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Productivity and age: Evidence from work teams at the assembly line ☆

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ABSTRACT

The authors study the relation between workers' age and their productivity in work teams, based on a new and unique data set that combines data on errors occurring in the production process of a large car manufacturer with detailed information on the personal characteristics of workers related to the errors. The authors correct for non-random sample selection and the potential endogeneity of the age-composition in work teams. The results suggest that productivity in this plant which is typical for large-scale manufacturing does not decline at least up to age 60.

Introduction

Productivity is at the core of economics. Growth in modern economies is dominated by productivity growth (Maddison, 2001). Employers are keen to increase productivity of their workers as this is an essential element in competition across firms. Population aging now gives productivity a new dimension: older workers are often thought to be less productive. This impression is widespread and implicit in many discussions about aging, even in our economic text-books.[2] If the impression were true, population aging would have negative effects on overall productivity as the share of older workers is increasing, and would thus directly reduce economic growth. This would amplify the economic strains on aging societies already exerted by increasing Social Security and Medicare bills. The impression of declining productivity by age has also implications on the micro level, e.g. on personnel policies by employers and on retirement choices made by employees. In many countries, the assertion that productivity declines with age is used as a motivation for early retirement policies. This paper provides unique data and employs a battery of econometric methods to generate new and maybe surprising evidence on the age-productivity relation, shedding doubt on the wide-spread assertion at least for the age range which is commonly referred to as the "early retirement window".

Estimating the relation between age and productivity has been on the agenda of labor economists for a long time, see the surveys by Skirbekk (2004), Gelderblom (2006), and *Labour Economics*' recent "Special Issue: Ageing and Productivity" (Vol. 22, June 2013)[3]. Such studies, however, have encountered three fundamental challenges: measurement, selectivity/endogeneity, and aggregation. These methodological challenges have made it hard to distinguish fact from fiction. This paper and the underlying large data collection effort are tailored to overcome these difficulties.

First, productivity is hard to measure directly. While it is well documented by occupational medicine, cognitive psychology, and gerontology that muscle strength, sight, lung, kidney, and heart functioning, and many other biometric indicators deteriorate from early age onwards, experience and the ability to deal with human nature appear to increase with age. Since the latter characteristics are hard to measure, there is a bias towards direct measures that

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[2] E.g., Lazear (1995), (p. 40, Fig. 4.1).
[3] Bloom and Sousa-Poza (2013), Göbel and Zwick (2013), Lovász and Rigó, 2013, Mahlberg et al. (2013), Romeu Gordo and Skirbekk (2013), and Vandenberghe (2013).

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decline early in life. This may have contributed to the above-mentioned impression. The main contribution of this paper is to collect new data in a setting where output is standardized and time controlled such that productivity is precisely defined.

A second challenge is the potential endogeneity of the age composition through various selection processes. Being in the labor force is endogenous since employers are more likely to hold on to productive than unproductive workers. Hence plant closures and early retirement tend to create a positive selection of productive workers. A related endogeneity problem exists for the age-structure on the company level. Since more productive firms are usually more profitable, they expand and increase their workforce. This leads to a rejuvenation of their workforce because new hires are more likely to be young. Relating productivity to the age of the workforce in this case results in a spurious negative correlation between productivity and age. This paper merges productivity data with longitudinal personnel data, thereby providing a unique opportunity to purge productivity from unobserved heterogeneity.

Finding the right level of aggregation is a third challenge. An individualistic view fails to take into account that workers often work in teams and thereby affect one another's productivity. Older workers may devote some of their working time to helping or teaching younger workers. In this case, an individualistic approach will underestimate older workers' and overestimate younger workers' productivity.[4] Related aspects are workers' contributions to their team's work climate and how teams deal with emergency situations. A plant or company view, on the other hand, obscures job heterogeneity and its interaction with motivation and thus productivity. One would expect, e.g., that the productivity effect of older workers on the shop floor whose careers have peaked is quite different from the productivity effect of equally old managers who still might have ambitions for a position at the company's top or a realistic chance to move to another company. Plant view regressions that average over different non-linear age-productivity profiles might therefore create misinterpretations. This paper – as a third innovation – measures productivity at the intermediate level of well-defined work teams.

Labor economists have a long-standing tradition to study the productivity of workers. Recent papers have focused on the relation between incentives, cooperation, peer effects, supervision, and productivity in work teams (Bandiera et al., 2005, 2007, 2009, 2010; Lazear, 2000; Lazear et al., 2015; Mas and Moretti, 2009). Earlier studies focusing on age can be broadly divided into four groups. There are many studies relating plant level productivity to the age of the plants' employees.[5] Plant level productivity can be measured easily and reliably but the level of aggregation is quite high when the goal is to study the relation between productivity and age. Furthermore, the age structure of companies is probably not exogenous as pointed out before.

A second group of studies uses individual's wages as a productivity measure.[6] Wages, however, often increase with age and/or seniority independently of productivity, and wage decreases are extremely rare.[7]

Third, a group of studies relies on managers' subjective evaluations of their employees' performance.[8] These supervisors' assessments are problematic because they may reflect prejudices about age-productivity profiles.

There are finally many studies which employ direct measures of individual productivity like, e.g., the number and quality of publications or Nobel prizes in academic research,[9] the number and quality of completed court cases,[10] the value of artists' paintings,[11] or performance in sports and chess.[12] These studies are able to measure productivity quite precisely but the range of occupations, where this approach is feasible, is small. Moreover, these studies usually refer to top performance. In everyday work life, however, the workflow is customized to average rather than top performance.

Our study is most closely related to this fourth group but relates to average performance. We have compiled our data from a truck assembly plant owned by a large German car manufacturer with plants in Asia, Europe and the U.S. At this plant, trucks are assembled by work teams on an assembly line. We have selected this plant because it features a taylorized production process typical for the manufacturing industry, and because it stacks our cards against finding flat or increasing productivity with age. Compared to many service-sector jobs, productivity in this plant requires more physical strength, dexterity, agility etc. (which tend to decline with age) than experience and knowledge of the human nature (which tend to increase with age).

These data permit us to overcome the above-mentioned methodological problems in an unprecedented way. The data have three innovative elements. First, we measure productivity in an assembly line environment in which the time to produce a unit of output is as standardized as the quality of the final product. As the assembly line has the same speed for all work teams and the design of the trucks is pre-defined, more productive work teams are not able to produce more or better output than less productive work teams. Workers, however, make errors which are detected at end control. More productive work teams differ from less productive work teams only in the errors they make. We therefore use the number and severity of production errors during the assembly process as a precise and well-observed measure of productivity. We exploit the daily variation in the team composition of work teams over four years to identify the age-productivity profiles.

Second, we have merged the production error data with longitudinal personnel data. This permits us to hold a broad range of workers' characteristics constant and, most importantly, to correct for the selection effects marring so many earlier studies due to the endogeneity of early retirement and redundancy decisions by employees and employers to productivity.

Third, we measure the joint productivity of workers in a work team. This takes into account the individual workers' contribution to their co-workers' productivity. Particularly the contribution of older workers may be underestimated if productivity is measured at an individual level. Examples for such potential contributions to a team's productivity are the instruction of younger workers,[13] being relaxed in tense or hectic situations, and contributing positively to the work climate. We think that our approach solves the major aggregation problems in earlier studies.

[4] In principle, it can also be the other way round: Young workers helping the old. In either case, the individualistic approach fails.

[5] E.g., Hellerstein and Neumark (2007), Hellerstein et al. (1999), Haltiwanger et al. (1999, 2007) for the U.S., Hægeland and Klette (1999) for Norway, Aubert (2003), Crépon et al. (2003), Aubert and Crépon (2007) for France, Hellerstein and Neumark (1995) for Israel, Grund and Westergård-Nielsen (2008) for Denmark, Ilmakunnas and Maliranta (2005, 2007), Daveri and Maliranta (2007) for Finland, Malmberg et al. (2008) for Sweden, Dostie (2011) for Canada, Prskawetz et al. (2006) for Austria and Sweden, Lallemand and Rycx (2009) for Belgium, van Ours (2009) for the Netherlands, Schneider (2007), Göbel and Zwick (2009) for Germany.

[6] E.g., Kotlikoff and Wise (1989), Kotlikoff and Gokhale (1992), and Laitner and Stolyarov (2005).

[7] Lazear (1979, 1981) explains the increasing age-earning profiles with incentive effects. Loewenstein and Sicherman (1991) and Frank and Hutchens (1993) show in experiments that workers have a preference for increasing wage profiles and explain this with loss aversion and problems of self-control.

[8] E.g., Medoff and Abraham (1980), Hunter and Hunter (1984), McEvoy and Cascio (1989), Salthouse and Maurer (1996), and Schneider and Stein (2006).

[9] Jones (2010), Jones and Weinberg (2011), Weinberg and Galenson (2005), van Ours (2009).

[10] Backes-Gellner et al. (2011).

[11] Galenson and Weinberg (2000, 2001), Galenson (2009) and Bayer et al. (2009).

[12] Fair (1994, 2007), Fair et al. (2005), van Ours (2009), and Castellucci et al. (2011).

[13] If an older worker helps a younger worker, the older worker's productivity, narrowly defined by individual, is zero as the older worker is not producing anything at that time. The contribution to the work team's productivity, however, is positive.