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»» SMEs and innovation: enterprises innovate less as their workforce ages

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Germany's workforce is ageing. The KfW SME Panel examined whether this trend affects the innovation activity of small and medium-sized enterprises.

The analysis demonstrated that the innovative output of SMEs declines as its workforce ages. This applies to both product and process innovations. The likelihood of a typical small or medium-sized enterprise bringing forth innovations declines by nearly one fourth when the proportion of its workers who are over the age of 54 is 75 instead of 16 %.

More significant steps to upgrade workforce skills are needed to prevent the demographically induced decline in innovation activity from compromising growth and prosperity. Organisational measures such as the formation of mixed-age teams can also contribute to maintaining businesses' innovative capacity.

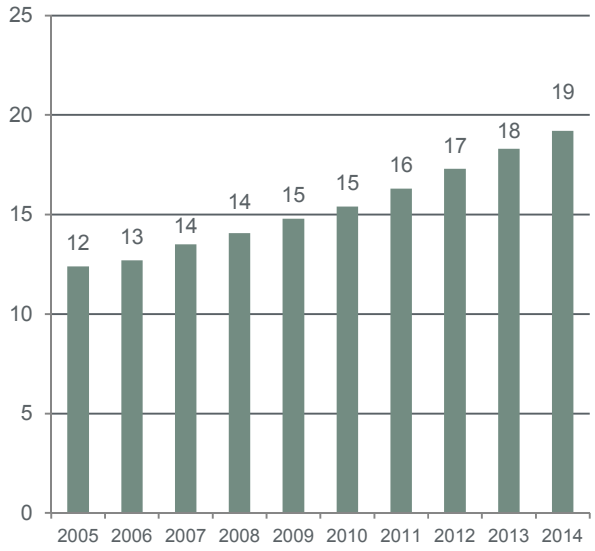
The working age population in Germany is declining and ageing. Already the proportion of over 54-year-old employees is 19 %, some seven percentage points higher than just ten years ago (Figure 1). That trend will continue into the 2030s, when the baby boomers leave the workforce. The impacts of an ageing workforce potential on the economy and society are therefore being intensively researched.[1] It is plausible to conclude that the age of the workforce will also impact on enterprises' innovation activity.

What age means for innovation potential

Various considerations suggest that workforce age affects an enterprise's innovative output. Psychology differentiates between fluid and crystalline intelligence as measures of cognitive ability.[2] Fluid intelligence refers to mental flexibility, closely related to creativity. It is important for solving new problems previously not encountered. Crystalline intelligence comprises the knowledge- and experience-based components of intelligence. These include, for example, thinking patterns acquired over time, successfully applied problem-solving routines and linguistic capabilities.

Both components develop differently with age. It is assumed that fluid intelligence declines from the age of 25 to 30 years. This suggests that increasing workforce age goes hand-in-hand with an enterprise's declining innovation potential. Crystalline intelligence, on the other hand, can increase into old age. As both components function differently, but often lead to the same outcomes, it is also possible that an increase in crystalline intelligence makes up for the decline in fluid intelligence.

Figure 1: Proportion of over 54-year-olds in the workforce



Note: The workforce includes blue-collar and white-collar employees, but excludes apprentices, trainees and public servants.

Source: Micro-census, own calculations

Active investment in human capital is on the decline

In economic theory, the ability to bring forth innovations is associated first and foremost with a person's human capital. Human capital is built up primarily before or at the beginning of the career. This is because investing in human capital yields the highest returns in an early phase of life because of the long remaining amortisation period.[3] In addition, active investment in human capital also declines as people grow older because learning becomes more difficult with age.[4] As human capital becomes obsolete as a result of technological progress, for example, the stock of human capital that is relevant, or in other words, still applicable, often declines again with age.[5]

Growing experiential knowledge

However, workers continue to learn on the job, they learn things by doing them, a process that counteracts the erosion of human capital that comes with age. Hence ageing expands experiential knowledge first and foremost. For this reason older persons are primarily able to draw on a stock of experiential knowledge, while newly generated knowledge can be expected mainly from younger persons.[6]

Note: This paper contains the opinion of the authors and does not necessarily represent the position of KfW.

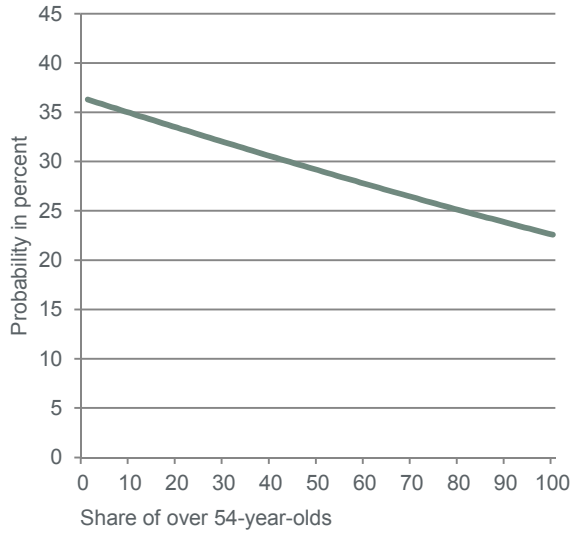
Innovations tend to devalue existing human capital. It is therefore also argued that older persons have fewer incentives to adopt technological (or even organisational) innovations or support their introduction.[7] For example, various studies demonstrate that older employees are slower to apply technologies that are based on new knowledge, such as computers or modern information and communication technologies, than younger employees.[8]

For this reason it is also possible that the returns may be higher when an employee who is rich in experiential knowledge or crystalline intelligence is tasked less with innovative work than an employee who is inexperienced or rich in fluid intelligence.

Influence of age on innovative output unclear based on theoretical considerations

An age-induced decrease in creativity, a lower stock of newly generated knowledge and an age-related drop in incentives to support innovations indicate that younger persons are better at bringing forth innovations. This is particularly the case for the development of radical innovations. However, because of their experiential knowledge, older persons may hold an advantage for innovations that are based on the further development of existing products and services, or which involve the need to integrate new ideas into an existing technological context.[9] It is unclear which aspect predominates and can drive the innovation activity of SMEs. Whether a correlation exists between workforce age and innovation can be investigated empirically.[10] The general rule is that older workers are held in high regard in small and medium-sized enterprises.[11]

Figure 2: Effect of workforce age on the probability of bringing forth innovations



Note: Model calculation based on regression results

Source: KfW SME Panel, own calculations

The higher the share of older employees, the lower innovative output ...

The multivariate analysis (box) conducted on the basis of the KfW SME Panel shows that innovative output, measured as process or product innovation, decreases the higher the proportion of over 54-year-olds is in a company's workforce. Thus, the probability of a typical small or medium-sized enterprise bringing forth innovations is around 34 % when the proportion of its workers who are over the age of 54 is 16 % (median). That probability drops to 26 % when the share of over 54-year-olds is three quarters of the workforce while all other company characteristics remain equal (Figure 2).[12]

... for product as well as and process innovations

The second step repeats the analysis, but distinguishes additionally between the output of process innovations and product innovations (Figure 3). The analysis confirms that innovation output declines with workforce age for both types of innovation. In addition, Figure 3 points to a weaker influence of age on the output of process innovations than on product innovations. This could be indicative of the greater importance of experiential knowledge for the output of process innovations as compared with new or improved products and services. An additionally conducted statistical test, however, demonstrated that the effect of workforce age does not systematically differ in output between product and process innovations.[13]

Conclusion

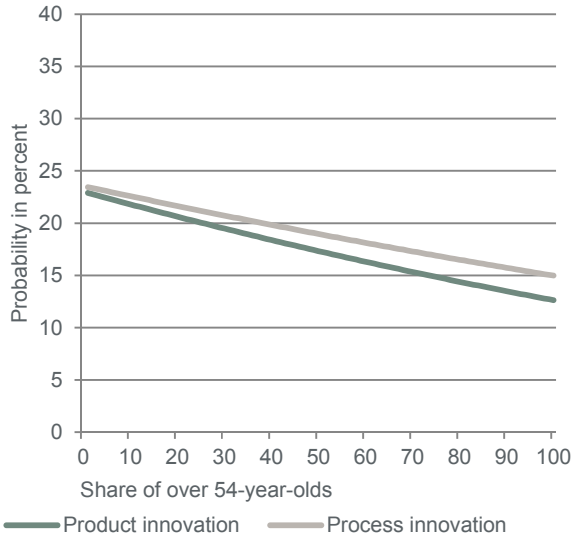
SMEs' innovation output decreases as workforce age increases. This applies to both product and process innovations. The influence of workforce age on the likelihood of bringing forth innovations is measurable: it drops by nearly one quarter when the share of older employees in an enterprise is 75 % instead of 16 %.

However, that does not mean that such enterprises cannot operate profitably anymore. But it does show that demographic change can also affect the innovative strength of the business sector and, thus, growth potential. After all, innovation is not just an important way for businesses to remain competitive, it is also a major driver of overall economic growth. Therefore, when innovation activity drops, growth and prosperity are at risk.

One response to this is to make optimal use of the workers' human capital and to keep it up to date as long as they remain employed. Continuous professional development and lifelong learning are two cornerstones of this approach. Already, 23 % of SMEs are providing ongoing training for their employees.[14] There are also indications that mixed-age teams lead to increased innovation output. That should be helpful where innovative strength is primarily a question of fluid intelligence versus crystalline intelligence.[15] However, this strategy is still relatively uncommon among SMEs, with just 10 % of enterprises having adopted it. Nevertheless, it is definitely worthwhile for entrepreneurs to step up their efforts

at continuously upskilling their workforce and/or adopting organisational measures to maintain their enterprise's innovative capacity into the future. ■

Figure 3: Effect of workforce age on the probability of bringing forth product and process innovations



Note: Model calculation based on regression results

Source: KfW SME Panel, own calculations

Box: Dataset and methodology

The survey analysed whether an SME brings forth product or process innovations within a three-year period. In order to isolate the influence of workforce age on innovation output, the following additional characteristics were taken into account in the regression: number of employees (in full-time equivalents), age of company (both logarithmised), employment of university graduates, sales region, three-year turnover expectations at the level of the industry in which the company operates,[16] collective industry to which it belongs, group to which it belongs, legal status, KfW support status, region of company's registered office and time of survey.

It was also analysed whether the results of the survey change when features of the entrepreneur are added (age, gender, level of education). It was not possible to ascertain any qualitative change in the result of the survey for the influence of workforce age on the likelihood of bringing forth innovations.[17] Since including entrepreneur features leads to a loss of around 20 % of the observations, this aspect was omitted in the final estimation equation.

Information on employee age was collected for the first time in the 2014 survey of the KfW SME Panel. The analysis takes into account data on innovative activity and the share of over 54-year-olds from the survey waves of 2014 and 2015. All further time-varying characteristics refer to the date preceding the measurement of innovation output.

The analysis was conducted with the aid of a probit model and a bivariate probit model (table at the end). It was based on almost 5,600 observations of 3,200 different enterprises. Standard errors were computed taking into account the fact that one enterprise may make several observations.[18]

Regression results are illustrated using model calculations. The influence of workforce age on innovation probability can be described by varying the proportion of older employees in model calculations when calculating innovation probability while leaving all other enterprise characteristics unchanged.

Table 1: Regression results innovation output of SMEs

	Probit model		Bivariate probit model			
	Innovation		Product innovation		Process innovation	
	Coefficient	robust t-value	Coefficient	robust t-value	Coefficient	robust t-value
Share of over 54-years-old	-0.40644	-2.51	-0.40562	-2.43	-0.31637	-1.72
Log (number of employees)	0.06914	2.89	0.00303	0.12	0.13822	5.48
Dummy: Group affiliation	0.09396	1.57	0.04766	0.78	0.07620	1.22
Log (age of company)	0.00635	0.23	-0.00049	-0.02	-0.03446	-1.19
Dummy: Employment of university graduates	0.18494	3.52	0.20470	3.72	0.15008	2.74
Sales region (Reference: 50km-region)						
Sales in Germany	0.10355	1.65	0.01892	0.28	0.16461	2.45
Sales abroad	0.38379	5.74	0.39724	5.59	0.34954	4.91
3-year turnover expectations in industry	0.86068	3.29	0.94536	3.50	0.58505	2.16
Industry (Reference: R&D-intensive manufacturing)						
Other manufacturing	-0.04171	-0.37	-0.07499	-0.68	0.11648	1.04
Construction	-0.31170	-1.81	-0.27198	-1.56	-0.19300	-1.09
Know ledge-based Services	0.06174	0.45	-0.04583	-0.34	0.22747	1.65
Other Services	-0.26278	-2.09	-0.29569	-2.40	-0.11530	-0.91
KfW support status: Not supported	0.01926	0.37	0.07621	1.42	-0.03473	-0.64
Legal Status: limited liability	0.11581	1.93	0.13843	2.17	0.04699	0.74
Region of company's registred office: east Germany	-0.12124	-2.36	-0.02083	-0.39	-0.18658	-3.49
Time of survey (Reference: 2014)						
2015	0.00504	0.37	0.00835	0.57	0.00185	0.13
Constant	-0.87734	-3.83	-1.06774	-4.57	-1.25003	-5.30
athrho			0.70175	19.02		
rho			0.60548			
Number of observations	5565.00		5544.00			
Number of firms	3178.00		3166.00			
Log Likelihood	-3497.20		-5970.02			
Pseudo R^2	0.08					
Wald Test			$chi^2(32)=426,80$			

Source: KfW SME Panel, own calculations

[1] Cf. Börsch-Supan, A. (2014): Ökonomie einer alternden Gesellschaft. Perspektiven der Wirtschaftspolitik, vol. 15, issue 1, p. 4–13 (in German).

[2] Cf. Horn, B. and R. B. Cattell (1967): Age differences in fluid and cristallized intelligence, Acta Psychologica 26: p. 107–129.

[3] Cf. Franz, W. (2013): Arbeitsmarktökonomik (*Labour market economics*). 8th edition, Berlin, Heidelberg: Springer, Gabler, p. 77ff.

[4] Cf. Pfeiffer, F. and K. Reuß (2008): Age-Dependent Skill Formation and returns to Education, Labour Economics 15(4): p. 631–646.

[5] Cf. MacDonald, G. and M. S. Weisbach (2004): The economics of Has-beens, Journal of Political Economy 112(1): p. 289–310.

[6] Cf. Aubert, P; Caroli, E. and M. Roger (2006): New Technologies, organization and age: firm level evidence, The Economic Journal 116: F73–F 93.

[7] Cf. MacDonald, G. and M. S. Weisbach (2004): The economics of Has-beens, Journal of Political Economy 112(1): p. 289–310.

[8] Cf. Weinberg, P. (2004): Experience and technology adoption. IZA Discussion Papers 1051, Forschungsinstitut zur Zukunft der Arbeit (IZA) oder Meyer, J. (2011): Workforce age and technology adoption in small and medium sized service firms, Small Business Economics 37: p. 305–324.

[9] Cf. Henseke, G. and T. Tivig (2009): Demographic change and industry-specific innovation patterns in Germany. In: Kuhn, M. and C. Ochsen (editors): Labor Markets and Demographic Change, p. 122–136, Wiesbaden: VS Research.

[10] Regarding the influence of entrepreneur age on the innovative output of their enterprise, cf. Zimmermann, V. (2013), Have the old still got what it takes? Differences in the innovative output of young and old entrepreneurs, KfW Economic Research, Focus on Economics No. 33, 1 October 2013.

[11] Cf. Leifels, A. (2016): Tafelsilber oder altes Eisen? Ältere Beschäftigte im Mittelstand *(Older workers in SMEs. A golden asset or liability?),* KfW Research, Focus on Economics No. 122, 5 April 2016 (in German).

[12] The model calculations are based on an enterprise with the following characteristics: 23.5 employees (in full-time equivalents) and 22 years of business operation. The values correspond with the medians in the sample. The enterprise is an R&D-intensive manufacturer, is not part of a group, does not employ any graduates and operates exclusively in the region of the company headquarters. Moreover, because of its legal status the enterprise does not have limited liability, has already received financial support from KfW and is located in western Germany. Turnover expectations within its industry are 14.8 on balance (median). The observation was taken from the 2014 survey wave.

[13] A Wald test does not reject the null hypothesis (to determine if the underlying regression coefficients are identical): $Chi^2(1)=0.23$; p-value=0.6299.

[14]Cf. Leifels, A. (2016), Mittelstand steht bei der Fachkräftesicherung in den Startlöchern (*SMEs are preparing to secure skills*), KfW Research, Focus on Economics No. 119, 18 February 2016 (in German).

[15] Cf. Arntz, M. and T. Gregory (2014): What Old Stagers Could Teach Us – Examining Age Complementaries in Regional Innovation Systems, ZEW Discussion Paper No. 14-050, Mannheim: Zentrum für Europäische Wirtschaftsforschung.

[16] The turnover expectations within an industry (typically on a two-digit level) are calculated as the balance of positive and negative expectations of the companies surveyed by the KfW SME Panel, while excluding from the calculation the assessment of the enterprise currently being observed.

[17] Regarding the influence of entrepreneur age on innovative output, cf. Zimmermann, V. (2013), Have the old still got what it takes? Differences in the innovative output of young and old entrepreneurs, KfW Economic Research, Focus on Economics No. 33, 1 October 2013

[18] Cf. Huber, P. J. (1967): The behaviour of maximum likelihood estimates under non-standard conditions, Proceedings of the Fifth Berkley Symposium on Mathematical Statistics and Probability 1: p. 221–233 and White, H. (1082): Maximum Likelihood Estimation on Misspecified Models, Econometrica 50: p. 1–25.