instead of comparing participants in training to non-participants, we narrow down the comparison group considering only those workers who wanted to participate in training but could not do so because the training session was cancelled for exogenous reasons. In DEFIS, the questions to identify these accidental non-participants to training are: “over the last twelve months, did you intend to participate in training courses to support a change in the work environment?” and “has this training session not started yet, been cancelled or delayed?”. Among the sample of 4731 workers aged 45 and over, 3945 did not participate in any training session aiming to support change. Of these non-participants, 933 individuals (23.7%) intended to participate in these training courses and 274 (6.95%) did not do so because the planned training session had not yet started or had finally been cancelled or delayed for reasons external to the worker.<sup>5</sup> Other reasons for non-participation are less exogenous: "your work schedule was too

<sup>5</sup> These shares are comparable to the ones described in the Leuven and Oosterbeek's paper. In their sample, among 1145 non-participants, 249 (21.75%) wanted to receive training course and 77 (6.72%) did not do so because of some random event.

busy", "the company refused to let you go", "funding for the training was refused", "family or personal constraints", "the training center was too far away"..

If the individual does not directly decide to cancel a training course, we can however discuss its exogeneity. Indeed, the cancellation of a training course may be the result of a decision at the level of the company. If, for example, a company realizes that the change in its production process is not so important after all, it may decide to cancel a planned training action. Training would then be endogenous at the company level. Since our sample consists of firms in which several workers were interviewed, we perform a cross-firm decomposition of the variance of the chosen dummy variable explaining non-participation<sup>6</sup>. The total variance of this variable is equal to 0.074 and its within-firm component constitutes 66%. This ensures that the variation exploited is mainly within firms. Furthermore, in 70% of the companies where at least one respondent reports that, his or her training session has not yet taken place, has been delayed or cancelled, no other worker reports such a contingency. This confirms the exogenous nature of the chosen non-participation variable used to narrow the comparison group.

To check whether narrowing down the comparison group allows correcting for the selection bias, we compare the characteristics of the participants' group and different comparison groups. The first comparison group includes all the workers who did not participate in any training session to support change (N=3945). The second comparison group retains non-participants who wanted to attend training to support change but did not do so (N=933). The third comparison group is further reduced to those non-participants whose planned training session to support change did not eventually occur for exogenous reasons (N=274). We test whether the differences between the participants' group and the comparison groups are significant for a set of variable likely to influence the participation.

The first two columns of Table 2 show that the participants' group and the first comparison group are significantly different on almost every variable considered. Workers who participated in training to support change are overrepresented among skilled workers who hold full-time jobs, have frequent meetings and learn from other colleagues. Participants' are more likely to be employed in large firms, which have developed autonomous workgroups and in which there is a dedicated training department. Replacing the first comparison group with the second one eliminates almost all significant differences the two groups. However, one significant difference remains. In the comparison group, the proportion of workers who report having learned work practices from their colleagues is statistically lower than in the participants' group. This difference is no more significant when we move to the third comparison group. Therefore, we make the non-participants' group comparable to the participants' one in terms of observable characteristics when we reduce it to those employees who wanted to attend the training but did not because the training session did not (yet) occur.

Table 2 Sample means for the participants' and comparison groups

Characteristics	Participants' group	Comparison group n°1	Comparison group n°2	Comparison group n°3
Female	0.366	0.321	0.322	0.325
Aged 45-49	0.455	0.423	0.497	0.511
Aged 50-54	0.331	0.359	0.360	0.377
Aged 55-59	0.214	0.217	0.243	0.212
Single	0.225	0.230	0.211	0.262
Primary education	0.081	0.128	0.036	0.052

<sup>6</sup> We thank our reviewers for this suggestion.

Vocational education	0.472	0.511	0.402	0.452
High-school education	0.103	0.097	0.103	0.163
Undergraduate education	0.192	0.173	0.187	0.204
Graduate/Post-graduate education	0.152	0.090**	0.172	0.128
Blue-collar workers	0.236	0.39***	0.182	0.207
Clerks	0.397	0.388	0.384	0.388
Engineers/managers	0.367	0.222***	0.434	0.405
Health limitations	0.104	0.169**	0.117	0.162
Part-time job	0.068	0.130**	0.090	0.095
Log of hourly wage	2.815	2.625***	2.859	2.848
Seniority				
<10 years	0.256	0.337**	0.227	0.222
10-20 years	0.315	0.279	0.306	0.319
20-30 years	0.286	0.236	0.299	0.304
> 30 years	0.143	0.148	0.169	0.155
<b>Working conditions</b>				
Works in teams	0.682	0.623	0.661	0.754
Has learned from other colleagues	0.587	0.387***	0.465**	0.533
Has frequent meetings	0.766	0.517**	0.759	0.721
Carries out repetitive tasks	0.447	0.524	0.399	0.490
<b>The employing firm</b>				
Is a subsidiary	0.761	0.551***	0.759	0.759
Size				
1-19 employees	0.124	0.277***	0.105	0.066
20-49 employees	0.091	0.138**	0.093	0.053
50-249 employees	0.227	0.184	0.209	0.260
250-1999 employees	0.221	0.197	0.219	0.257
2000 employees and more	0.336	0.205**	0.373	0.365
Manufacturing	0.275	0.262	0.328	0.330
Building	0.049	0.099**	0.049	0.059
Retail trade	0.171	0.191	0.123	0.177
Transports	0.126	0.106	0.085	0.045
Hostels/restaurants	0.017	0.046**	0.007	0.005
Information/communication	0.066	0.041	0.090	0.071
Housing/finance/insurance	0.103	0.076	0.141	0.125
Services to other firms	0.143	0.132	0.116	0.128
Has set autonomous workgroups	0.642	0.505**	0.665	0.713
Has apprenticeships	0.682	0.568	0.695	0.712
Has a growing workforce since 3 years	0.313	0.249	0.268	0.291
Has a department dedicated to training	0.594	0.451**	0.613	0.641
Has experienced recruitment difficulties	0.708	0.638	0.703	0.650
<b>Number of observations</b>	786	3945	933	274

Comments: The comparison group n°1 includes all the employees who did not participate in any training session to support change. The comparison group n°2 includes only non-participants who wanted to attend training to support change but did not do so. The comparison group n°3 further reduces the comparison group to non-participants whose planned training to support change was eventually cancelled. Statistical significance for differences in means between participants' and comparison groups: \*\*\* p<0.01, \*\* p<0.05, \*p<0.1

#### 4.2 The effect of participation in training to support change on knowledge transmission after age 45

We then estimate the effect of participation in training to support change on the probability that workers aged 45-59 will frequently transmit their knowledge to their colleagues. We consider different combinations of participants' and comparison groups and report the results from the corresponding Probit models in Table 3<sup>7</sup>. In Panel A, we focus on participants' and comparison groups in the overall sample of workers aged 45-59. Sample n°1 includes all the participants and non-participants (N=4731); Sample n°2 includes all the participants and the non-participants who wanted to attend training but did not do so (N=1719); Sample n°3 include all the participants and the non-participants whose planned training session to support change did not (yet) occur (N=1060).

In Panel B, to disentangle the activity of knowledge transmission from management responsibilities, we narrow down the analysis to the subsample of individuals who report having no subordinates. In the same vein as in Panel A, sample n°4 includes the participants' and the first comparison groups (N=2927), sample n°5 includes the participants' and the second comparison groups (N=949) and sample n°6 is made up of the participants' and the third comparison groups (N=545). We use the full set of variables in Table 2 as control variables.

We report the marginal effect of participation in training to support change on knowledge transmission and the standard error of this effect. In Panel A whatever the sample considered, the marginal effect is positive but small and insignificant even at a 10% level. The fact that workers with hierarchical positions transmit knowledge to their subordinates as part of their functional role may blur the identification of the specific effect of training to support change. This is comforted in Panel B, where we observe an effect that is both positive and statistically significant. When we consider the subsample of workers without any subordinates, whatever the comparison group considered participation in a training session to support change raises the probability for workers aged 45-59 to frequently show work practices to other colleagues by 8.4-13.3 pp. This type of training allows workers aged 45 and over to continue to pass on the part of their expertise that remains valuable and thus to maintain their contribution to the knowledge base of the production.

One can argue that firms facing major changes can either train their workers or lay them off. Consequently, our sample is a selected one in the sense that it includes only workers who have stayed in the firm. In the overall sample of respondents aged 45-59, we observe that about 90% of those aged 45-54 years old are still in employment in the same firm 18 months after having been selected in the sampling frame<sup>8</sup> but only 74% of those aged 55-59 years old. The selection bias is likely to be particularly important for the latter group. To test the robustness of our main findings to this selection effect, we performed the same regressions as in Table 3 but restricting our sample to workers aged 45-54 years old<sup>9</sup>. This does not qualitatively change the results. For instance, if in sample n°6 (last column

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<sup>7</sup> We report in Table 6 in the Appendix the other coefficients estimated for the baseline Probit regression

<sup>8</sup> As mentioned in section 3, selected individual were working in the responding firms in December 2013, but were interviewed about 18 month later, in 2015.

<sup>9</sup> We thank one of our reviewers for a comment on this issue. The corresponding results are available upon request.

of panel B in Table 3) we retain only workers aged 45 to 54 (N=451), we find a marginal effect of training that is really similar to the one obtained in Table 3 (around 0.12) and significant at the 5% level.

Table 3 – The effect of participation in training to support change on the probability of being a knowledge transmitter among workers aged 45-59

Panel A: Overall sample of workers aged 45-59

	Sample n°1	Sample n°2	Sample n°3
<b>Marginal effect of participation in training to support change</b>	0.041	0.038	0.017
<b>Standard errors</b>	(0.033)	(0.039)	(0.049)
Number of observations	4731	1719	1060

Panel B: Subsample of workers aged 45-59 without any subordinate

	Sample n°4	Sample n°5	Sample n°6
<b>Marginal effect of participation in training to support change</b>	0.084**	0.101**	0.133***
<b>Standard errors</b>	(0.032)	(0.040)	(0.048)
Number of observations	2927	949	545

Comments: The samples n°1, 2 and 3 are constructed considering workers aged 45-59. Sample n°1 includes all the participants and non-participants in training session aiming to support change. Sample n°2 includes participants and non-participants who wanted to attend training to support change but did not do so. Sample n°3 includes participants and non-participants whose planned training session to support change did not (yet) occur. Samples n°4, 5 and 6 are constructed in the same way but considering only the subsample of workers aged 45-59 without any subordinate. The full set of variables in Table 2 are used as control variables.

Statistical significance for marginal effect obtained from Probit models: \*\*\* p<0.01, \*\* p<0.05, \*p<0.1

Source : CNEFP-France compétences-Céreq, DEFIS 2015

#### 4.3 The influence of other types of training on knowledge transmission after age 45

Our baseline hypothesis is that participation in training to update skills after a change occurred in the work environment allows workers aged 45 and over to maintain their contribution to the knowledge base of the production by transmitting to their co-workers the part of their expertise that remains valuable. This hypothesis implies that the observed effects are related to the changes occurred in the work environment. If another mechanism explains the relationship between knowledge transmission and training, then other types of training would also be likely to have a positive effect on knowledge transmission.

Apart from “supporting a change in the work environment”, DEFIS identifies four other motives for training. In our sample, workers aged 45-59 without subordinates, followed in total over the past twelve months 2437 training sessions. The breakdown of their motives is as follows. They aimed respectively at “supporting change” (15.76%), “being more efficient” (30.57%), “taking on new responsibilities” (12.43%), “having a better knowledge of the work environment” (26.3%) and “reinforcing team building” (14.94%). The median duration is almost the same regardless of the reason for the training and varies from two to three days. A trainer internal to the firm has carried out about 40% of these sessions. This proportion does not really depend on the type of training.



In Table 4, for each alternative type of training, we present marginal effects and standard errors for three combinations of participants' and comparison groups composed of workers without any subordinate. Whatever the comparison group, all the marginal effects are small and non-significant even at a 10% level. These alternative types of training, which are unrelated to technological or organizational change, have no effect on the probability of frequently showing work practices to other colleagues.

Table 4 – The effect of participation in training for other motives than supporting change on the probability of being a knowledge transmitter after age 45

Marginal effect of participation in training to...	Sample n°4	Sample n°5	Sample n°6
...be more efficient at work	0.035 (0.027)	0.055 (0.040)	0.046 (0.053)
...take on responsibilities	0.034 (0.039)	0.032 (0.048)	0.010 (0.053)
...have a better knowledge of the work environment	0.029 (0.029)	0.026 (0.041)	0.005 (0.046)
...reinforce team building	0.005 (0.037)	0.015 (0.044)	-0.048 (0.049)
Number of observations	2927	949	545

Comments: The samples n°4, 5 and 6 are constructed considering workers aged 45-59 without any subordinate. Sample n°4 includes all the participants and non-participants in training session aiming to support change. Sample n°5 includes participants and non-participants who wanted to attend training to support change but did not do so. Sample n°6 includes participants and non-participants whose planned training session to support change was eventually cancelled. The full set of variables in Table 2 are used as control variables.

Statistical significance of marginal effects obtained from Probit models: \*\*\* p<0.01, \*\* p<0.05, \*p<0.1

Source : CNEFP-France compétences-Céreq, DEFIS 2015

#### 4.4 Knowledge transmission, training and technological or organizational changes

It could be that the type of training we consider, i.e. training to support change, takes place when the participants have not encountered any change, either technological or organizational, in their daily activities. This would invalidate our basic assumption that training for workers aged 45-59 is effective if it is used in response to a change that may inhibit them from contributing to knowledge exchanges. To investigate the influence of technological or organizational change on the training-transmission relationship after age 45, we exploit information available in the data. Indeed, DEFIS asks workers the following questions: “has your work been modified by a change in techniques or processes or by an organizational change since January 2014”. This information allows computing our marginal effect of interest both for workers who have reported a change in their work and for those who have not reported any.

Table 5 – The effect of participation in training to support change on the probability of being a knowledge transmitter among workers aged 45-59 according to technological or organizational changes occurred in the workers' environment

Panel A: Subsample of workers aged 45-59 without any subordinate who did not experience any change in their daily work

	Participants +		
	Comparison group n°1	Comparison group n°2	Comparison group n°3
<b>Marginal effect of participation in training to support change</b>	0.035	0.051	0.086*
<b>Standard errors</b>	(0.059)	(0.049)	(0.050)
Number of observations	1703	409	202

Panel B: Subsample of workers aged 45-59 without any subordinate who did experience a technological or organizational change in their daily work

	Participants +		
	Comparison group n°1	Comparison group n°2	Comparison group n°3
<b>Marginal effect of participation in training to support change</b>	0.123***	0.110**	0.192***
<b>Standard errors</b>	(0.043)	(0.049)	(0.067)
Number of observations	1224	536	343

Comments: The comparison group n°1 includes all the non-participants in training session aiming to accompany the change. The comparison group n°2 includes only non-participants who wanted to attend training but did not do so. The comparison group n°3 further reduces the comparison group to untrained workers who wanted to participate in a training session aiming to accompany the change and whose training session has been eventually cancelled. The full set of variables in Table 2 are used as control variables.

Statistical significance of marginal effects: \*\*\* p<0.01, \*\* p<0.05, \*p<0.1

Source : CNEFP-France compétences-Céreq, DEFIS 2015

Note first that the two variables, i.e. having experienced a technological/organizational change at work and having participated in training sessions to support change are strongly correlated. Among workers aged 45-59 who have not reported any change at work, the proportion of participants in such training sessions is only 9.97% while it amounts to 24.99% among workers who have encountered a technological or organizational change. When considering the subsample of workers aged 45-59 without any subordinate, these shares are respectively 7.22% and 21.32%. Nevertheless, a substantial part of the participants in training sessions to support change had not experienced any change at the time when they were interviewed. A possible reason for this discrepancy is that the change had not yet occurred or it had not affected the daily activity of the respondent.

We conduct this further investigation in Table 5. We consider the subsample of workers aged 45-59 without subordinates and we look at the effect for different combinations of participants' and comparison groups as in Table 3. We observe in Table 5 that marginal effects are positive both in Panel A where workers experienced no change and in Panel B where they did. However, these effects are strong and significant for all comparison groups in panel B only. Thus, without restricting the comparison group training with the intention to support change increases knowledge transmission for training participants by 12.3 pp (significant at the 1% level) if workers have experienced a change in their work environment (Panel B) but has no significant marginal impact if they have not had to face such a situation (Panel A). Reducing the comparison group to those who wished to undergo such training, the effects are +11 pp in the presence of technological or organizational changes, but are not significant in their absence. Reducing the comparison group further to those whose planned training session to support the change did not take place, these effects are +19.2 pp in the former case and +8.6 pp points (significant at the 10% level) in the latter.

This confirms our interpretation that the training/transmission relationship after age 45 is not systematic. As long as older workers are not penalized by a change that prevents them from contributing to the production knowledge base, training and transmission are not significantly related. It is when they face a major change that training becomes effective in mitigating the tangible risk for experienced workers to be excluded from their work group. In that case, it allows workers aged 45-59 to continue to interact with their colleagues and to transmit their knowledge gained through experience, thus reducing the risk of firms losing critical knowledge assets.

## **5. Concluding remarks**

Starting from the fact that workers aged 45-59 are under-represented among those who frequently transmit their knowledge to other workers, we have investigated the role of training. From data drawn from the matched employer-employee DEFIS survey, we have estimated the marginal effect of participation in training sessions to support change on the probability for workers aged 45-59 of frequently showing work practices to their co-workers. To disentangle knowledge transmission from supervising role, we have also considered a subsample of workers aged 45-59 who report having no subordinates.

To control for the potential selection bias, we have exploited the richness of information provided by the survey, restricting non-participants in training to those workers who wanted to attend training but who did not and reducing further this comparison group to non-participants whose planned training session to support change did not (yet) occur for exogenous reasons. We have checked that this empirical strategy allows to make participants' and restricted comparison groups comparable in terms of characteristics likely to influence the probability of transmitting knowledge.

We find that participation in training to support change for workers aged 45 and more increases significantly the probability of showing frequently work practices to colleagues but only for workers who have no subordinate. This strong positive effect holds when narrowing down the comparison group to correct for selection bias. More interestingly, this training-transmission relationship after age 45 is not systematic. Indeed, training helps workers aged 45-59 to keep on participating to the knowledge base of production only if it intervenes as a response to mitigate potential negative effects of technological or organizational change occurred in the workers' environment. We fail to find any significant positive effect of other types of training on the probability of transmitting knowledge and only find a low and weakly significant positive effect for the narrowest comparison group when respondents have not effectively experienced a change in working environment. These results are consistent with those found by Greenan and Messe (2018) using an earlier edition (2006) of a French matched employer employee survey on computerization and organizational change.

This study sheds a new light on the effectiveness of older workers' training. Some contributions argue that older workers' training is less effective as it has no significant effect on job duration (Stenberg et al., 2012; Behaghel, 2014; Boockman et al., 2018), earnings (Belloni et Villosio, 2015) or on relative older workers' productivity (Göbel and Zwick, 2013). We show that specific types of training to update skills after a technological or organizational change allows older workers to keep on interacting with their colleagues and transmitting their knowledge acquired through experience, which reduces the risk for firms of losing critical knowledge assets. This happens when new techniques or management changes affect a sub-group of tasks within those that are bundled into older workers' jobs, creating a situation where the use of the non-affected skills becomes conditional on mastering a new tool or method.

In terms of research, our findings suggest that two main aspects have to be accounted for when investigating the effectiveness of older workers' training. First we have to carefully check the motives of training and especially if it intervenes as a response to a technological or organizational change occurred in the workplace. Second, we should account for the potential interactions between generations of workers.

If the public debate acknowledges that employee learning and development is critical in times of structural change and crisis (De Grip, 2015), the outcomes of knowledge transmission within workplaces in terms of job satisfaction, turnover intentions, productivity or innovation, which we do not address in this paper, deserve further research. In particular, knowledge transfers between older workers and their co-workers is an important area of investigation, likely to be affected by human resource management practices. Indeed, the main studies that examine the effect of training on the productivity of older workers assume perfect substitution between age groups, leaving no room for potential complementarities or interactions between older workers and their colleagues. In particular, we believe that studying how training that supports technological and organizational change influences the relationship between age diversity and firm productivity is a promising avenue for future research.

The implication of this paper for human resources managers is that not updating older workers' skills after a technological or organizational change may imply a cost for firms. As stressed by the recent literature on the consequences of the ongoing technological transformation, a large share of jobs is likely to be only partially automated implying that while some tasks will disappear, making the corresponding skills obsolete, others will persist and their associated skills will remain valuable for organizations (Arntz et al. 2017; Nedelkoska and Quintini, 2018; Pouliakas, 2018). If older workers are excluded from their workgroup after these changes, because their skills have not been updated through training, valuable organizational knowledge from these experienced employees will be lost. Once these older workers retire, the organization will discard part of its human capital and productivity will be affected negatively. Several papers put forward that the organizational knowledge loss attributable to the departure of experienced workers may bring about a strong fall in productivity (Massingham, 2010; Joe et al., 2013; Bartel et al. 2014; Massingham, 2018). Human resource managers in their tradeoff between exit policies or employee development measures should more carefully account for this point for workers in the second part of their careers.

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## Appendix

Table 6 – The determinants of being a knowledge transmitter

Characteristics	All workers aged 45-59 years old	Only those without any management responsibilities
Female	-0.013 (0.033)	-0.010 (0.032)
Aged 45-49 (reference)		
Aged 50-54	-0.046 (0.028)	-0.043 (0.029)
Aged 55-59	-0.048 (0.033)	-0.029 (0.034)
Single	-0.047 (0.029)	-0.061** (0.028)
Primary education	0.009 (0.067)	0.046 (0.063)
Vocational education	-0.029 (0.047)	0.007 (0.047)
High-school education	-0.072 (0.058)	-0.002 (0.060)
Undergraduate education	-0.056 (0.043)	0.037 (0.046)
Graduate/Post-graduate education (reference)		
Blue-collar workers	-0.089* (0.052)	-0.027 (0.051)
Clerks	-0.082** (0.041)	-0.055 (0.044)
Engineers/managers (reference)		

Health limitations	0.033 (0.035)	0.042 (0.031)
Part-time job	-0.165*** (0.044)	-0.098*** (0.041)
Log of hourly wage	0.140*** (0.051)	0.141*** (0.057)
Seniority		
<10 years	-0.007 (0.033)	-0.028 (0.032)
10-20 years	0.020 (0.034)	0.007 (0.036)
20-30 years (reference)		
> 30 years	0.055 (0.038)	0.070* (0.042)
<b>Working conditions</b>		
Works in teams	0.067** (0.026)	0.029 (0.026)
Has learned from other colleagues	0.056** (0.023)	0.042** (0.024)
Has frequent meetings	0.093** (0.029)	0.031 (0.029)
Carries out repetitive tasks	0.006 (0.026)	-0.011 (0.027)
<b>The employing firm</b>		
Is a subsidiary	-0.020 (0.029)	-0.017 (0.032)
Size		
1-19 employees	0.040 (0.043)	0.022 (0.046)
20-49 employees	0.047 (0.041)	0.003 (0.048)
50-249 employees (reference)		
250-1999 employees	0.041 (0.037)	0.062 (0.042)
2000 employees and more	0.116*** (0.038)	0.153*** (0.041)
Manufacturing (reference)		
Building	0.050 (0.043)	-0.014 (0.048)
Retail trade	0.003 (0.037)	0.012 (0.037)
Transports	-0.060 (0.049)	-0.082 (0.054)
Hostels/restaurants	0.115 (0.093)	0.222** (0.101)
Information/communication	-0.172*** (0.043)	-0.115*** (0.044)
Housing/finance/insurance	0.027 (0.041)	0.024 (0.046)
Services to other firms	-0.020 (0.042)	-0.019 (0.037)
Has set autonomous workgroups	0.021 (0.026)	0.037 (0.027)
Has apprenticeships	-0.029 (0.034)	-0.061* (0.035)
Has a growing workforce since 3 years	0.062** (0.027)	0.059 (0.026)
Has a department dedicated to training	-0.071*** (0.025)	-0.066** (0.028)
Has experienced recruitment difficulties	0.071*** (0.028)	0.070*** (0.029)

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<b>Number of observations</b>	4731	2927
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