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Ageing workforce and productivity: The unintended effects of retirement regulation in Italy

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Abstract

Making use of the quasi-natural experimental setting provided by the unexpected and sudden change in Italian retirement legislation at the end of 2011 (Fornero law), this article estimates the effect on productivity of a reduction of sorting mechanisms among older workers. The estimation uses provincial-level data. The increase of retirement age and restrictions on early retirement plans locked older employees into the workplace with a negative impact on productivity. Assessing the sorting effect contributes to the age-productivity debate, isolating more precisely the average effect of ageing on productivity.

Keywords: Ageing workforce; Labour productivity; Pension reforms; Quasi-natural experiments
JEL Classification: C33; H55; J26; O47

1. Introduction

During the past decade, the age composition of the workforce has dramatically changed in Italy, as in many other countries (Bloom and Souza-Poza 2013). This change is due both to demographic evolution and to new retirement legislation. On the one hand, the size imbalance between ageing baby boomers and the smaller younger generations has led to an increasing share of older people in the workforce. On the other hand, from the early 2000s onwards, concerns have emerged about the economic sustainability of pension systems. Until the beginning of the new century, weak eligibility requirements for receiving an early retirement benefits were used both as a measure of social welfare for employment affected by firm or industry-wide crises and as a way to rejuvenate firms' employment. Then, the age imbalance and increasing life expectancy led to the introduction of more restrictive retirement regulations. As stated by Hedge and Borman (2012) (pp. 663): '[F]or the most of the 20th century, government and employer policies tended to be "pro-retirement", encouraging workers to exit the labor force at a set age.' Today,

'[a]s the population … ages, there is an increasing pressure to encourage people to work past the traditional retirement age'. These tendencies are indeed common in many developed countries, which have imposed restrictions on early retirement plans (ERP) and increased the age of compulsory retirement, often while abandoning defined benefits (DB) in favour of defined contribution (DC) pension plans.

In Italy, this process occurred through a series of reforms aimed at gradually achieving the long-term equilibrium of the pension system. The stepwise re-equilibration of the pension system drastically accelerated at the end of 2011, when, under the pressure of the Italian sovereign debt crisis, the government headed by Mario Monti enacted a new reform (Law 201/2011 'Fornero', from the name of the Ministry of Labour). This quickened the adoption of the Notional Defined Contribution (NDC) system[1] already in place for entrant workers, increased the compulsory retirement age and restricted access to ERPs.

The debate on effects of the reforms is still on-going and involves several issues, from the sustainability of the pension system to intergenerational equity and the consequences for the labour market and firms' productivity. But, while it is easy to assess the consequences on the long-term equilibrium of the pension system, less clear are the macroeconomic consequences on the labour market, productivity and growth.

This paper, considering the effect of the ageing workforce on productivity, aims to contribute to the debate on the macroeconomic consequences of the pension reform. Despite the long-lasting slowdown of Italian productivity, few studies have focused on the effect of ageing on productivity in Italy. Whether workforce ageing affects productivity or not is a debated issue. In this study, we exploit the abrupt and unexpected change to the pension system to evaluate the effect on productivity growth of a sudden increase in the number of older workers locked into the workplace due to the reform.

[1] A more precise description of the NDC system is provided in Section 3.

To achieve this aim, we use panel data drawn from Italian provinces. The variability of the provincial composition of the workforce can help us detect important phenomena. The most important contribution of this paper is to highlight the effect on productivity of compulsory retirement delays and ERP restrictions. In the past only the most productive workers did not exploit the opportunity for early retirement; the reform drastically reduced the possible effects of sorting. To the best of our knowledge, this is the first attempt to assess empirically the role of the sorting mechanism in levelling differences in productivity between older and prime-age workers. In accordance with a wide range of literature, this paper shows that ageing is not in itself an impediment to productivity growth. However, productivity equalisation among age groups is sustained by the sorting process put in place through firms' and individuals' choices. As it will be explained below, the introduction of rigid retirement regulation, undoing the mechanism for sorting older workers according to their individual productivity, has made apparent the effect of an ageing workforce on productivity.

The paper proceeds as follows. In Section 2 we discuss the literature on the effect of an ageing workforce. We define our research hypothesis in Section 3. In Section 4, we describe the data and methods before we present the results in Section 5 and offer conclusions in Section 6.

2. Literature review and research questions

2.1 Theoretical contributions

Consequences and problems of an ageing labour force have been addressed from different perspectives.

A first issue is the effect of ageing on individual productivity.[2] On the one hand, it is expected that experience increases with age, having a positive effect on productivity; on the other hand, older workers are expected to be less productive and less able to adapt to new roles, tasks or technologies. These two effects suggest the hypothesis of an inverted U-shaped relationship between age and productivity, with productivity reaching its peak during the prime working ages. The assumption of a decline in individual performance with age has been widely criticized on the ground of prevalent psychological, biological and sociological theories of ageing (Baltes, Rudolph and Bal 2012). As stated by McDaniel et al. (2012): '[A]n inverted U-shaped relationship exists between age and job performance. The effects, however, are probably moderated by job complexity and whether experience with specific job content can buffer against expected age-related physical and cognitive decline'. Moreover, it is underlined that this relationship also depends on workers' educational level. Human capital acquired through education interacts with experience obtained in the workplace, thus modifying or displacing the expected relationship between age and productivity. In general, age is a poor predictor of individual job performance and, despite the decline of some capacities, potential exists for keeping high productivity levels, especially when an employer accommodates the declining capabilities of older workers and capitalizes on their strengths. Furthermore, even if older adults show poorer training performance (Kubeck et al., 1996), there several studies attempting to understand how to use on the job training to preserve older workers productivity levels (Kraiger, 2017; Jeske et al., 2017).

[2] In this review, we leave aside the debate on the relationship between an ageing population and growth. The 'secular stagnation' view is well represented by Robert Gordon's (2016) book, which identifies demographic changes as being among the main causes of slowdown in the developed world. In contrast, Acemoglu (2010) and Acemoglu and Restrepo (2017) support the view that labour shortages can encourage innovation. If, according to this second view, an ageing population has the twofold effect of decreasing labour force and increasing innovation, it is possible that ageing goes on hand with increased total factor productivity (TFP) (and growth). We do not enter into this debate because what matters in this stream of literature is labour scarcity, not specially ageing. Innovation driven by labour scarcity would affect productivity of the entire labour force, while our concern is the productivity of older workers.

A second issue is related to the effect of technological change on an ageing workforce. Technological advancements can have a twofold effect: from one side, they can help overcome age-related limitations, with respect to physical and cognitive deficits, and enhance social activities; on the other side, ageing can be an obstacle to technology acceptance and impair access to new devices (Thompson and Mayhorn 2012). Here again, what seems to matter is how the workplace accommodates the ageing workforce through technology design and training.

A third source of concern is how the labour market reacts to ageing workers. A common view is that old workers have lower mobility and, once exited from a job, face increasing difficulty in reallocation. According to several studies (Van Dalen et al. 2010; Klehe et al. 2012), the re-employability of older workers is impaired by persisting stereotypes. This justifies stricter employment protection legislation for older workers and the use of early retirement plans in the case of job loss.

Overall, there are no reasons to justify early retirement plans based on worsened performance or weaker adaptation to new technologies. Older workers' performances depend on personal attitudes and training and on firms' human resource policies. Moreover, job reallocation can be facilitated by a labour market less sensitive to stereotypes and more capable of helping reallocate older workers to workplaces where they can be more productive. Ultimately, the assessment of the average impact of ageing is an empirical matter aimed at verifying how firms and workers adapt to the phenomenon.

2.2 Empirical studies: Firm level analysis

Theoretical hypotheses have been tested at both the firm (or establishment) level and aggregate level (countries, regions or industries). The analytical issues faced by the two types of studies are similar, particularly with respect to the treatment of endogeneity that has a particular effect on the results. If a negative correlation between productivity and age were observed, this could result either from declining

capabilities with age or from the fact that less productive firms grow (and hire) less and consequently have a higher share of older workers.

This endogeneity effect was first isolated by Auber and Crépon (2003), who made use of French firm data in the late 1990s. They used an augmented Cobb–Douglas and compared within and between estimations. The productivity decline observed in the OLS estimations nearly disappeared in GMM estimates that account for endogeneity problems. Productivity decline was limited to the higher age class and to manufacturing, and was not observed in services. A similar strategy was used by Goebel and Zwick (2011), who considered the waves 1997–2005 of the German linked employer–employee dataset (LIAB). They, too, did not observe a decline of productivity with age once endogeneity was cleared. Cardoso et al. (2011) also used GMM with Portuguese manufacturing and service firms data between 1986 and 2008: they observed an increase of productivity until the age of 54; afterwards, productivity remained constant. Daveri and Maliranta (2007) studied three sectors (forestry, machinery and electronics) in Finland during the period 1995–2002 and found an inverted U-shaped relationship between age and productivity only in electronics. *De Economist* and *Labour Economics* dedicated special issues in 2011 and 2013, respectively, to the relationship between age and productivity. Both issues contained relevant analysis based on linked employer–employee datasets (see Vandenberghe 2011; Bloom and Sousa-Poza 2013). Weak or no evidence of a relationship between age and productivity were found by van Ours and Stoeldraijer (2011). A similar result was observed by Mahlberg et al. (2013) regarding Austrian firm data, while Dostie (2011), using Canadian data, observed a concave relationship between age and productivity. At an even finer level of analysis, it is worth noting the 'insider firm' econometric estimation by Börsh-Supan and Weiss (2016), who carried out a highly-detailed study of work-teams' productivity on a Mercedes-Benz assembly line without finding evidence of a decline of productivity, measured by the number of errors on the line among older workers. Overall, the majority of firm-level studies show higher productivity among prime age workers compared with younger

workers, confirming the effect of learning. On the other hand, the evidence on older workers' productivity is weak.

2.3 Empirical studies: Country and regional level analysis

Firm-level analyses can overlook the rebalancing effect due to workers' inter-firm mobility. Despite being less refined, geographically aggregated data add new insights to the firm-level analysis.

A negative influence of the share of older workers on productivity was observed by Tang and MacLoad (2006) using data from ten Canadian provinces (1982–2001), and the interaction with education level showed that less-educated people contribute more to the productivity decline. The hypothesis of an inverted U-shaped relationship between age and productivity, with productivity reaching its peak during prime ages and declining afterwards, is supported by several studies on aggregated data. Vandenberghe (2015), using EU-KLEMS industry-level data from 34 industries, found that 'older workers may possess more experience but this does not suffice to counterbalance the negative impact of age on productivity'. Illmakunas and Miyakoshi (2013) studied the drivers of total factor productivity (TFP) using panel data on manufacturing in 13 countries from 1970–2005 taken from the same EU-KLEMS dataset and found that ageing is a negative driver of productivity among the low-skilled, but not among high-skilled workers. Brunow and Hirte (2009) investigated the impact of the age of a highly skilled labour force on average productivity using cross-sectional data from some NUTS3 German regions, correcting for spatial autocorrelation. They found evidence of a U-shaped pattern, with the age cohort 30–39 significantly less productive than the younger and older cohorts.

However, the same endogeneity problem, highlighted by Auber and Crépon (2003) in their firm-level investigation, also affects the results from aggregated data: highly productive and successful firms tend to hire more than less-productive firms do and, consequently, they present a more age-balanced

workforce than firms that stop hiring. Appropriate treatments of endogeneity were therefore also adopted in aggregated analyses. Feyer (2007) gleaned data on 87 countries collected at five-year intervals between 1960 and 1990. Productivity variations and single components (TFP, labour productivity and capital intensity) were regressed on the share of the workforce at ten-year intervals. The endogeneity issue was addressed by instrumenting age-specific participation rates with population data. It was shown that the demographic structure strongly affects growth, mainly through the productivity residual. A central age (40–49 years) was associated with higher productivity than younger cohorts; however, the results were less clear for older cohorts (50 and above), with coefficients still negative but less than for younger cohorts and less precisely estimated. A proper account of the endogeneity bias seems to weaken the inverted U-shaped hypothesis between age and productivity – or at least limits its validity to special cases. Recently, however, using country data from the euro area for the period 1984–2007 and using lagged population data as an instrument, Ayar et al. (2016) found evidence that an ageing workforce significantly affects country productivity, particularly through the TFP component.

Even if a majority of studies at the aggregate level show that, after correcting for endogeneity, the age effect weakens or disappears, the results are still controversial. The question of whether age negatively affects productivity, and whether there are consequences from a growing ageing workforce, therefore remains unanswered. From a methodological point of view, it is worth noting that there are two sources of endogeneity. The first, which has been tackled by some of the aforementioned studies, derives from the potential reverse causality behind the correlation between an age structure and productivity. Less attention, however, has been devoted to a second source of endogeneity resulting from sorting: employers are more likely to retain productive employees and to encourage those who are less productive to accede to ERPs. At the same time, less motivated or psychologically or physically exhausted employees tend to anticipate retirement. On the opposite direction, rules on the minimal contribution

years could have restrained from retirement low productive workers, especially females.[3] Assessing the effect of sorting on the age–productivity relationship is of the utmost importance because, as has been shown, workforce ageing depends both on demographics and on the reform of retirement legislation and ERP restrictions that affect the sorting process.

Our research hypothesis is that the sorting process made possible by flexible ERPs played an important role in the past in maintaining high productivity levels by the older workforce. More precisely, we state the following hypotheses:

Hp 1: There is not a negative impact of ageing workforce on productivity.

Hp 2: More productive older workers stay longer in their jobs compared to less productive ones. Sorting played a fundamental role in weakening the negative effect of age of workers on productivity.

The unexpected increase in the retirement age and the ERP restrictions imposed by the new Italian legislation in 2011 offered the chance for a quasi-natural experiment on the impact of a compulsorily delayed retirement. If indeed sorting mechanisms played a role in keeping the most productive employees at work, it is reasonable that restrictive rules influenced the productivity observed after the introduction of the new law. By looking at the difference between the pre- and post-treatment, it is possible to assess the role of sorting mechanisms in keeping only the most productive workers employed.

3. The institutional setting

[3] We are grateful to our anonymous reviewer to have highlighted this counterbalancing effect.

In the twenty years between 1992 and 2012, the Italian pension system passed through a long process of reforms aimed at controlling the large and increasing weight of pension spending on the public budget and at rationalising the highly uneven retirement regulations for different categories of workers. Major steps in this process were the Amato (1992), Dini (1995) and Fornero (2011) reforms. The Amato reform changed the conditions for early retirement and introduced a gradual increase of the eligibility age by one year of age every two years, until it reached age 65 for men and 60 for women. Three years later, a new law passed by Prime Minister Lamberto Dini changed the requirements for early retirement, but – most importantly – modified the benefit computation method from the previous defined benefit (DB) to a notional defined contribution system (NDC). With the previous DB system, pensions were calculated on the basis of the more recent salaries earned by the retiring worker. This had a twofold effect. First, expected pension payments were higher than the contributions workers paid during their working lives, as active workers were supposed to bear the difference between contributions and payments: this intergenerational transfer was no longer affordable in the face of generational imbalances. Second, as designed, the DB system incentivised early retirement. Once workers reached their expected top salary, they would enjoy great advantages from retirement. Under the new NDC system, contributions are calculated as a fixed percentage of earnings and are capitalized at an annual return equal to the average growth rate of gross domestic product (GDP) in the previous five years. At retirement, the notional stock of contributions is converted into a pension through a pre-defined actuarial coefficient, varying with age. The new system was introduced gradually to new entrants in the labour market. This implied a slow impact on pension spending, which was abruptly corrected by the 2011 Fornero reform, approved under the pressure of the international sovereign debt crisis of the same year. The goals of the reform were to accelerate the transition towards a NDC system and increase the age of eligibility. Minimum retirement age was increased from to 66 years for males and to 62 years for females, and it was linked with life expectancy:, an additional quarter of year was added from 2013 to 2015 for males, and one year and three

quarters for females in order and reduce some remaining differences between the eligibility age of men and women and close the gender retirement gap in few years

From the point of view of this article, the relevant aspects of the reform are the sudden delay of retirement and the change of rules for early retirement. First, the compulsory retirement age of workers, previously established at 65 for men and 60 for women,[4] was increased for men to 66 years in 2012 and 66 and three months in 2013, and for women to 62 years in 2012 and 62 and three months in 2013. Second, the mechanism used to anticipate access to early retirement was modified: the previous mechanism, which jointly considered age and work life, was substituted with a criterion of 42 work-life years. Both provisions had an immediate impact on pension spending, locking a large share of workers into the workplace. As will be detailed in the data description, the majority of workers locked into the workplace by the reform were males aged 64–65 and females aged 59–60.

4. Data and empirical strategy

Given the unavailability of a linked employer–employee dataset in Italy, the analysis was run at the provincial level (NUTS3). We are aware of the many limitations of using aggregate data: an ideal assessment would require matching individuals with firm data, thus isolating the effect of age and the condition of employees locked into the workplace. The use of aggregate data on productivity and the proxy for locked-in workers permitted only a rough approximation of the phenomenon under consideration. Is it possible, however, to exploit the high variability of provincial data to gather some important hints that will need to be more precisely assessed in further studies.[5]

[4] The retirement age of independent workers was slightly different.
[5] Bertoni and Brunello (2017) similarly use provincial and regional data to assess the effect of the raised retirement age on young employment: they exploit the fact that minimal retirement age is set at the national level, but the impact of national changes on the number of employees non eligible to retire varies across local areas.

The most important source of data on employment is the quarterly survey of labour forces, a survey administered to a sample of 250,000 families (more than 600,000 individuals) in Italy, conducted by the Italian National Institute of Statistics (ISTAT). Based on survey data, we calculated estimates of employment composition for Italian provinces from 2009–2015.[6] Employment data were matched with regional economic data from ISTAT and other economic indicators from the European Regional Database by Cambridge Econometrics at the level NUTS3, corresponding to Italian provinces. Because regional economic data were available for the period 2009–2013, the time span considered in the final database after the data integration was 2009–2013. Table 1 contains a detailed description of the resulting database. Table 2 presents some descriptive statistics of the variables. The share of workers at least 55 years old was highly variable, with a minimum of 9.5%, a maximum of 21.9% and an average of 14.9%. The measure of the intensity of exposure to the increase in the retirement age across provinces (*Exposed_share2011*) is a continuous variable that represents the share of workers locked in the workplace as a consequence of the Fornero reform. This measure also varied significantly between 0.8% and 3.9%, with an average of about 1.6% (see also Figure 1). A wide diversity among provinces could also be observed in terms of the share of workers with tertiary education. As is known from the literature, education has an important (positive) effect on workers' productivity, and it is distributed unevenly among different age groups.

Overall in Italy, in the period 2009–2013, the share of workers aged 55 or over (groups 55–64 and 65 and older) increased from 13% to more than 16.5%, while the 25–34 group declined from nearly 23% to 19% (see Figure 2). Figure 3 shows the box-plot of the shares of employees aged 55 or older in Italian provinces between 2009 and 2013. Each box-plot refers to one year, and the central horizontal line is the median; first and third quartiles were used to build the box so that the middle 'box' represents

[6] Sample weights have been provided by ISTAT.

the middle 50% of scores for the group. The share of the 55 or older group increased by about five percentage points in seven years. This shift is in place for the entire distribution. Indeed, boxes along the years maintain a similar shape but shift upwards. In Figure 4, the distribution of employment by age group in the provinces shows that southern provinces have a higher share of older employees, while prime-age workers participate more in north and central Italy. At the same time, southern provinces have the lowest level of labour productivity (Figure 5). A simple univariate regression between productivity and the share of older workers reveals a negative coefficient, as appears in Figure 6.

Figure 7 shows the consequences of reform on retirement age. The average effective age of retirement increased slowly and discontinuously throughout the decade following 2000 due to the many exceptions to the stricter legislation. However, after the 2011 Fornero reform, there was an abrupt increase of the retirement age.

To obtain a better understanding of the relationship between the participation of older workers and productivity, the following research strategy was adopted. First, an analysis similar to the ones described in the literature review was carried out. In this step, we checked whether, after controlling for endogeneity, an effect of ageing on productivity was still observable (Hp 1). Second, making use of the exogenous shock provided by the Fornero law, we tried to understand what role the sorting process could have played in shaping the relationship between age and productivity (Hp 2).

For the first step, we carried out a multivariate regression analysis over the period 2009–2013. The baseline specification is a two-way fixed-effect model where the aggregate labour productivity of the province *i* at time *t* (LP_{it}) is assumed to be a function of the proportion of the workforce in the age class *T* (less than 34, 55 or older, 55–59 or 60 or older, depending on specifications) (Q_{it}^{T}), a set of time-varying control variables X_{it}, a time-invariant province fixed-effect μ_i and a time-specific effect common to all provinces τ_t.

$$LP_{it} = \delta Q_{it}^{T} + \beta X_{it} + \mu_i + \tau_t + \varepsilon_{it} \qquad (1)$$

The coefficient δ was interpreted as the resulting effect on labour productivity of a shift of workforce share within the group of workers aged in T years interval.

The specification in (1) is subject to endogeneity issues because the participation rate within age cohorts may be endogenous; a change in productivity may induce changes in the participation rate, which in turn may introduce a bias into the results. To address this problem, a GMM estimation strategy was adopted, using the lags of the potentially endogenous variables as instruments.[7]

For the second step, endogeneity concerns stemming from the selection process were addressed: if only more productive older workers remain at work, what is observed from data does not represent the average productivity of the older workforce but only the more productive part of it.

In the middle of 2011, the Italian government was in danger of becoming insolvent unless it implemented immediate savings. Along with other measures, an increase in the retirement age requirement was decided upon and came into operation immediately. Since this postponement of retirement was unexpected, it offered the chance for a quasi-natural experimental setting.[8] To deepen the analysis on the effect of retaining older workers on labour productivity, we used the Fornero law as an exogenous shock: after 2011 all older workers were forced to stay on the job, hindering any sorting process related to workers' individual productivity.

[7] Following previous research (Feyer 2007; Ayar et al. 2016) an IV approach was also attempted by instrumenting each province's share of the workforce aged 55 or older with the population share of those aged 45–64 ten years previously. Tests of the validity of the instrument suggested abandoning this approach.

[8] The use of the Fornero law as a quasi-natural experiment, justified by the unanticipated approval and immediate application of the new regulation, was suggested by Boeri, Garibaldi and Moen (2016).

In particular, we exploited the fact that provinces with a larger share of workers close to retirement when the Fornero law was approved suffered a bigger shock than did provinces with a lower share. Formally, we refer to the following model:[9]

$$LP_{it} = \theta Exposed\_share2011_i + \beta X_{it} + \varepsilon_{it} \qquad (2)$$

where *Exposed_share2011*$_i$ is a variable that defines a measure of the exposure of the province to the shock due to the increase in the retirement age and is equal to zero before 2011 and has the value of the share of female workers 59–60 years old and male workers 64–65 years in province *i* in 2011. X_{it} is a set of time-varying control variables. In particular, controls were introduced for the sheer age effect (the proportion of the workforce aged older than 60 years [Q_{it}^{60+}]), and for the effect of the business-cycle dynamics, making use of the unemployment rate (*Unempl_rate*$_{it}$) and regional GDP (*Reg_GDP*$_{it}$).

The specification used in Equation (2) exploits the increase in retirement age imposed by the 2011 Italian legislation. The variable of interest is *Exposed_share2011*$_i$, which is continuous.[10] The coefficient θ captures the effect of the postponement of retirement on productivity irrespective of the individual worker productivity of such cohorts of individuals. A negative significant value of θ signals that, on average, older workers belonging to the cohorts forced to stay at their jobs have a negative effect on labour productivity. That would be consistent with the hypothesis that the new restrictive rules on retirement hindered the previously operating mechanisms for sorting the workforce.

Equation (2) was also estimated using a 'placebo' treatment; namely, the model was re-estimated under the assumption that the treatment took effect at an earlier date. In particular, the variable

[9] A similar econometric strategy can be found in Guadalupe and Wulf (2010). They analyse the effect of the 1989 Canada–US Free Trade Agreement on firms' organizational flattening. Their variable of interest is zero before 1989 and assumes the value of the average level of tariffs on Canadian imports in the industry pre-1989 (their degree of exposure of each statistical unit to the institutional discontinuity).

[10] Note that all Italian provinces have been exposed to the discontinuity identified by the new law.

Placebo_treat$_i$ was assumed to be zero until 2010 and subsequently equal to the share of female workers 59–60 years old and male workers 64–65 years old in a province in 2011. Given that the placebo treatment precedes the exogenous shock, the estimated coefficient for θ should be zero.

5. Results

Table 3 presents fixed effect panel estimates of Equation (1). In Column 1, the estimated coefficient of the logarithm of the share of workers equal to or more than 55 years old (Q^{55+}) is negative. The result holds if we add the level of education as an additional control (Column 2) and if we also consider the cohort of workers less than 34 years old (Q^{-34}) (Column 3).

Columns 4 presents a model in which we split the class of older workers into two: workers between 55 and 59 years old (Q^{55-59}) and workers equal to or more than 60 years old (Q^{60+}). If a sheer age effect were at work, a negative and significant coefficient of increasing magnitude would have been observed. That is, the coefficient for the class of workers between 55 and 59 years old should be smaller – in absolute value – than that of the class of workers more than 60 years old. However, the results in Column 4 show instead that (i) for the class Q^{55-59}, the coefficient is negative and significant; (ii) for the older class (60+), the coefficient is smaller and not even significant. This casts doubt on the hypothesis of a sheer age effect on labour productivity.

In Columns 5, 6 and 7, GMM estimations using the lags of potentially endogenous variables as instruments are shown. The GMM estimation is consistent if lagged values of explanatory variables are valid instruments. To assess the validity of the GMM approach, a Sargan over-identification test was performed. The null hypothesis is that 'the instruments as a group are exogenous': a failure to reject the null hypothesis implies that the instruments are valid. The Sargan tests did not reject the null hypothesis on the validity of the instruments used. In addition, AR(1) and AR(2) tests were performed to check

whether the instruments used were able to remove the serial autocorrelation after two time lags. The results did not reject the null hypothesis of serial autocorrelation after two time lags.

Looking at the results, we can see that the estimated coefficient for the older workforce is negative, but not significantly different from zero. This result holds if (i) we use the proportion of worker older than 55 years (Q^{55+}) (Column 5), (ii) we use as an additional control variable the share of workers less than 34 years old (Q^{-34}) or (iii) we split into two the older cohort of workers (Column 7).
Summarising, estimations in Table 3 confirm, in accordance with the majority of the literature, that the ageing of the workforce does not affect productivity at the provincial level once endogeneity is controlled for. We find support for our Hypothesis 1 (H1).

As has been explained, however, this result might conceal the sorting effect that existed until 2010 and was abruptly interrupted in 2011 by the Fornero law. To isolate this effect, the exogenous shock provided by the Fornero law was taken into consideration through the estimation of Equation (2) presented in Table 4.

In this model the variable of interest is the share of workers locked into the workplace by the reform. With respect to previous models of Table 3, we added as independent variables (i) the unemployment of the province and (ii) the regional GDP in order to capture business-cycle spatially differentiated effects. Column 1 (Benchmark model) shows that a 1% increase of locked-in workers implies a decrease of value added per worker of about 0.6%. This result is robust to the introduction in the model of the share of workers more than 60 years old (Q^{60+}), which turns out to be not significant (Column 2). The model was also estimated in first-differences using only two years as pre and post Fornero reform (Column 3). The results still support the negative relationship between the share of locked-in workers and labour productivity.

Comparing the results of GMM models in Table 3, which show a non-significant effect on value added per employee of older workers, with the results of Table 4, Columns 1 and 2, we can hypothesize

that, while before Fornero older, less productive workers were leaving their jobs, guiding the non-significant result, after the law, candidates for leaving their jobs were forced to stay irrespective of their productivity, having a negative impact on productivity.

With respect to the magnitude of the estimated coefficient, to correctly assess the entity of the treatment effect, it must be considered that the share of workers locked into the workplace is small, being on average less than 1.6%. Nevertheless, the difference between the lower and the higher value is around 3.1% (see Table 2). Despite the small average entity of the effect, some provinces might have been greatly affected by the compulsory increase in the retirement age.

To support the validity of the estimation strategy, a placebo regression was run. In these regressions, whose results are shown in Columns 4 and 5, the coefficient for the variable *Placebo_treat* is not statistically different than zero, lending support to our hypothesis on the role of the Fornero law.

Summarizing, H2 cannot be rejected: the sorting of more productive workers played a role in keeping the observed productivity of older workers not significantly different from that of prime aged and younger workers.

6. Conclusions

The results presented confirm the role of the mechanisms of sorting in keeping older-worker productivity at a level indistinguishable from that of younger age groups. The abrupt interruption of that mechanism impaired productivity with a stable negative shock. Before adding some comments, it is worth highlighting the limits and possible extensions of this result, as several factors not considered here could affect it in terms of either over or underestimating the phenomenon.

First, the share of workers locked into the workplace at the end of 2010 is surely underestimated. The Fornero law not only increased the compulsory retirement age, but also introduced more selective

rules for ERPs. Without going into the details of the provisos for early retirement, it is clear they affected the retirement decisions of workers younger than the ones considered in this paper as a proxy of the affected population.

A second issue depends on the impact of the reform on the composition of the workforce. The abrupt change of the retirement system was enacted in a dualistic labour market, where younger cohorts face more flexible hiring and dismissal rules. The compulsory retention of locked-in workers was compensated for by a reduction in the hiring of young people, regulated by more flexible legislation than that regulating older employees (Boeri, Garibaldi and Moen 2016). A more complete view of the effects of the compulsory delay of retirement age should also take into account the consequences of retaining old and less productive young workers.

Our results are an indirect confirm of the existence of a sorting process in the link between ageing and productivity: More productive older workers have higher probability to remain on the job compared to less productive older workers. In other words, the existence of a sheer effect of age of workers on productivity seems to be not the appropriate interpretation for present Italian.

A more precise estimation of the effect considered here would require a firm-level data for the whole period under scrutiny, which are not yet publicly available in Italy. Nonetheless, the results of the present exercise open the way for further considerations. First, worries about the effects of ageing on productivity must be reconsidered. Firm policies aimed at retaining active ageing employees, together with retirement flexibility, can easily overcome the risks of the negative effects of ageing on productivity. In this respect, on one hand, firms must learn how to make better use of older employees through training and proper human resource management; on the hand, public policies must introduce more flexible retirement rules. Indeed, while a defined benefit system tends to incentivise early retirement, defined

contribution systems are, by their nature, compatible with flexible exits[11] without impairing the pension system' financial equilibrium.

Nevertheless, the productivity shock may hamper efforts to increase productivity after the twenty-year slow down. It is not easy to reorganise firms and reshape industrial structure when part of the workforce is locked into the workplace. To this end, greater inter-firm, inter-industry and inter-generational mobility are needed.

[11] The same compulsory retirement age can be, in this regard, reconsidered.

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Table 1 Description of variables

Variable	Description
LP	Labour productivity measured as value added per employee
Q^{-34}	Share of workers aged under 34 years
Q^{55+}	Share of workers aged over 55 years
$Q^{55–59}$	Share workers 55–59 years old
Q^{60+}	Share of workers aged over 60 years
Educ	Share of employees with tertiary education
Part_rate	Participation rate measured as total employment divided by total population
Dep_ratio	Dependency ratio, measured as the ratio between the sum of the young population, i.e. people with less than 15 years, and people aged over 65 years and working age population (people 15–64 years old) (see Choudhry et al. 2016)
Unempl_rate	Unemployment rate
Reg_GDP	Regional (NUTS2) Gross Domestic Product
Exposed_share2011	Sum of the share of female workers 59–60 years old plus the share of male workers 64–65 years old in 2011

Table 2 Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
LP [€]	515	54279.1	6244.6	41055.8	75092.1
Exposed_share2011 [%]	515	1.6	0.5	0.8	3.9
Q^{-34} [%]	515	25.9	3.0	18.0	34.0
Q^{55+} [%]	515	14.9	2.3	9.5	21.9
Q^{55-59} [%]	515	9.4	1.5	5.2	13.5
Q^{60+} [%]	515	5.5	1.2	2.9	10.1
Dep_ratio [%]	515	53.7	3.8	43.5	65.3
Educ [%]	515	16.9	3.3	7.5	26.9
Part_rate [%]	515	37.9	6.1	23.3	48.3
Unempl_rate [%]	515	9.6	4.7	2.1	26.8
Reg_GDP [bn €]	515	112.2	91.4	4.2	348.2

Table 3 The effect of workforce ageing on labour productivity

Dep. Var.: Ln(LP)	(1) FE	(2) FE	(3) FE	(4) FE	(5) GMM	(6) GMM	(7) GMM
$Ln(Q^{55+})$	-0.0333***	-0.0360**	-0.0366***		-0.2380	-0.2444	
	(0.0126)	(0.0127)	(0.0128)		(0.1541)	(0.1506)	
$Ln(Q^{-34})$			-0.0060			-0.0511	
			(0.0159)			(0.1426)	
$Ln(Q^{55-59})$				-0.0275***			-0.0686
				(0.0095)			(0.1729)
$Ln(Q^{60+})$				-0.0072			-0.1531
				(0.0075)			(0.1018)
Ln(Part_rate)	0.0111	0.0111	0.0138	0.0091	0.1763	0.1645	0.1170
	(0.0365)	(0.0364)	(0.0371)	(0.0365)	(0.1582)	(0.1516)	(0.1606)
Ln(Dep_ratio)	0.2702***	0.2554**	0.2489**	0.2650**	0.5086**	0.4967**	0.6404***
	(0.1027)	(0.1025)	(0.1041)	(0.1033)	(0.2097)	(0.2128)	(0.2287)
Ln(Educ)		0.0205**	0.0200*	0.0207**	0.1070***	0.0986***	0.1055***
		(0.0101)	(0.0102)	(0.0101)	(0.0253)	(0.0338)	(0.0269)
Constant	9.8571***	9.8665***	9.9056***	9.8116***	8.5433***	8.8437***	8.0109***
	(0.4081)	(0.4066)	(0.4198)	(0.4091)	(0.3087)	(0.8805)	(0.5650)
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nr. Obs.	515	515	515	515	515	515	515
R^2 within	0.3012	0.3083	0.3085	0.3095			
R^2 between	0.3579	0.3884	0.4000	0.3643			
R^2 overall	0.3198	0.3425	0.3523	0.3259			
Sargan test χ^2(gr) [*p*]					6.90(8); [0.547]	6.76(12); [0.873]	11.68(12); [0.472]
AR(1) test [*p*]					-1.15 [0.249]	-1.12 [0.261]	-0.88 [0.379]
AR(2) test [*p*]					-0.79 [0.432]	-0.77 [0.442]	-0.83 [0.404]

NOTES: * indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level. Standard errors are reported in round brackets. Specifications in (1)–(4) were estimated using the within-group fixed effects estimator. Specifications in (5)–(7) were estimated using the one-step GMM system estimator based on level equations; the first and second lags were used as instruments of variables; the Sargan test is a test of over-identifying restrictions, distributed as chi-square under the null of instrument validity; the first order AR(1) and second order AR(2) test for serial correlation of the error term are distributed as standard normal N(0,1) under the null of no serial correlation. Year dummies are included in all specifications.

Table 4 The effect of the Fornero law. Fixed effect panel data estimators.

Dep. Var.: Ln(LP)	(1) Benchmark model	(2) Benchmark model	(3) Benchmark model	(4) Placebo model	(5) Placebo model
Exposed_share2011	-0.0059***	-0.0061***	-0.0088***		
	(0.0017)	(0.0017)	(0.0021)		
Placebo_treat				-0.0005	-0.0007
				(0.0013)	(0.0013)
Ln(Q^{60+})		0.0062	-0.0095		0.0041
		(0.0070)	(0.0094)		(0.0072)
Ln(Dep_ratio)	0.2188***	0.2034**	-0.4148**	0.1265	0.1177
	(0.0833)	(0.0851)	(0.2094)	(0.0832)	(0.0847)
Ln(Educ)	0.0182*	0.0171*	0.0166	0.0133	0.0126
	(0.0099)	(0.0100)	(0.0140)	(0.0100)	(0.0101)
Ln(Part_rate)	-0.0363	-0.0373	0.0030	-0.0376	-0.0383
	(0.0359)	(0.0360)	(0.0597)	(0.0365)	(0.0365)
Ln(Unempl_rate)	0.0054	0.0044	-0.0074	-0.0044	-0.0050
	(0.0063)	(0.0064)	(0.0096)	(0.0059)	(0.0060)
Reg_GDP	0.0032***	0.0032***	0.0037***	0.0035***	0.0035***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Constant	9.7353***	9.7924***	0.0142***	10.1081***	10.1395***
	(0.3515)	(0.3574)	(0.0025)	(0.3532)	(0.3578)
Nr. Obs.	515	515	206	515	515
R^2 within	0.3024	0.3038		0.2810	0.2816
R^2 between	0.1907	0.1891		0.1879	0.1871
R^2 overall	0.1882	0.1866		0.1852	0.1844
R^2			0.6009		

NOTES: * indicates significance at the 10% level; ** indicates significance at the 5% level; *** indicates significance at the 1% level. Standard errors are reported in round brackets. The specifications (1), (2), (4) and (5) were estimated using the within-group fixed effects estimator; specification (3) was estimated in first-differences.

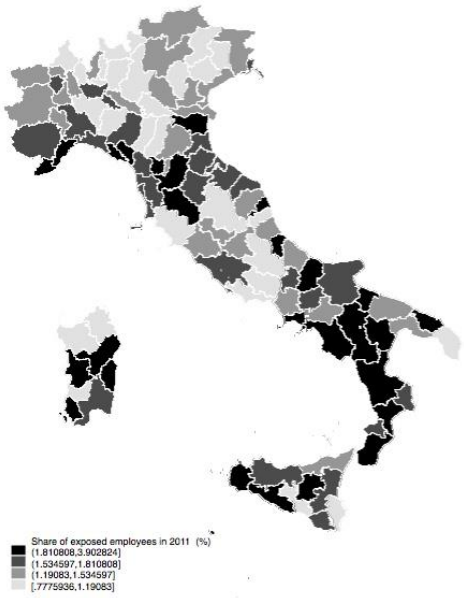

Fig. 1 Distribution of the intensity of exposure to the Fornero law across Italian provinces. Source: Our elaborations based on the ISTAT labour force survey

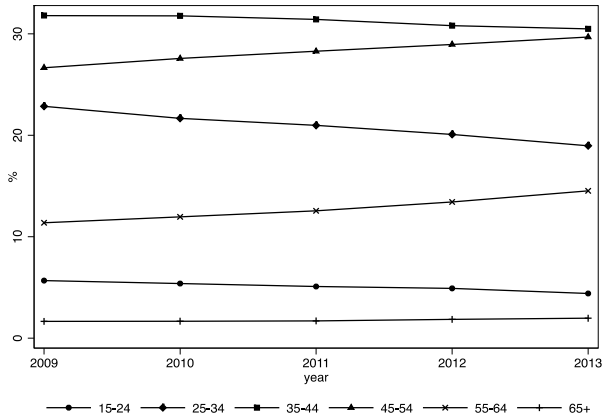

Fig. 2 Italian workforce composition by age groups: 2009–2013. Source: ISTAT labour force survey

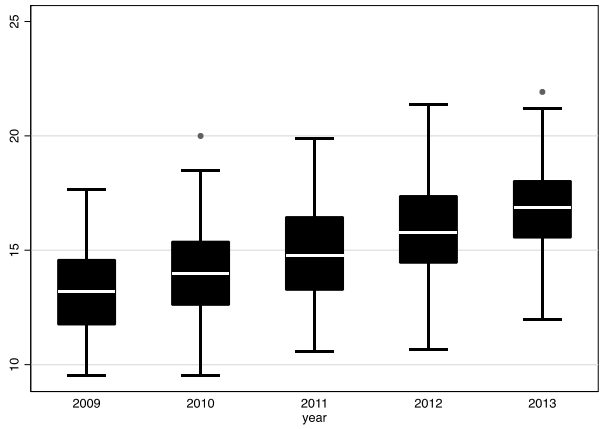

Fig. 3 Distribution of the share of workers aged 55 or older in Italian provinces: 2009–2013. Source: Our elaborations based on the ISTAT labour force survey. Notes: box-plot report median, Q1 and Q3. Extreme values are those values that exceed 90% of the distribution. Dots represent outliers of the distributions

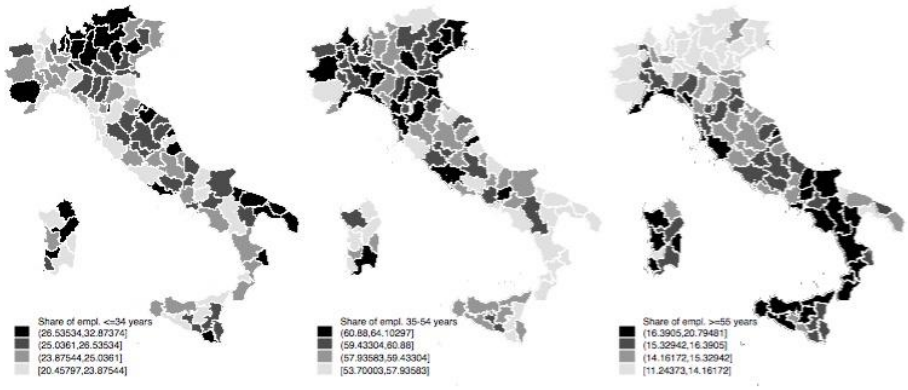

Fig. 4 Distribution of employment by age group in Italian provinces: 2009–2013. Source: Our elaborations based on the ISTAT labour force survey

Fig. 5 Average value added per employee in Italian provinces: 2009–2013. Source: ISTAT

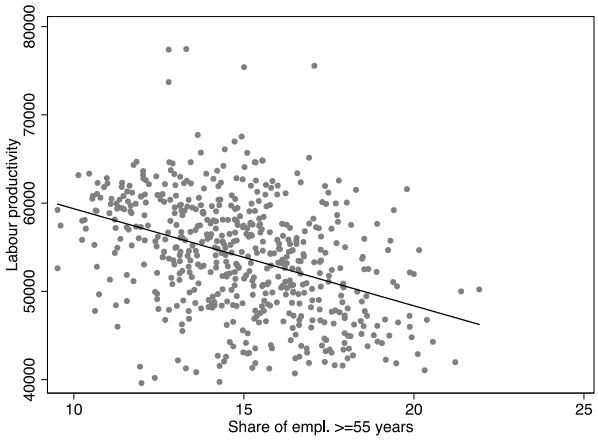

Fig. 6 Univariate linear regression line between value added per employee and employee aged over 55 years in Italian provinces. Source: Our elaborations based on the ISTAT labour force survey

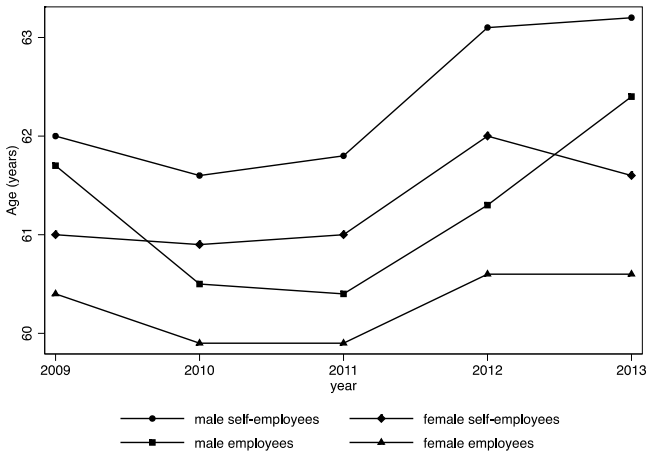

Fig. 7 Average age of retirement: 2009–2013. Source: INPS

ANSWER TO THE EDITOR

Dear Prof. Bogliacino,

First of all, thanks for your appreciation of the manuscript. We took into account all the points raised by the referees in this second round of revision and hopefully we fulfill all their requests. In particular, we added an empirical model to address the request of referee 1 (See answer to query 1.3) and we added some entries in bibliography to account for additional related literature together with related comments in the paper. All the other minor comments were addressed in this manuscript version. Please see the document with the answers to referees for details.
Thanks again for your consideration.

ANSWER TO REVIEWERS' COMMENTS:

REVIEWER #1:

"The authors have replied to most of the comments that I rise at the first stage. Major effort has been done in order to improve both literature review and methodological parts of the paper which is now almost suitable for publication. Indeed as the authors recognized, a proper investigation of the labour market reform on pension plans in Italy would require employer-employee data. The revisions that I have recommended at the first stage have been implemented. The text has been reorganized and major attention has been devoted to the empirical strategy."

Query 1.1) *"However some sentences still need an English revision such as at pag. 2 "Discussion..." which sounds written in Italian."*

Answer to query 1.1: We further checked the manuscript for the English language. In particular, the sentence cited was revised.

Query 1.2) *"Furthermore, I will stress the link with the "on the job learning" literature."*

Answer to query 1.2: Thanks for the remark. We added also (p.4) some comments about the role of on-the-job learning and training in determining the productivity of older workers.

Query 1.3) *"Furthermore, I am not sure that the variable they use for "exposed share" in equation 2 should be time invariant after 2011 (year of the reform) and after 2010 (taking into account the "placebo treatment"). Otherwise it does not make sense to apply fixed effect and GMM instead of performing a diff in diff strategy. Guadalupe et al. (2010) consider the first difference of the variable of interest, they compute a delta. This point has been raised by reviewer 2. Given that, I would add a further estimation trying to face the research question with a diff. in diff. approach even using only two years as pre and post Fornero reform."*

Answer to query 1.3: In addition to the models added in response to Referee n.2 concerns on this point of the previous round of revisions, we also took into account the present comment estimating the model using data for the years around the discontinuity identified by the policy change. Results are in line with other estimations. We added comments in the paper (p.17). Results are added to Table 4 (column 3).

REVIEWER #2:

"The paper has largely benefited by the authors' revisions and, in my opinion, it is almost ready to be publishable. I only suggest the authors to take into account some further minor revisions:"

Query 2.1) *"I suggest the authors to read (and quote if needed) the very recent IZA discussion paper by Bertoni and Brunello who, using a methodology similar to their methodology, inquire whether the pension reform affected young workers employability in Italy."*

Answer to query 2.1: We followed the suggestion and we consequently integrated in the paper discussion the study (p.11).

Query 2.2) *"At pag. 3 (or pag. 8) a caveat about the higher productivity of not sorted workers should be included (eventually in footnote). Indeed, if it is certainly true that, on the one hand, early retirement pensions allowed the least productive workers to retire earlier, on the other hand, rules about contribution years (at least 36 years before the reform) constrained some low productive workers (especially females) to continue to work up until to the old-age."*

Answer to query 2.2: We added some comments on the point at p.8-9 and in footnote n.3.

Query 2.3) *"2 commas should be included at pag. 3 after "as it will be explained below" and at pag 17 after "summarizing""*

Answer to query 2.3: We added the commas.

Query 2.4) *"at pag 10 (even if it is not crucial for the paper) I would add that retirement ages keep increasing in Italy (otherwise a non Italian reader could believe that a difference in retirement age between males and females will persist in Italy)"*

Answer to query 2.4: We added a comment that aims at clarifying the point (please see p.10-11).

Query 2.5) *"please replace that at pag. 10 that the rate of return of the NDC scheme is the "average growth rate of GDP in the previous five years" instead than "the average increase of GDP""*

Answer to query 2.5: We corrected the definition.

Query 2.6) *"at the beginning of pag. 12 the authors mention the variable "exposed_share2011" that is explained only 2 pages later. Thus, please advance, at least shortly, what this variable refers to."*

Answer to query 2.6: We added the definition of the variable where suggested by the referee at p.12.

Query 2.7) *"please clarify that (as I guess) figure 7 refers to effective retirement age (not on statutory age)"*

Answer to query 2.7: We clarify the meaning of Figure 7.