Assessing the role of ageing, feminising and better-educated workforces on TFP growth

A. Ariu and V. Vandenberghe

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Assessing the role of ageing, feminising and better-educated workforces on TFP growth

A. Ariu[$] & V. Vandenberghe[£]

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Abstract

This paper uses Belgian firm-level data, covering the 1998-2006 period, to assess the impact on TFP growth of key labour force structural changes: ageing, feminisation and rise of educational attainment. Based on a Hellerstein-Neumark analytical framework, our work shows that an ageing workforce negatively affects TFP growth, whereas its feminisation and its tendency to be better educated do not have any independent positive or negative impact. Therefore, the TFP slowdown induced by the ageing process is neither gender biased nor counterbalanced by the rising educational attainment of the workforce. These findings are robust to many additional treatments applied to the data, and controlling for the different sources of endogeneity. Quantitatively, ageing workforces may have accounted for a -4.5 percentage points loss in terms of cumulative TFP growth over the 1991-2013 period. Projections suggest that this number could reach -7 percentage points by the mid-2020s. This pattern is not so much dictated by Belgium's demography, but rather its commitment to attain an overall employment rate of 75% by 2020. The latter almost inevitably implies almost doubling the current employment rate of individuals aged 55-64.

Keywords: TFP growth, Ageing, Feminisation, Rising Educational Attainment, Firm-Level Analysis

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[$] McDonough School of Business, Georgetown University, USA. Email: aa1540@georgetown.edu
[£] Corresponding author. Economics Department, IRES, Economics School of Louvain (ESL), Université catholique de Louvain (UCL), 3 place Montesquieu, B-1348 Belgium email : vincent.vandenberghe@uclouvain.be
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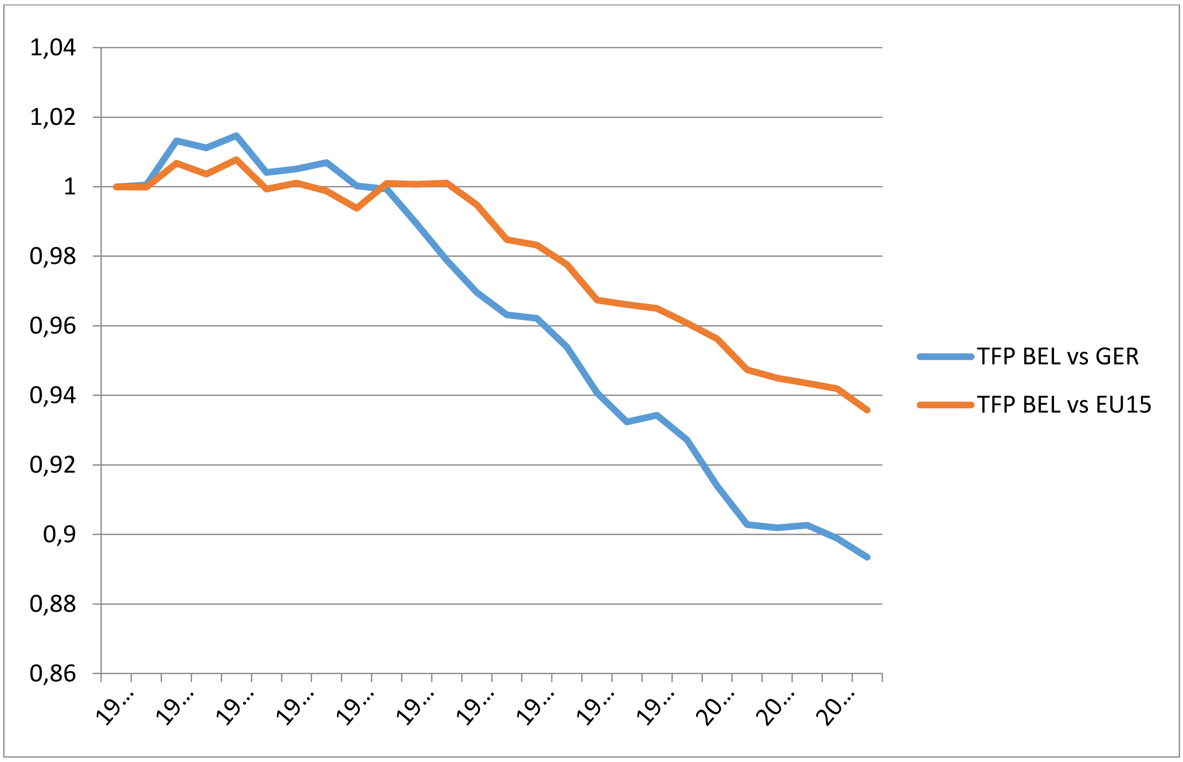
1. Introduction

TFP growth is the most important factor explaining long-term income growth (Ashenfleter, 2012). Changes in total factor productivity have a very important impact on many key aspects of the economy: competitiveness, sustainable wage growth…. That is why understanding the determinants of TFP growth is of utmost importance. In addition, during the past years, Belgium has experienced a decrease in TFP growth (Biatour et al., 2011) and, as it is possible to see in Figure 1, its performance in the early 1990s started being disconnected from that of both the EU 15 and Germany. Between 1990 and 2005, Belgium accumulated a handicap with respect to Germany exceeding 10 percentage points; and of 5 percentage points with respect to the EU15.

Figure 1: Belgian TFP growth with respect to Germany and EU15, 1980-2005.



Source EUKLEMS database

Such a trend is raising many questions about the underlying reasons of such a puzzling decline. With this paper, we take a firm-level perspective and we analyse how changes in the composition of the workforce can affect TFP dynamics at the level of the firm. We are particularly interested in three types of phenomena. The first is the ageing of the available workforce; the second the increasing participation of (older) women in the labour market and the third that of rise of the educational attainment of (older) workers.

The fact that Belgium' workforce is ageing stems from well-documented and abundantly commented demographic changes[1]: the share of workers aged 50 and more increased from 18% in 1980 to 21% in 2005, while the share of workers with less than 35 years decreased from more than 30% in 1980 to about 20% in 2005.[2] Such a trend is likely to remain stable for the foreseeable future and it might be boosted in the coming years, as Belgium will want to comply with EU recommendations in terms of its overall employment rate.[3] To alleviate the rising cost of old-age publicly funded pension schemes, the Belgian authorities will keep trying expanding (the currently relatively low) employment rate among those aged 50-64.[4] In the general context of TFP growth, the question is that of the contribution of this particular category of workers to the production process. In particular, can old workers be conducive to firm-level productivity growth? Can they provide the complementary skills needed for economic success?

Another important socio-demographic trend is the increasing participation of older women into the labour market, leading to a feminization of ageing. The share of older women into private-economy activities almost doubled, passing from more than 3% in 1980 to 6% in 2005.[5] As pointed out by Peracchi & Welch (1994), the relative contribution of older women to TFP growth can be influenced by the higher willingness of new cohorts to participate to labour market and by their time spent in productive activities.

Finally, it is important to investigate the connection between TFP growth performance and the composition of firms' workforce in terms of (rising) educational attainment. Over the 2002-2011 period, private firms located in Belgium have experienced a marked rise of their share of tertiary-educated workers. On average, the share of 2-year-college-educated workers has increased from 17.9% to 19.2% and the share of university-educated employees from 7.4% to 8% (Vandenberghe & Lebedinski, 2013). The dominant view among economists is that in advanced (or frontier) economies like Belgium, productivity gains should be driven by the expansion of higher/tertiary education.

Each of these three phenomena raises crucial issues that have received little attention so far from the empirical literature. Many existing studies look at the consequence of ageing population in terms of higher dependency rates and rising social security costs (Gruber & Wise, 2004). Another strand of the literature on ageing examines the retirement behaviour of older individuals (Mitchell & Fields, 1984) and its determinants by gender; for example how non-economic factors (i.e. family considerations) influence the decision of older women to retire (Pozzebon & Mitchell, 1989). True enough, some existing papers consider the impact of age and/or gender on productivity in the Belgian context (Lallemand & Rycx, 2009; Cataldi, A., S. Kampelmann & F. Rycx, 2011; Vandenberghe, 2013 ; Vandenberghe, Rigo & Waltenberg, 2012, Vandenberghe, 2011a,b), and many more do so for other European countries (Crépon,

[1] Between 1999 and 2009, the share of individuals aged 50-65 in the total population aged 15-65 rose from 25.2% to 28.8% (http://statbel.fgov.be).
[2] Source: EUKLEMS dataset.
[3] Namely, the EU2020 objective of an employment rate of 75% for individuals aged 20-65.
[4] According to Eurostat, that rate has risen a bit, from 30% in 2007 to 37% in 2010, but is still well below the EU average.
[5] Source: EUKLEMS dataset.

Deniau & Pérez-Duarte, 2002; Van Ours & Stoeldraijer, 2011; Cardoso, Guimarães & Varejão 2011; Börsch-Supan & Weiss, 2011). But these works aim primarily at assessing the determinants of labour productivity (or wages),[6] not TFP. The shift from labour productivity to TFP measurement is important. The dynamics of labour productivity can result from changes in the capital-labour ratio, without reflecting changes in the underlying overall ability to use labour and capital input. Economists with a focus on growth thus prefer TFP as a productivity concept, despite the problems arising from its measurement.

As to education, it is quite surprising that most economists have neglected the level of the firm to study the education-productivity relationship. There exists substantial evidence, based on the analysis of individual data, that general education (schooling) increases wages. Card (1999) for instance, summarizes various Mincer-inspired studies and concludes that the impact of a year of schooling on wages is about 10%. Similar results exist for Belgium (de la Croix & Vandenberghe, 2004) and many other OECD countries, pointing at slightly lower returns. The puzzling element of that micro level approach is that productivity is never measured or estimated. It is inferred from variation of wages under the assumption that wage differences must reflect labour productivity differences. And, again, the (implicit) dependent variable is labour productivity, not TFP. Macroeconomists focus more on TFP-related dimensions (e.g. GDP per head). They analyse country-level time series, and find some evidence in support of the idea that the continuous expansion of education has contributed positively to productivity (Krueger & Lindahl, 2001). But at that level, identification of the proper contribution of education is complicated by the difficulty to separate — using cross-country data over long time periods — the causal effect of education on income, from the wealth-driven surge of the demand for education.

In short, most of the above-mentioned works aim primarily at assessing the determinants of labour productivity (or wages) and focus on labour market issues. Few (if any) studies have examined the consequences of structural socio-demographic changes of the workforce on TFP growth, using firm-level evidence. Our study intend to fill that gap by analysing the combined effect on TFP growth of an increasingly older, feminized and better-educated working force, taking a firm-level perspective.

Our analysis primarily uses firm-level data covering Belgium's private economy over the 1998-2006 period. These data contain good-quality information about firms' performance and the composition of their workforce. Our work takes a sequential path: we start by focusing on the age dimension and simply control for the gender structure (i.e share of female workers); and indirectly for the overall skill mix of the firm, using proxies like the share of blue-collar workers and the cohort of birth of workers; in a second step we introduce separately the gender and educational dimensions of ageing and finally we focus on all three dimensions together. We base the analysis on the Hellerstein & Neumark (1995) framework and we take all necessary steps to correctly measure TFP and avoid possible endogeneity concerns. Our results suggest that most of the TFP growht slowdown observed in Belgium is driven by the ageing process, with the old categories of workers contributing less to TFP growth than the others. This effect

[6] And determining the employability of different categories individuals, by comparing labour productivity profiles to labour cost profiles.

displays no gender bias, and the increased educational attainment does not significantly counterbalance the negative effect of the ageing process. Moreover, the negative effect of ageing tends to of similar magnitude across different industries and regions as well as across domestic- vs foreign-owned firms and multinationals vs non-multinationals. Therefore, the negative effect of ageing does not come from industry or regional differences, and it is not influenced by possible different managerial practices characterising foreign-owned and/or multinational firms. In the final section, we take a more macroeconomic stance, in the sense that we try to quantify the aggregate impact of ageing on TFP growth, both retrospectively (back to the early 1990s) and prospectively (from now until 2040). The key idea is to use the firm-level estimated contributions to TFP growth of different age groups, and apply them of observed and projected values (covering the period 1991 to 2040) of the labour shares by age for the whole country. The main result is that ageing-related TFP loss could be substantial, with a -4.5 percentage points loss in terms of cumulative growth over the 1991-2013 period. And we estimate that, by the mid 2020s, that cumulative loss could reach -7 percentage points.

Demographic data show that older individuals' share of the total working age population will keep expanding until the mid-2020s. More importantly, if Belgium is to fulfil the EU 2020 employment rate target, it will almost inevitaby need to rapidly boost the employment rate of its older citizens. In that context, our results[7] pose challenges for policy makers. Lifting older individuals' employment rate is an absolute must-do to counter the surge of the dependency ratio.[8] But, *ceteris paribus*, that policy may translated into lower TFP growth. The tentative conclusion is that more research and experimentation are needed to identify the mechanisms governing the relationship between age and productivity, and offer policy makers new insights as to what could be done to combat Belgium's age-related productivity decline.

The structure of the paper is the following: in the Section 2 we present the Hellerstein-Neumark framework used in the paper; in Section 3 we describe the data and provide some descriptive statistics; in Section 4 we present the key econometric results. Section 5 contains the results of a simulation exercise aimed at estimating the magnitude of the overall negative impact of ageing on TFP growth, using 1991-2040 population and employment rate data/projections. Section 6 concludes.

2. Methodology

2.1. Basic model

Consider a labour-augmented Cobb-Douglas technology specified for a firm *i* in year *t*:

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[7] As to the negative link between age and productivity in the Belgian private economy, our results are largely in line with those of Cataldi, Kampelmann & Rycx (2011) or Lallemand & Rycx (2009). The reader interested by a discussion of Belgium's labour market institutions, as well as a review of the Belgian evidence concerning the age-wage relationship, should refer to Zaks (2014).

[8] The ratio of dependents--people younger than 15 or older than 64--to the working-age population--those ages 15-64.

[1.] $Y_{it}=A_{i0}\,K_{it}^{\alpha}\,(QL_{it})^{\beta}\,e^{\tau.t+\omega it}$

Where Y_{it} is productivity K_{it} capital and QL_{it} a labour-aggregate à la Hellerstein–Neumark (HN hereafter) specified as a CES to allow for imperfect substitutability between labour types L_{it}^{j}

[2.] $QL_{it}=\left[\mu_1\,[L_{it}^{1}]^{\rho}+....+\mu_n\,[L_{it}^{n}]^{\rho}\right]^{1/\rho}$

with

$j=1\ldots n$ labour types (e.g age/gender/education categories)

μ_j reflects contribution to productivity of firm *i* of type *j* labour

A_{i0} the starting value of TFP for firm *i*

$e^{\tau.t+\omega it}$ capturing the dynamic of TFP (nb: τ is the constant rate of growth, common to all firms)

$\omega_{it}=\Theta_i+\delta_{it}$ the residual that adds up to the constant/common rate of growth, that may comprise a firm fixed effect Θ_i correlated with the other explanatory variables

To simplify notation, one can choose a reference category $j=r$ and divide/multiply all the labour terms by $\mu_r\,L_{it}^{\rho}$. The labour aggregate becomes

[3.] $QL_{it}=\mu_r^{1/\rho}\,L_{it}\,\left([S_{it}^{r}]^{\rho}+\lambda_{1r}\,[S_{it}^{1}]^{\rho}+....+\lambda_{nr}[S_{it}^{n}]^{\rho}\right)^{1/\rho}$

with

$S_{it}^{j}=L_{it}^{j}/L_{it}$; $j=1\ldots n$ the share of labour of type *j*;

$\lambda_{jr}\equiv\mu_j/\mu_r$; $j=1\ldots n$ reflecting the (relative) contribution to productivity of type *j* labour

Finally, taking the log of [1] and injecting [3], the productivity equation becomes

[4.] $\ln Y_{it}=B_{i0}+\alpha\ln(K_{it})+\beta\ln(L_{it})+\beta/\rho\ln\Omega_{it}+\tau.t+\omega_{it}$

with $B_{i0}\equiv\ln(A_{i0})+\beta/\rho\ln(\mu_r)$ and $\Omega_{it}=[S_{it}^{r}]^{\rho}+\lambda_{1r}\,[S_{it}^{1}]^{\rho}+....+\lambda_{nr}[S_{it}^{n}]^{\rho}$

Note that the first variables of the left-hand part of [4] correspond to the usual inputs of a Cobb-Douglas production function ($\ln K_{it}$, $\ln L_{it}$). By definition, the part of $\ln Y_{it}$ that is not accounted for by these amounts to TFP. Thus, the HN labour aggregate, with its labour shares, is *de facto* a determinant of TFP. In other words, specification [4] show that TFP is a function of $\ln\Omega_i$ and thus of the different labour shares (S_{it}^{j}). Being interested in assessing the impact of the workforce's structure on TFP, the key issue is thus to know if the λ_{jr}'s differ from 1 and whether there is (im)perfect substitutability ($\rho\neq 1$). Indeed, in the case of perfect substitutability ($\rho=1$) and all λ_{jr}'s are equal to 1, $\ln\Omega_{it}=0$. Expression [4] simplifies to the standard log linearized Cobb-Douglas, where all labour types contribute equally to production.

2.2. Growth specification and accounting for firm fixed effects

Now, since we focus our analysis on TFP growth, a further critical step consists of resorting to the growth-equivalent of [4] (i.e. lag *T* differences of logs, or log of ratio of Y_{it} to its lagged *T* values).

[5.] $ln(Y_{it}/Y_{it-T}) = \tau T + \alpha ln(K_{it}/K_{it-T}) + \beta ln(L_{it}/L_{it-T}) + \beta/\rho ln(\Omega_{it}/\Omega_{it-T}) + \omega_{it} - \omega_{it-T}$

This specification sets the TFP growth rate as function of the growth rate of Ω_{it}. Hence, computing the evolution over the years of Ω_{it} is a direct way to capture the sensitivity of TFP growth to changes of the structure of the labour force between the beginning and the end of the panel (more on this in Section 5).

Note also that this growth specification leads to the elimination of the firm fixed effects: i.e. initial level of TFP A_{i0} and Θ_i (as $\omega_{it} - \omega_{it-T} = \delta_{it} - \delta_{it-T}$). This transformation can be crucial to account for time-invariant firm-level unobservables, in particular the propensity of workers of different type (i.e. age, gender…) to distribute unevenly across firms/sectors that intrinsically diverge in terms of their level of productivity/TFP.

2.3. Simultaneity bias and two-step estimation

So far, we have assumed a two-term structure for the error term. But many econometricians would recommend considering the possibility of a three-component error term.

[6.] $\omega_{it} = \Theta_i + \gamma_{it} + \delta_{it}$

In this case, the ordinary least squares (OLS) sample-error term potentially consists of i) an unobservable firm fixed effect Θ_i; ii) a short-term shock γ_{it} (whose evolution may correspond to a first-order Markov chain, causing a simultaneity bias), and is observed by the firm (but not by the econometrician) and (partially) anticipated by the firm, and, iii) a purely random shock δ_{it}.

As explained above, the parameter Θ_i in [6] represents firm-specific characteristics that are unobservable but driving TFP level such as: the vintage of capital in use, the overall stock of human capital, firm-specific managerial skills and location-driven comparative advantages. These might be correlated with the labour force structure of the firm's workforce, biasing OLS results. More educated workers for instance might be underrepresented among plants built a long time ago that use older technology. However, as stated above, the panel structure of our data allows for the estimation of models that eliminate these fixed effects (FE).

This said, another challenge is to go around the simultaneity bias (Griliches & Mairesse, 1995) caused by short-term shock γ_{it}. The economics underlying that concern is intuitive. In the short run, firms could be confronted to productivity deviations, γ_{it}; say, a lower turnover, itself the consequence of a missed sales opportunity. Contrary to the econometrician, firms may know about γ_{it} (and similarly about its short-term dynamics). An anticipated downturn could translate into a recruitment freeze, and possibly also, into a multiplication of layoffs. A recruitment freeze affects presumably younger and more educated workers, and translates into falling share of more educated workers during negative spells, creating a positive correlation between more educated workers' share and productivity, thereby leading to overestimated estimates of their productivity (when resorting to OLS or even FE estimates). Equation [6] suggests estimating a model where the dependent variable is the (estimated) TFP, following a two-stage strategy. The first stage consists of estimating the log of TFP as the residual of the regression of output on capital and total labour:

[7.] $ln(\widehat{TFP_{it}})= ln\ (Y_{it}) - \hat{\alpha} ln(K_{it}) - \hat{\beta} ln(L_{it})$

It is at this stage that one can control for the presence of $\gamma_{it.}$ We follow here the strategy of Olley & Pakes (1996), then developed by Levinsohn & Petrin (2003) (LP henceforth), and more recently by Ackerberg, Caves & Fraser (2006). All these methods consist of using observed intermediate input decisions (i.e. purchases of raw materials, services, electricity…) to "control" for unobserved short-term productivity shocks γ_{it} and the residual of that first-stage LP-estimated equation can be used to estimate the second-stage equation

[8.] $ln(\widehat{TFP_{it}})= B_0 + \tau.t + \beta/\rho\ ln(\Omega_{it}) + \Theta_i + \delta_{it}$

where the error term only consists of the random term, plus the firm fixed effect. The latter can easily be accounted for when turning the TFP growth specification [9]. The dependent variable is not directly observed, but can be estimated as the residual of a regression of total output on capital (growth) and total labour (growth). And the residuals (in levels or growth rates) can then be regressed on Ω_{it}.and the labour share it contains

[9.] $ln\ (\widehat{TFP_{it}/TFP_{it\text{-}T}}) = \tau T + \beta/\rho ln\ (\Omega_{it}/\Omega_{it\text{-}T}) \quad + \ \delta_{it} - \delta_{it\text{-}T}$

3. Data

In this section we describe the data used for the analysis and present some descriptive statistics. The data underpinning this paper consist of a panel of about 9,000 firms with more than 20 employees located in Belgium and representing all sectors of the private economy — with the exclusion of agriculture & mining — for the period running from 1998 to 2006. The advantage of using this time span is that it does not include the recent Great Recession, and so its potentially atypical impact on TFP performances. The data come from the Bel-first dataset and includes information on sector, location, size, capital, labour and value added, the average education attainment of the workforce and details on the ownership nationality and the multinational status. The information on the structure/composition of the labour force comes from the Carrefour database (i.e. social security registers). From this source we get individual-level information on age, gender and blue-collar vs white-collar status of the workers. We aggregate this information at firm level and merge it with Bel-first data, using firms' unique identifiers. The resulting firm-level panel contains information on the age, gender and educational attainment of the workers employed by the firms. Note that educational attainment as such is only available at firm-level in the Bel-first data, while age, gender and blue/while-collar status exists at individual level in the Carrefour data. The consequence is that it not possible to compute workforce shares at firm level that interact educational attainment with age and gender. That is why we proxy education using the white/blue collar status and interact it with the two other dimensions. We provide evidence that this approximation is reasonable. In the following we describe the other features of the data.

3.1. Ageing

Table 1 contains the means by year of the key variables used in the analysis. The last two columns (age mean; age standard deviation) suggest that ageing was already taking place between 1998 and 2006, and also that age heterogeneity was on the rise. Table 2 contains the breakdown of the workforce in 7 age groups (those used in the HN share-based specification used in our econometric analysis). It confirms the systematic reduction of the shares of workers aged less than 35; and, in parallel, the rise those of workers aged 40 and more.

Table 1: Ageing. Descriptive statistics. Means by year

	Value added [log]	N. of empl. [log]	Capital [log]	TFP [log]	TFP growth	Age-mean	Age-std
1998	7.743	3.762	5.921	-0.089	.	36.208	9.179
1999	7.818	3.803	5.964	-0.057	0.032	36.485	9.261
2000	7.911	3.876	6.024	-0.036	0.015	36.712	9.371
2001	7.978	3.934	6.119	-0.033	0.007	37.079	9.433
2002	8.036	3.966	6.184	-0.011	0.016	37.418	9.462
2003	8.084	3.986	6.246	0.012	0.017	38.017	9.587
2004	8.168	4.020	6.292	0.060	0.046	38.353	9.625
2005	8.202	4.041	6.328	0.072	0.008	38.734	9.675
2006	8.265	4.071	6.380	0.102	0.024	39.111	9.777
N	75,437						

Source: Bel-first; Carrefour. Weight: number of fte workers in the firm

Table 2: Descriptive statistics: shares by age

	<30	30-35	35-40	40-45	45-50	50-55	55-65
1998	0.299	0.186	0.160	0.130	0.103	0.077	0.045
1999	0.290	0.179	0.163	0.134	0.106	0.080	0.048
2000	0.281	0.176	0.166	0.136	0.108	0.083	0.051
2001	0.269	0.172	0.167	0.140	0.112	0.085	0.056
2002	0.257	0.169	0.169	0.143	0.114	0.087	0.061
2003	0.241	0.165	0.167	0.146	0.118	0.091	0.072
2004	0.234	0.158	0.164	0.151	0.123	0.094	0.077
2005	0.227	0.150	0.163	0.155	0.127	0.097	0.082
2006	0.221	0.143	0.159	0.158	0.131	0.102	0.088
N	75,437						

Source: Bel-first; Carrefour. Weight: number of fte (full-time equivalent) workers in the firm.

3.2 Feminization of ageing

The second point we raise in this paper is that the workforce is not only becoming older, but also more female. Figure 2 shows that, in Belgium in general, the employment rates of women aged more than 55 years increased faster than that of men of the same age category. This trend is likely to continue in the future for many reasons; one of them being simply the size of the current employment rate gender gap among the older segments of the working age population characterizing Belgium (and many other European countries) (Figure 3). Turning to our firm-level data, Table 3 shows that older women represent a growing share of the workforce of the Belgian private economy during the period 1998-2006. This is especially true for the category of workers aged more than 50, as shown by the last two columns of Table 3.

Figure 2: Employment rate beyond 55, by gender

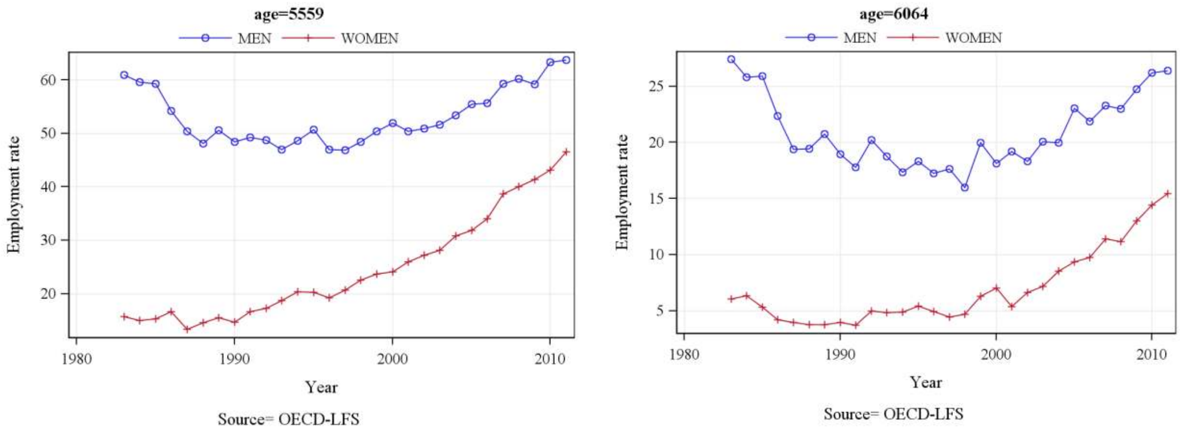
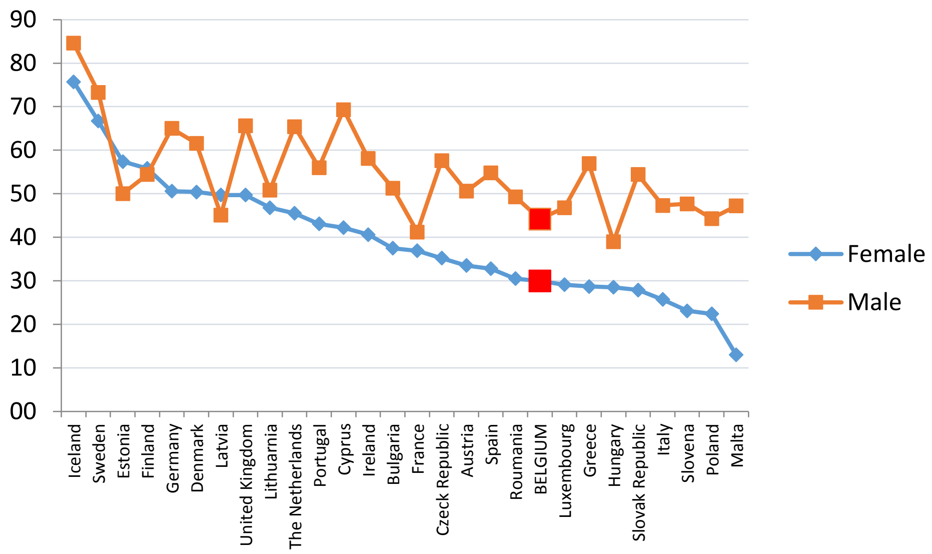


Figure 3: Male vs. Female aged 55-64 employment rates. Europe, 2010



Source: EU-LFS, 2010

Table 3: Descriptive statistics. Share of older women by age group, levels and trends (ref=1998)

Year	<30	30-35	35-40	40-45	45-50	50-55	55-65
				Shares Levels			
1998	0.309	0.282	0.248	0.243	0.219	0.176	0.150
1999	0.311	0.286	0.252	0.248	0.223	0.183	0.151
2000	0.315	0.295	0.261	0.250	0.229	0.188	0.158
2001	0.315	0.302	0.266	0.256	0.236	0.198	0.163
2002	0.316	0.304	0.273	0.257	0.240	0.202	0.168
2003	0.316	0.310	0.282	0.256	0.247	0.209	0.171
2004	0.313	0.311	0.286	0.258	0.250	0.215	0.175
2005	0.311	0.309	0.295	0.260	0.254	0.222	0.180
2006	0.311	0.310	0.301	0.270	0.256	0.231	0.187
Share Indices (100= 1998)							
1998	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1999	100.7	101.4	101.7	102.0	101.8	104.0	100.9
2000	101.8	104.4	105.1	103.0	104.6	106.4	105.7
2001	101.7	107.1	107.1	105.5	107.6	112.3	108.6
2002	102.0	107.7	110.2	105.8	109.3	114.6	112.3
2003	102.1	110.0	113.6	105.5	112.6	118.4	113.9
2004	101.1	110.2	115.3	106.2	114.1	122.2	116.4
2005	100.5	109.6	118.8	107.0	115.7	125.8	120.2
2006	100.5	109.9	121.5	111.3	117.0	131.0	124.9

Source: Belfirst; Carrefour. Weight: number of fte (full-time equivalent) workers in the firm.

3.3 Older but better-educated workers

The third point we raise in this paper is that the workforce is getting more and more educated. Table 4 shows the age and the share of women increases together with a decrease in the share of blue-collar workers and a consequent increase of the average number of years spent in education. While the increase in the share of old workers might be compromising the capacity of firms to generate productivity gains, we expect the rising educational attainment to work in the opposite direction. Indeed, there is extensive evidence, based on the estimation of Mincerian equations, that better-educated individuals earn more. To the extent that wages are informative about productivity, more educated people should contribute more to increasing productivity. Some macroeconomists, analysing cross-country time series, also support the idea that the continuous expansion of education has contributed positively to growth.

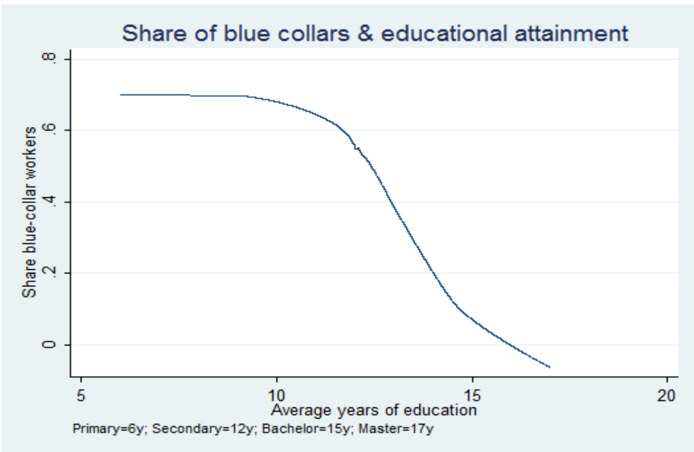
Table 4: Ageing-Feminisation and rising educational attainment

	Age-mean	Share female	Share blue collars	Aver. years education*
1998	36.567	0.249	0.563	11.490
1999	36.609	0.256	0.551	11.562
2000	36.695	0.262	0.541	11.631
2001	36.764	0.271	0.529	11.709
2002	37.336	0.280	0.488	11.769
2003	37.873	0.281	0.482	11.818
2004	38.109	0.284	0.481	11.766
2005	38.363	0.289	0.475	11.816
2006	38.689	0.294	0.465	11.803
N	75,437			

Source: Bel-first; Carrefour. Weight: number of fte (full-time equivalent) workers in the firm.
*Primary degree=6; Secondary degree=12, Bachelor=15 and Master=17 years

As previously mentioned, the individual-level Carrefour database reports the white/blue collar status of the worker (alongside age and gender) but not the number of years of education. Therefore, there is an open question based on whether the white/blue collar status of workers of different age can be a good proxy for their educational attainment. One way to answer that question is to use firm-level data on the average education attained by the workforce present in the Bel-first dataset; and see if it is correlated with the share of white/blue collars. Figure 4 suggests that this is the case since it displays a clear negative relation between the average years of education at the level of the firm and the share of blue-collar workers. Therefore, in what follows, we can be relatively confident about using the blue/white collar as indicator of the (rising) educational attainment at the level of the firm.

Figure 4- Share of blue-collar workers & average educational attainment. Year 2006.



Source: Bel-first; Carrefour. Weight: number of fte (full-time equivalent) workers in the firm. Based on lowess estimation i.e. locally weighted regression of *y* on *x*.

4. Econometric results

4.1. Ageing

We start with the econometric analysis of ageing, leaving aside for the moment the two other structural trends of interest. The results are estimated using non-linear least squares due to the non-linearity of the problem and the need of estimating the substitutability parameter of our CES-within-Cobb-Douglas model. Our results are shown in Table 5: the first column corresponds to the analysis of the determinants of the level of TFP; while all the other columns present the results of the estimation of the TFP growth specification. In column [3] we control for the overall share of women and the share of blue-collar workers. In column [4], we control for cohort effect, which is likely to correlate with educational differences characterizing successive generations of workers. In column [5] we replicate the estimation in column [4], but we adopt the 2-stage strategy exposed in Section 2.4: value added is first regressed on total labour and capital using the Levinsohn & Petrin (2003) strategy; thus correcting for the biases induced by unobserved short-term productivity shocks using the consumption of intermediate goods (here purchase of services and other goods) as instruments. In the second stage, the residual is regressed on labour shares.[9]

All our results convey the idea that workers older than 40 years are less productive and contribute negatively to TFP and TFP growth. The inferred marginal productivities (that we report at the bottom of Table 5) — particularly those for the growth specifications — show that relative marginal productivities decline regularly with age, even when we control for the share of women, the share of blue-collars workers and cohort of birth (with the last two variables proxying for education). Model [3] suggests that workers aged 45-49 are 6.6 percentage points less productive than those aged 35-39. Those aged 50-54 appear 25 percentage points less productive and the productivity handicap is estimated to be 32.5 percentage points for those aged 55+. These numbers tend to be very similar across the different specifications. Note that the results obtained with the level specification are much less trustworthy, as there is no control for firm fixed effects, which tend to capture age-based assortative matching (i.e. the propensity of young/older workers to concentrate in firms that are intrinsically less/more productive). The comparisons of growth vs. level equation results suggests that this phenomenon is particularly important among younger workers: they appear much more productive when one takes a growth (i.e. “within” firm) perspective. Note finally that our results for the growth specification deliver estimate for the age elasticity of substitution (i.e. $\sigma \equiv 1/(1-\rho)$) that ranges from 2.2 to 4.8, in line with what is be found in the literature (Card & Lemieux, 2001).

[9] We report only the results of the second step of the estimation in column 5 of Table 5. The complete set of results is available upon request.

Table 5 - Econometric analysis of the role of age(ing) on & TFP level and growth- 7 age groups:<30,30-34,35-39[ref],40-44,45-49,50-54,55-64

	[1] Level	[2] Growth(FE)	[3] Growth(FE)+ controls	[4] Growth(FE)+ controls incl. cohorts	[5] Growth(FE)+ controls incl. cohorts/2steps LP
Cst	4.110***	0.0377***	0.0280***	0.0488**	0.0684***
	(0.0266)	(0.00115)	(0.00400)	(0.0180)	(0.0199)
α	0.112***	0.0317***	0.0423***	0.0423**	
	(0.00119)	(0.00271)	(0.00313)	(0.0148)	
β	0.908***	0.638***	0.574***	0.571***	0.273***
	(0.00250)	(0.00487)	(0.00583)	(0.0244)	(0.0677)
ρ	1.054***	0.792***	0.794***	0.790***	0.540***
	(0.0163)	(0.0128)	(0.0169)	(0.0383)	(0.0710)
$\eta_{<30}$ (a)	-0.599***	0.079**	0.217***	0.187**	0.263*
η_{30-34}	0.209***	-0.026	0.010	-0.013	-0.087
η_{40-44}	-0.212***	-0.144***	-0.066	-0.039	-0.140
η_{45-49}	-0.537***	-0.237***	-0.116**	-0.057	-0.210*
η_{50-54}	-0.566***	-0.360***	-0.318***	-0.236***	-0.436***
η_{55-64}	-0.143***	-0.376**	-0.396***	-0.277**	-0.580***
Controls	Year*Sector	Firm fixed effects	Firm fixed effects+ Share of women, blue-collar wks	Firm fixed effects+ Share of women, blue-collar wks + cohort	Firm fixed effects+ Share of women, blue-collar wks + cohort
Nobs	75,437	65,750	48,777	48,777	48,076
σ≡1/(1- ρ)	-18.643	4.810	4.865	4.751	2.172
	Implied relative marginal productivities (1=35-39 ref)				
$RMP_{<30}$	0.403	1.014	1.151	1.121	1.156
RMP_{30-34}	1.192	0.982	1.025	1.002	0.965
RMP_{35-39}	1(ref)	1(ref)	1(ref)	1(ref)	1(ref)
RMP_{40-44}	0.771	0.880	0.954	0.983	0.923
RMP_{45-50}	0.449	0.812	0.935	0.999	0.920
RMP_{50-54}	0.417	0.701	0.744	0.835	0.704
RMP_{55-64}	0.814	0.699	0.674	0.809	0.554

Standard errors in parentheses All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first; Carrefour * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(a): $\eta \equiv \lambda\text{-}1$

4.2. Ageing and gender

As stated above, another important trend is the increasing participation of older women into the labour market leading to a feminization of ageing. How does that affect TFP performance for Belgium? We investigate this question by examining the role of the age and gender structure of the workforce on TFP growth. Table 6 contains the results for model [3] where the total workforce is split into the 7 age groups and the 2 genders. Please note that the reference category is represented by the male workers aged 35-39.

Results in Table 6 convey the idea that men older than 45 are less productive and contribute negatively to TFP growth. This is in line with the results of Section 4.1. The retrieved/inferred marginal productivities (that we report at the bottom of Table 6) show a regular decline with age beyond 45. As to older women, Table 6 shows that both the estimated *η's* and the implied marginal productivities tend to be more or less in line with that of old men. If anything, it is for younger women that there seems to be a productivity handicap affecting TFP growth. The gender productivity/TFP gap turns out to be statistically significant only for women aged less than 50. In other words, we do not find any significant gender bias in the ageing process affecting TFP.

Table 6 - Age-gender & TFP growth- 7 age groups:<30,30-34,35-39,40-44,45-49,50-54,55-64

	[3] Growth(FE) + controls		
Cst	0.0713***		
	(0.0177)		
α	0.0266***		
	(0.00517)		
β	0.515***		
	(0.0272)		
ρ	0.774***		
	(0.0335)		
	Women	Men	Prob η_j W=M
$\eta_{<30}$ (a)	-0.112	0.181**	0.001***
$\eta_{30\text{-}34}$	-0.170	-0.048	0.242
$\eta_{35\text{-}39}$	-0.240	0 (ref)	0.048**
$\eta_{40\text{-}44}$	-0.246**	-0.048	0.064*
$\eta_{45\text{-}49}$	-0.218*	-0.149*	0.591
$\eta_{50\text{-}54}$	-0.239**	-0.248***	0.950
$\eta_{55\text{-}64}$	-0.432***	-0.202*	0.290
Controls	Firm fixed effects+ Share of part-time workers, blue-collar wks		
Nobs	40,969		
$\sigma \equiv 1/(1-\rho)$	4.432		
	Implied relative marginal productivities (1=35-39 ref)		
$RMP_{<30}$	0.925	1.117	
$RMP_{30\text{-}34}$	0.905	0.975	
$RMP_{35\text{-}39}$	0.835	1 (ref)	
$RMP_{40\text{-}44}$	0.833	0.970	
$RMP_{45\text{-}49}$	0.875	0.896	
$RMP_{50\text{-}54}$	0.868	0.814	
$RMP_{55\text{-}64}$	0.654	0.883	

Standard errors in parentheses. All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first 1998-2006; Carrefour. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
(a): $\eta \equiv \lambda - 1$

4.3. Ageing and educational attainment

In this section we analyse whether the rising educational attainment of workers has an effect on TFP. Indeed, we can examine the role of the age and blue/white collar structure of the workforce on TFP growth using the same HN framework. Table 7 contains the results for model [3] where the total workforce is split into 7 age groups and blue/white-collar status. Please note that the reference category is represented by the white-collar workers aged 35-39. Results in Table 7 suggest an absence of real difference between blue- and white-collars across the ages. If anything, it is for the category of white collars aged 55-64 that age leads to statistically significant larger productivity handicap. The inferred marginal productivities show for blue collars aged 55-64 a handicap of 28 percentage points. The equivalent figure for their white-collar peers is above 50 percentage points.

Table 7 – Age, blue/white collar status & TFP growth- 7 age groups:<30,30-34,35-39,40-44,45-49,50-54,55-64

	[3] Growth(FE) + controls		
Cst	0.0826^{***}		
	(0.0189)		
α	0.0250^{***}		
	(0.00590)		
β	0.560^{***}		
	(0.0248)		
ρ	0.856^{***}		
	(0.0319)		
	Blue collars	White collars	Prob η_j blue=white
$\eta_{<30}$ (a)	0.019	-0.101	0.238
η_{30-34}	-0.119	-0.110	0.928
η_{35-39}	-0.081	0 (ref)	0.395
η_{40-44}	-0.213**	-0.236**	0.814
η_{45-49}	-0.331***	-0.282***	0.681
η_{50-54}	-0.391***	-0.479***	0.524
η_{55-64}	-0.275*	-0.604**	0.065*
Controls	Firm fixed effects+ Share of part-time workers, blue-collar wks		
Nobs	47,830		
σ≡1/(1- ρ)	6.947		
	Implied relative marginal productivities (1=35-39 ref)		
$RMP_{<30}$	0.903	0.873	
RMP_{30-34}	0.824	0.888	
RMP_{35-39}	0.850	1 (ref)	
RMP_{40-44}	0.732	0.781	
RMP_{45-49}	0.633	0.752	
RMP_{50-54}	0.591	0.551	
RMP_{55-64}	0.729	0.418	

Standard errors in parentheses. All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first 1998-2006; Carrefour. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

(a): $\eta \equiv \lambda - 1$

4.4. Age, gender and white/blue-collar status

In this section we combine together all the dimension analysed above. Table 8 contains the results for model [3] where the total workforce is split into 3 age groups and blue/white collar status (the reference category being the male white collars aged 35-39). We need to reduce to 3 age bands: <30, 30-49 (the reference category) and 50-64, in order to avoid high dimensionality problems and the loss of precision of estimators that comes with it.

The results are reported in Table 8 and they are qualitatively in line with those presented above. Older workers age 50-64 contribute negatively to TFP growth regardless of their gender and blue/white collar status. Implied marginal productivities reported at the bottom of Table 8 indicate that older blue collar women are 32 percentage points less productive at than white-collar prime age men (the reference group). The handicap of older male blue collar is estimated to be of 23 percentage points and that of older white-collar female and male workers of respectively 44 and 28 percentage points. However, these handicaps tend to diverge in magnitude between the different categories of older workers (male versus female, blue-collar versus while collar), none of the differences are statistically significant. Therefore, the key determinant of TFP slowdown is the ageing process. This does not have a gender bias and it is not counterbalanced by the increased education of the workforce.

Table 8 - Age (<30,30-49,50-64), gender, blue/white collar status & TFP growth

	[3] Growth(FE) + controls							
Cst	0.0814***							
	(0.0168)							
α	0.0255***							
	(0.00575)							
β	0.564***							
	(0.0240)							
ρ	0.861***							
	(0.0317)							
	Blue collars			White collars			Prob η_j Blue=White	
	Women	Men	Prob η_j W=M	Women	Men	Prob η_j W=M	M	W
$\eta_{<30}$ (a)	-0.076	0.045	0.241	-0.201	-0.019	0.110	0.502	0.349
η_{30-49}	-0.276*	0.009	0.067*	-0.187	0 (ref)	0.184	0.927	0.610
η_{50-64}	-0.354**	-0.207*	0.455	-0.489***	-0.335**	0.458	0.431	0.553
Controls	Firm fixed effects+ Share of part-time workers							
Nobs	50,398							
$\sigma \equiv 1/(1-\rho)$	7.180							
	Implied relative marginal productivities (1=30-49 white collar man ref)							
	Blue collars			White collars				
	Women	Men		Women	Men			
$RMP_{<30}$	0.904	0.933		0.814	1.003			
RMP_{30-49}	0.718	0.891		0.847	1 (ref)			
RMP_{50-64}	0.681	0.775		0.559	0.715			

Standard errors in parentheses
All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering.
Source: Bel-first; Carrefour 1998-2006
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
(a): $\eta \equiv \lambda - 1$

4.5. Industry, Region, Foreign Ownership and Multinational Status

After having analysed the average effect of the workforce structural changes on TFP growth, in this section we check whether the effect of ageing varies across different types of firms. In particular, we consider the (broadly-defined) industry, their region, the foreign ownership and the multinational status of the firm.

- *Industry*

Results in Table 9 replicate the analysis focused on age (model [3]), but with a breakdown by broadly-defined sectors: manufacturing versus services.[10] The aim is to assess the potentially divergent effect of age on TFP across different industries. This is because ageing might matter less for productivity in a service-based economy than in one where manufacturing dominates. Results do not completely validate this assumption. Marginal productivity by age profiles, as reported at the bottom of Table 9 are relatively similar. Yet, we find that older workers aged 55-64 have a productivity handicap of 50 percentage points in manufacturing, whereas that handicap is only of 24 percentage point for those who work in the service industry.

[10] A detailed definition of these two large sectors in terms of NACE 2 categories is to be found in Annex 1.

Table 9 - Econometric analysis of the role of age(ing) on & TFP level and growth- 7 age groups:<30,30-34,35-39[ref],40-44,45-49,50-54,55-64. Manufacturing vs Services

	[3] Growth(FE)+ controls	[3] Growth(FE)+ controls: Manufact.	[3] Growth(FE)+ controls: Services	
Cst	0.0280***	0.0343***	0.0256***	
	(0.00400)	(0.00618)	(0.00571)	
α	0.0423***	0.0280***	0.0540***	
	(0.00313)	(0.00435)	(0.00450)	
β	0.574***	0.653***	0.519***	
	(0.00583)	(0.00894)	(0.00783)	
ρ	0.794***	0.803***	0.781***	
	(0.0169)	(0.0232)	(0.0245)	Prob η_j Ind=Service
$\eta_{<30}$ (a)	0.217***	0.260***	0.154*	0.183
η_{30-34}	0.010	0.022	0.003	0.781
η_{40-44}	-0.066	-0.063	-0.063	0.997
η_{45-49}	-0.116**	-0.171***	-0.031	0.098*
η_{50-54}	-0.318***	-0.318***	-0.312***	0.942
η_{55-64}	-0.396***	-0.607***	-0.213**	0.000***
Controls	Firm fixed effects+ Share of women, blue-collar wks	Firm fixed effects+ Share of women, blue-collar wks	Firm fixed effects+ Share of women, blue-collar wks	
Nobs	48,777	26,081	22,696	
$\sigma\equiv 1/(1-\rho)$	4.865	5.067	4.568	
Implied relative marginal productivities (1=35-39 ref)				
$RMP_{<30}$	1.151	1.207	1.072	
RMP_{30-34}	1.025	1.043	1.012	
RMP_{40-44}	0.954	0.955	0.960	
RMP_{45-49}	0.935	0.872	1.035	
RMP_{50-54}	0.744	0.739	0.759	
RMP_{55-65}	0.674	0.442	0.875	

Standard errors in parentheses. All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first; Carrefour * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
(a): $\eta\equiv \lambda-1$

- Region

Table 10 shows the results of the estimation of model [3] for each region of Belgium. The idea is that different regions might experience dissimilar ageing patterns, thus leading TFP growth to be different across firms based in different regions. Results show that the two biggest regions, Flanders and Wallonia, do not register any significant difference when considering the negative effect of ageing on TFP, while firms based in Brussels shows that not only “old” workers perform poorly, but also the “young” ones.

Table 10 – Econometric analysis of the role of age(ing) on & TFP level and growth- 7 age groups:<30,30-35,35-39[ref],40-44,45-49,50-54,55-64. Brussels, Flanders, Wallonia

	[3] Growth(FE)+ controls		
	Brussels	*Flanders*	*Wallonia*
Cst	*0.0328**	*0.0333****	*0.0149**
	(0.0162)	*(0.00509)*	*(0.00708)*
α	*0.0192**	*0.0269****	*0.108****
	(0.00845)	*(0.00389)*	(0.00677)
β	*0.520****	*0.567****	*0.626****
	(0.0168)	*(0.00719)*	*(0.0123)*
ρ	*0.820****	*0.804****	*0.772****
	(0.0665)	*(0.0220)*	*(0.0276)*
η <30 (a)	*0.810****	*1.315****	*1.173****
η 30-34	*0.606****	*1.068****	*1.050****
η 40-44	*0.754****	*0.981****	*0.905****
η 45-49	*0.705****	*0.897****	*0.920****
η 50-54	*0.581****	*0.636****	*0.834****
η 55-64	*0.417***	*0.628****	*0.651****
Controls	*Firm fixed effects+ Share of women, blue-collar wks*	*Firm fixed effects+ Share of women, blue-collar wks*	*Firm fixed effects+ Share of women, blue-collar wks*
Nobs	*4,960*	*32,540*	*11,277*
σ≡1/(1- ρ)	*5.559*	*5.092*	*4.392*
	Implied relative marginal productivities (1=35-39 ref)		
RMP<30	*0.772*	*1.243*	*1.111*
RMP 30-34	*0.612*	*1.084*	*1.065*
RMP 40-44	*0.769*	*1.001*	*0.927*
RMP 45-49	*0.739*	*0.948*	*0.974*
RMP 50-54	*0.619*	*0.694*	*0.910*
RMP 55-64	*0.448*	*0.703*	*0.729*

Standard errors in parentheses. All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first 1998-2006; Carrefour. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
(a): *η≡ λ-1*

- Foreign Ownership and Multinational Status

In Table 11 we replicate the same exercise distinguishing among firms that are owned by foreign investors[11] and those that have affiliates abroad.[12] The idea is that foreign owned firms and firms that have affiliates abroad might be able to better master the ageing problem by transmitting from abroad the knowledge and the processes to better use the ageing human capital with respect to the domestic and non-multinational ones. Results in Table 11 show that this is not the case: both domestic firms and foreign owned and multinational and non-multinationals suffer similarly from the ageing process. This can be interpreted as evidence that the ageing problem is not caused by bad managerial practices of Belgian firms that lead firms to do not value the “old” workers. Rather, this is evidence that the ageing process is affecting evenly different types of firms, regardless of their international activity.

[11] We consider a firms as foreign owned if more than 50% of the equity is owned by non-Belgian company, as defined in the Global Ultimate Owner indicator of the Amadeus Dataset.
[12] We define a firm as multinational if it has at least one affiliate abroad using the Amadeus Dataset.

Table 11 – Econometric analysis of the role of age(ing) on & TFP level and growth- 7 age groups:<30,30-35,35-39[ref],40-44,45-49,50-54,55-64. Foreign Ownership and Multinational Status

	[3] Growth(FE)+ controls			
	Domestic	*Foreign Owned*	*Non-Multinational*	*Multinational*
Cst	*0.0237****	*0.0707****	*0.0315****	*0.0202***
	(0.00409)	*(0.0152)*	*(0.00484)*	*(0.00746)*
α	*0.0474****	*0.0241****	*0.0462****	*0.0339****
	(0.00356)	*(0.00687)*	*(0.00373)*	*(0.00575)*
β	*0.543****	*0.719****	*0.560****	*0.602****
	(0.00622)	*(0.0160)*	*(0.00702)*	*(0.0105)*
ρ	*0.787****	*0.790****	*0.784****	*0.796****
	(0.0179)	*(0.0517)*	*(0.0210)*	*(0.0284)*
η <30 (a)	*1.219****	*1.310****	*1.183****	*1.283****
η 30-34	*1.008****	*1.073****	*0.984****	*1.062****
η 40-44	*0.941****	*0.880****	*0.946****	*0.909****
η 45-49	*0.899****	*0.797****	*0.902****	*0.830****
η 50-54	*0.641****	*0.912****	*0.701****	*0.599****
η 55-64	*0.597****	*0.570****	*0.470****	*0.773****
Controls	*Firm fixed effects+ Share of women, blue-collar wks*	*Firm fixed effects+ Share of women, blue-collar wks*	*Firm fixed effects+ Share of women, blue-collar wks*	*Firm fixed effects+ Share of women, blue-collar wks*
Nobs	*41,176*	*7,601*	*34,309*	*14,468*
σ≡1/(1- ρ)	*4.703*	*4.772*	*4.637*	*4.892*
	Implied relative marginal productivities (1=35-39 ref)			
RMP<30	*1.146*	*1.266*	*1.114*	*1.220*
RMP 30-34	*1.023*	*1.093*	*0.999*	*1.080*
RMP 40-44	*0.962*	*0.903*	*0.969*	*0.928*
RMP 45-49	*0.951*	*0.852*	*0.959*	*0.875*
RMP 50-54	*0.700*	*1.008*	*0.769*	*0.652*
RMP 55-64	*0.667*	*0.655*	*0.528*	*0.863*

Standard errors in parentheses. All models are estimated using non-linear least squares, with standard errors robust to firm-level clustering. Source: Bel-first 1998-2006; Carrefour. [*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$
(a): $\eta \equiv \lambda - 1$

5. Quantifying the aggregate impact of ageing on TFP growth.

In this final section, we take a more macroeconomic stance, in the sense that we try to quantify the aggregate impact of ageing on TFP growth in Belgium, both retrospectively (back to the early 1990s) and prospectively (from now until 2040).

5.1. The method

Referring to the growth specification of our model, the idea is to compute the value of TFP loss (in percentage points) driven by the gradual decline of $\beta/\rho \, ln(\Omega_{it} / \Omega_{it-1})$ in

[10.] $ln\,(Y_{it}/ Y_{it-1}) = \tau + \alpha ln(K_{it}/K_{it-1}) + \beta/ln(L_{it}/L_{it-1}) + \beta/\rho \; ln\,(\Omega_{it}/\Omega_{it-1}) + \delta_{it} - \delta_{it-1}$

The key idea is to use estimated $\hat{\lambda}$'s, $\hat{\beta}$ and $\hat{\rho}$ (stemming from the estimation of model [3] described in Section 4 using 1998-2006 firm-level data) alongside observed and projected values of the labour shares by age[13] S_t^j, in order to estimate

[13] Note the drop of index *i* reflecting the fact that we no longer work with firm-level Bel-first data

[11.] $\hat{\beta}/\hat{\rho}\ ln\ (\Omega_t\ /\Omega_{t-1})$

with $\Omega_t \equiv \left[[S_t^r]^{\hat{\rho}} + \hat{\lambda}_{1r}\ [S_t^1]^{\hat{\rho}}\ ....+ \hat{\lambda}_{nr}\ [S_t^n]^{\hat{\rho}} \right];\ j=1...\ n$ age categories

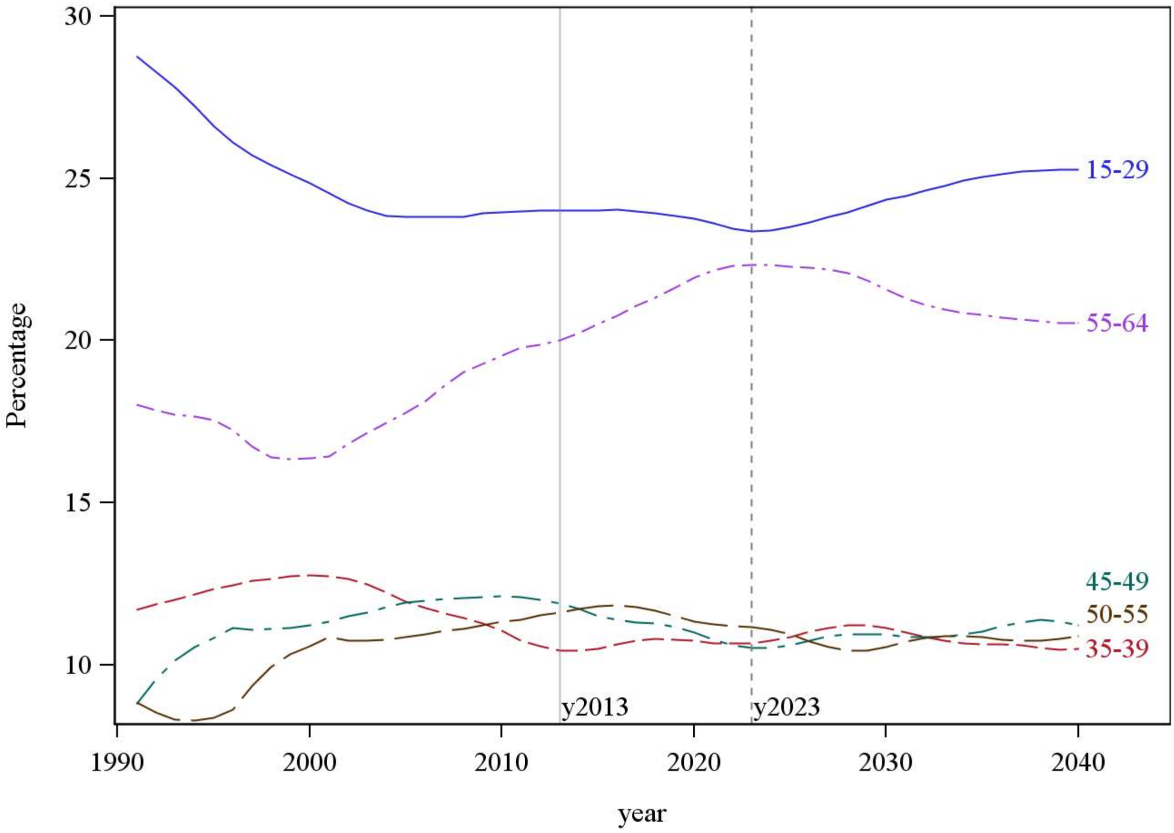
5.2. The Data

The age labour shares (S_t^j) we use here — and to which we apply (firm-level) estimated $\hat{\lambda}$*'s,* $\hat{\beta}$ and $\hat{\rho}$ — cover the period 1991 to 2040; a much larger period that the one examined so far using firm-level Bel-first data. We calculate these shares, using *i)* population-by-age data published by Statistics Belgium;[14] and *ii)* employment rates by age computed by the OECD using LFS[15] surveys. The latter only cover the period 1991-2013. This means that we need to formulate assumptions regarding the evolution of the employment rate by age over the period 2014-2040. This will be discussed in detail subsequently.

The first element to be considered is the evolution of the age structure of the working age population (Statistics Belgium, 2013). The noteworthy trends, in the context of this paper, are visible on Figure 5. The first one is the rise of the share of older individuals in the age band 55-64. The second one is the decline of the share of young individuals (15-29). These two trends are well in line with what most observers have been saying about demographics in Belgium (and elsewhere in Europe): less youth, more oldies! A less publicised fact is that the ageing process (of the working age population) should peak around year 2023. Beyond, the population projections from Statistics Belgium suggest that the share of the individuals aged 55-64 with start declining and that, almost simultaneously, the share of young (15-29) will pick up. Anticipating somehow on our quantitative results, this suggests that the negative impact of demography (as such) on TFP growth should stop somewhere around 2023.

[14] http://statbel.fgov.be/fr/modules/publications/statistiques/population/population_-_perspectives_demographiques_2013-2060.jsp
[15] http://stats.oecd.org/Index.aspx?DataSetCode=STLABOUR

Figure 5 - Evolution of shares of population by age of the working age population (15-64)



Source: INS 2014, population perspectives 2013-2060

This said, demographics is only one part of the full story. What really matters is the evolution of the employment shares. And these are driven by the product of population shares by (relative) employment rates.[16] For the period 1991-2013, all data needed are available. The resulting employment shares by age are reported in Figure 6. Beyond 2013, as mentioned earlier, assumptions need to be formulated about the possible evolution of employment rates, on average and for earch age group. Hereafter, we expore three scenari (Table 12): the first (Scena1) assumes that employment rates by age will remain what they were in 2013; the second (Scena2) corresponds to the realisation of the EU2020 objective of an employment rate of 75% for individuals aged 20-65. We assume that this objective will be attained primarily by raising the employment rate of individuals aged 50 and more. More precisely, we assume that the employment rate of individuals aged 50-54 will rise (linearly) from 75% in 2013 to 80% in 2020; and the one of individuals aged 55-64 from 42% to 80%. In the third scenario (Scena3) we assume that it will take an extra 10 years to reach the EU2020 target. Technically, this simply means that individuals aged 50 and more will attain the 80% threshold only in

[16] $S_t^j=(ER_t^j/ER_t).P_t^j$ where P_t^j is the share of the (working age) population of age j, ER_t^j the employment rate applicable to that age group, and ER_t the overall employment rate of the working age population. Note that the latter can be computed as the weighted sum of age-specific employment rates, where the weight are the corresponding P_t^j.

2030.

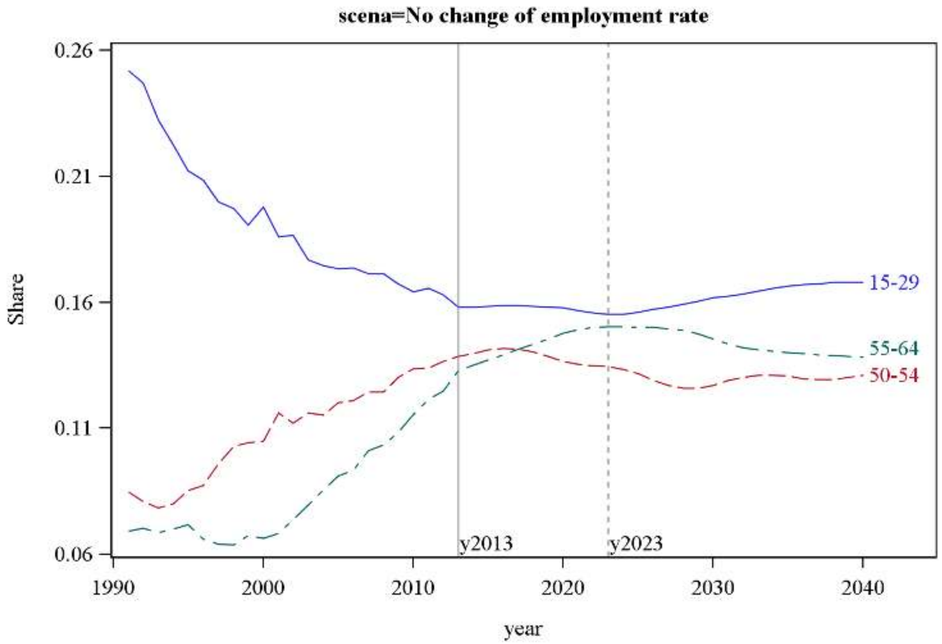
Table 12: Hypothesis about evolution of employment rates by age (2014-2040)

Scenario 1	<30	30-34	35-39	40-44	45-49	50-54	55-64
2013	.414	.803	.815	.817	.805	.751	.417
2020	.414	.803	.815	.817	.805	.751	.420
2030	.414	.803	.815	.817	.805	.751	.420
2040	.414	.803	.815	.817	.805	.751	.420
Scenario 2							
2013	.414	.803	.815	.817	.805	.751	.417
2020	.414	.850	.850	.850	.850	.800	.800
2030	.414	.850	.850	.850	.850	.800	.800
2040	.414	.850	.850	.850	.850	.800	.800
Scenario 3							
2013	.414	.803	.815	.817	.805	.751	.417
2020	.414	.822	.829	.831	.824	.771	.576
2030	.414	.850	.850	.850	.850	.800	.800
2040	.414	.850	.850	.850	.850	.800	.800

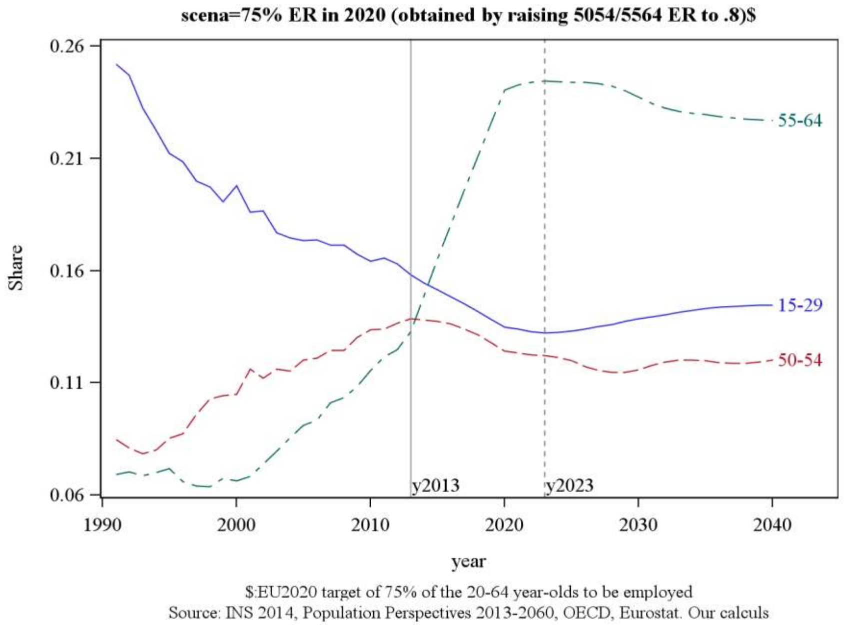
Source: OECD-LFS, our calculus

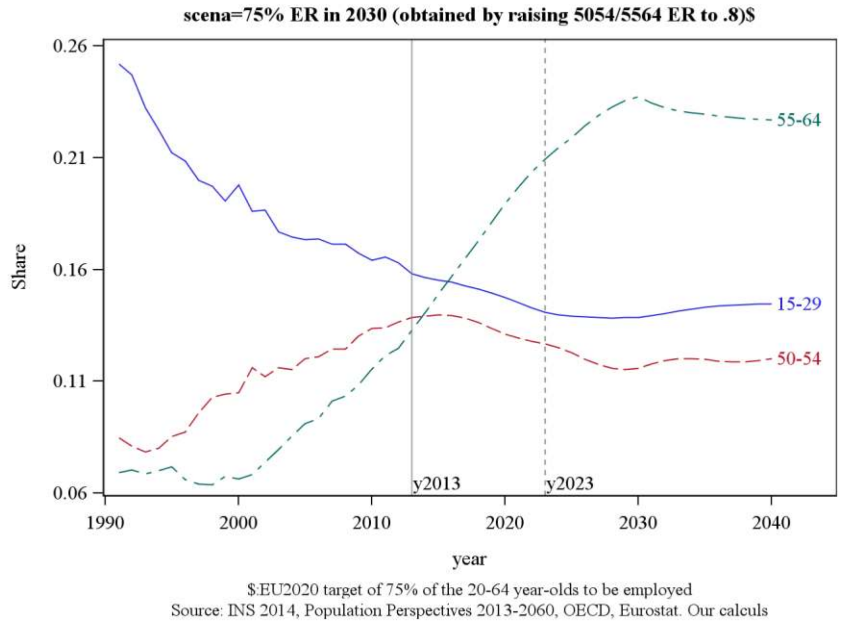
The evolution of employment shares by age underpinning our analysis is displayed in the different panels of Figure 6. In the upper panel, we freeze employment rates to their 2013 level. And in this case, we logically get projections that are driven only by demographics. Quite logically, we get curves that replicate what was visible in Figure 5, beyond 2013. If we focus for a moment on the 1991-2013 period, it is quite striking to observe the intensity of the ageing process. This has been simultaneously driven by, both, the sharp fall of the share of young workers and the rise of the shares of workers aged 50 and more. The latter increase goes beyond what demographics dictates, and it highlights the prominent role of higher employment rate among older individuals since 1990 for the 50-54 category, and since 2000 for the older individuals. As to the future, under the first scenario (no further increase of older employment rates), Figure 6 (upper panel) shows that the ageing process of the workforce should peak rather soon than late. The other two scenari — where we assume that the employment rate of old workers will rise in order to fulfil the European target of a 75% overall employment rate — show that the ageing of the workforce will become even more pronounced, with a sharp rise of the share of individuals aged 55-64. While scenario 1 predicts the share of workers aged 55-64 to attain 15% by the year 2023; scenario 2 suggests that the latter could reach 25% the same year. Scenario 3 leads to similar conclusions, except that the 25% peak is postponed by a few years, essentially reflecting the more gradual rise of the employment rate among individuals aged 55-64.

Figure 6 –Evolution of the employment shares by age (1991-2040), under 3 prospective scenari.



S:EU2020 target of 75% of the 20-64 year-olds to be employed
Source: INS 2014, Population Perspectives 2013-2060, OECD, Eurostat. Our calculs


scena=75% ER in 2020 (obtained by raising 5054/5564 ER to .8)$
0.26
0.21
0.16
0.11
0.06
Share
1990
2000
2010
2020
2030
2040
year
y2013
y2023
55-64
15-29
50-54
$:EU2020 target of 75% of the 20-64 year-olds to be employed
Source: INS 2014, Population Perspectives 2013-2060, OECD, Eurostat. Our calculs


scena=75% ER in 2030 (obtained by raising 5054/5564 ER to .8)$
0.26
0.21
0.16
0.11
0.06
Share
1990
2000
2010
2020
2030
2040
year
y2013
y2023
55-64
15-29
50-54
$:EU2020 target of 75% of the 20-64 year-olds to be employed
Source: INS 2014, Population Perspectives 2013-2060, OECD, Eurostat. Our calculs

Figures 7a and 7b show the most important results of our simulation exercise. They are essentially fourfold. First, the ageing of the workforce may have affected Belgium's TFP growth performance for quite a long time: the blue line in Figure 7a indicates that this phenomenon has been kicking since 1991, with a tendency to accelerate over the more recent years. The second result is that the magnitude of annual TFP growth losses remains quite limited; ranging from 0.3 to 0.4 percentage points. Third, as to the future, the demographics-only scenario ('No ER change') logically points at continuation of TFP losses until 2023, although at a more limited pace than what has been observed recently. However, the more realistic scenari — those where the employment rate of older workers rise markedly — translate into much larger annual TFP losses until 2020, reaching 0.55 percentage points, and then receding rapidly. Fourth. Focusing on cumulative TFP losses (Figure 7b) conveys a more synthetic perspective of the consequences of ageing under the three scenarios. Using 1991 as a reference year, we see that, up to now, ageing has caused a 4.5 percentage points TFP growth loss. In the future, the cumulative loss could reach almost 7 percentage points. Again, whether Belgium reaches the EU202O EU target in 2020 or 2030 only makes a small difference to the level of cumulative losses between now and 2030.

Figure 7a – Impact of ageing on annual and cumulative TFP growth: 1991-2040, three scenarios

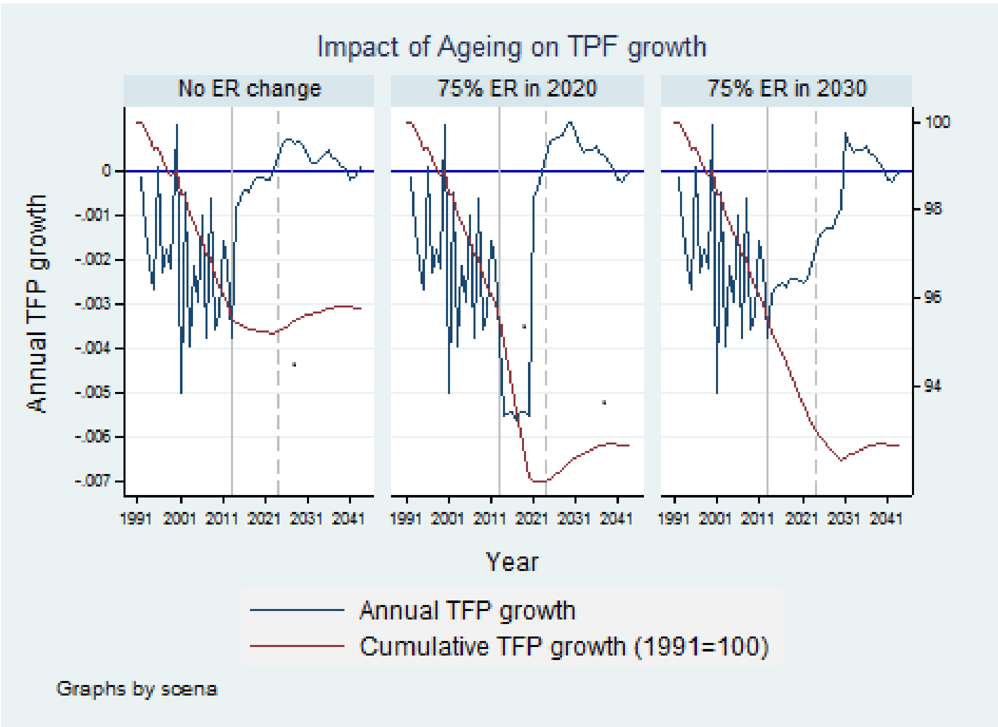
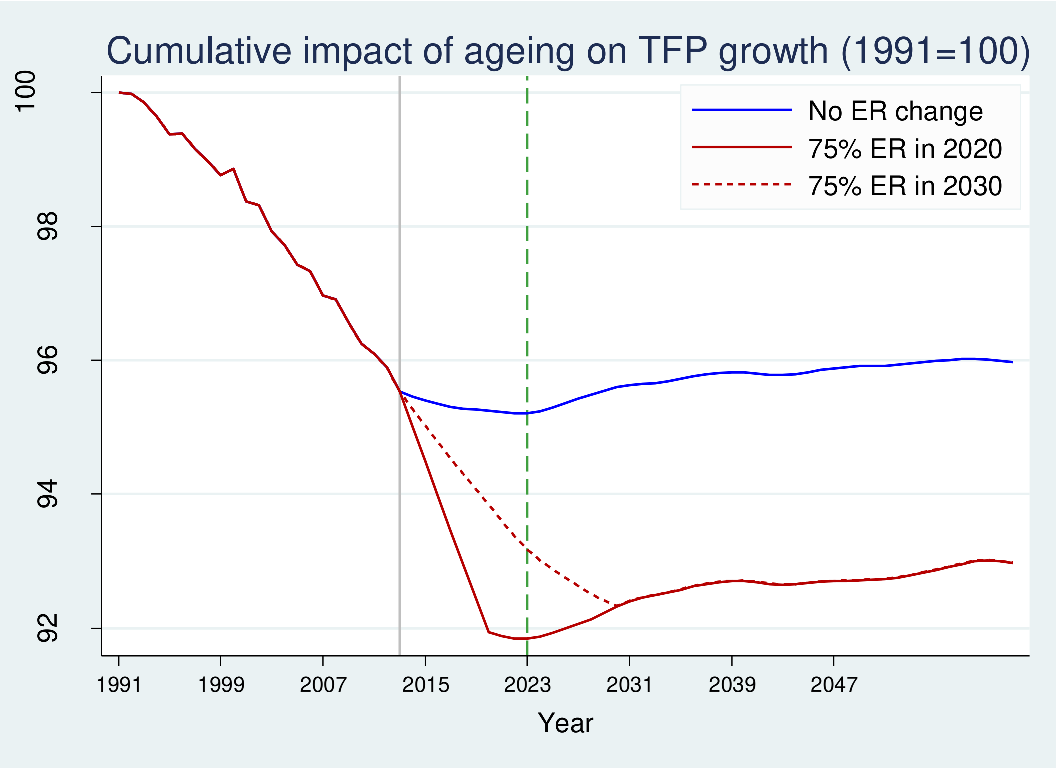


Figure 7b – Ageing and Cumulative TFP growth: 1991-2040, three scenari



6. Conclusions

This paper examines the role of different structural changes in the composition of the workforce on the dynamics of TFP. In particular, we focus on three main phenomena. The first one is the ageing of the workforce; the second is the increased participation of women in the labour market, and the third is the increased educational attainment of workers. Using data on Belgian firms for the period 1998-2006 we show that most of the TFP slowdown observed in Belgium is driven by the ageing process, with the old categories of workers contributing to TFP growth less than the other ones. This effect does not have a gender bias and the increased educational attainment does not counterbalance the negative effect of the ageing process in a significant way. This effect tends to be quite homogeneous across firms pertaining to different industries, regions and to different international involvement.

Finally, when combining our firm-level results on ageing with country-level demographic and employment data, we estimate that, over the 1991-2013 period, ageing workforces may have already dented cumulative TFP growth by -4.5 percentage points. Simulations indicate that this cumulative loss could climb to -7 percentage points by 2020-2030. This pattern is not so much dictated by Belgium's demography (the ageing of the working age population should peak around 2023). Rather, we show that it is primarily driven by Belgium's commitment/obligation to attaining a 75% overall employment rate. Raising older individuals' employment rate is an absolute must-do to counteract the rise of the dependency ratio. But, *ceteris paribus*, at least in the case of Belgium, that policy may translate into lower TFP growth for a while.

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Annexes

Annex 1 : Sectors (Manufacturing versus Services) and NACE2 codes/definitions

Nac2 code	Manufacturing
10 to 12	Manufacture of food products, beverages and tobacco products
13 to 15	Manufacture of textiles, apparel, leather and related products
16 to 18	Manufacture of wood and paper products, and printing
19	Manufacture of coke, and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of pharmaceuticals, medicinal chemical and botanical pro
22 + 23	Manufacture of rubber and plastics products, and other non-metallic
24 + 25	Manufacture of basic metals and fabricated metal products
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment n.e.c.
29 + 30	Manufacture of transport equipment
31 to 33	Other manufacturing, and repair and installation of machinery and e
35	Electricity, gas, steam and air-conditioning supply
36 to 39	Water supply, sewerage, waste management and remediation
41 to 43	Construction
45 to 47	Wholesale and retail trade, repair of motor vehicles and motorcycles
	Services
49 to 53	Transportation and storage
55 + 56	Accommodation and food service activities
58 to 60	Publishing, audiovisual and broadcasting activities
61	Telecommunications
62 +63	IT and other information services
64 to 66	Financial and insurance activities
68	Real estate activities
69 to 71	Legal, accounting, management, architecture, engineering, technical
72	Scientific research and development
73 to 75	Other professional, scientific and technical activities

77 to 82	Administrative and support service activities
90 to 93	Arts, entertainment and recreation
94 to 96	Other services
97 to 98	Activities of households as employers; undifferentiated goods
99	Activities of extra-territorial organisations and bodies

Institut de Recherches Économiques et Sociales
Université catholique de Louvain

Place Montesquieu, 3
1348 Louvain-la-Neuve, Belgique

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