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Are firms willing to employ a greying and feminizing work-force?

by V. Vandenberghe

No. 2012/01

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Are firms willing to employ a greying and feminizing workforce?*

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Abstract

Are employers willing to employ more older individuals, in particular older women? Higher employment among the older segments of the population will only materialise if firms are willing to employ them. Although several economists have started considering the demand side of the labour market for older individuals, few have considered its gender dimension properly; despite evidence that lifting the overall senior employment rate in the EU requires significantly raising that of women older than 50. In this paper, we posit that labour demand depends to a large extent on the ratio of workers' productivity to their cost to employers. Our Belgian data permit a direct estimation of age-gender/productivity and labour cost profiles, where the parameter estimates can be directly interpreted as conducive to weak or strong labour demand. We take advantage of the panel structure of our data to identify age/gender-related differences from within-firm variation. The endogeneity of the age/gender mix in production function is addressed by using and improving the structural approach of Ackerberg, Caves & Frazer (2006), alongside more traditional IV-GMM methods where lagged value of labour inputs are used as instruments. Results suggest a limited negative impact of rising shares of older men on firm's productivity-labour cost ratio, but a large negative effect of larger shares of older women. Another interesting result is that the vast and highly feminized services industry does not seem to offer working conditions that mitigate older women's productivity and employability disadvantage, on the contrary.

Keywords: ageing workforce, gender, productivity, labour cost, linked employer-employee data, endogeneity and simultaneity bias

JEL Codes: J11, J14, J21

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1. Introduction

Expanding the range of employment opportunities available to older workers will become increasingly important in most EU countries as demographics (ageing populations[1]) and public policy[2] will combine to increase the share of older individuals in the labour force. Across the EU, with the exception of some Nordic countries, there is also that older women are clearly less present in employment than older men.[3] But this should change.

The first point we raise in this paper is that a greying workforce will also become more female. Two elements combine in support of this prediction. The first one is the lagged effect[4] of the rising overall female participation in the labour force (Peracchi & Welch, 1994).[5] The second factor is labour policy. Policymakers will concentrate on promoting older women's employment because - conditional on a certain young- or prime-age participation record - women still leave the labour market earlier than men[6] (Fitzenberger *et al.*, 2004).

The second focal point of this paper is the idea that higher employment among the older segments of the EU population (male or female) will only materialise if firms are willing to employ these individuals. One cannot take for granted that older individuals who are willing to work - and are strongly enticed to do so because (early)retirement benefits are no longer accessible - do obtain employment. Anecdotal evidence abounds to suggest that firms "shed" older workers. Dorn & Sousa-Poza (2010)[7] show, for instance, that *involuntary* early retirement is the rule rather than the exception in several continental European countries: in Germany, Portugal and Hungary more than half of all early retirements are, reportedly, not by choice.

In short, there is a need to understand better the capacity of EU labour markets to adapt to ageing and feminizing workforces.

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1 In Belgium, 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 The Lisbon Agenda suggested raising employment of individuals aged 55-64 to at least 50% by 2010.

3 See the European Labour Force Survey (EU-LFS) 2010.

4 Also referred to as a cohort effect.

5 Driven, *inter alia*, by a higher educational attainment of women and a lower fertility of the younger generations.

6 In other words, life-cycle participation/employment profiles vary by gender. And the female profiles have not changed markedly across cohorts.

7 The International Social Survey Program data (ISSP) allows them to identify individuals who *i)* were early retirees and *ii)* assessed their own status as being involuntary, using the item "I retired early - by choice" or "I retired early - not by choice" from the questionnaire.

The existing economic literature primarily covers the supply side of the old-age labour market. It examines the (pre)retirement behaviour of older individuals (Mitchell & Fields, 1984) and its determinants, for example how the generosity of early pension and other welfare regimes entices people to withdraw from the labour force (Saint Paul, 2009). In the Belgian case, there is strong evidence that easy access to early retirement benefits[8] and old-age pension systems made it financially unattractive to work after the age of 55. The implicit tax on continued work has risen strongly since the 1960s and has played a significant role in the drop in the employment rate among older individuals (Blondäl & Scarpetta, 1999; Jousten *et al.*, 2008). Other papers with a supply-side focus examine how poor health status precipitates retirement (Kalwij & Vermeulen, 2008) or the importance of non-economic factors (i.e. family considerations) in the decision of older women to retire (Pozzebon & Mitchell, 1989; Weaver, 1994).

The demand side of the labour market for older individuals has started to receive some attention from economists. Some have started examining the relationship between age and productivity at the level where this matters most: firms. They have estimated production functions expanded by the specification of a labour-quality index à la Hellerstein & Neumark (1995) (HN henceforth).[9] According to Malmberg *et al.* (2008), an accumulation of high shares of older adults in Swedish manufacturing plants does not negatively impact plant-level productivity. By contrast, Grund & Westergård-Nielsen (2008) find that both mean age and age dispersion in Danish firms are inversely U-shaped in relation to firms' productivity. But these authors use cross-sectional approaches. More recent analysis of the German evidence by Göbel & Zwick (2009), using panel data to control for the endogeneity of age structure, produces little evidence of an age-related productivity decline. By contrast, Lallemand & Ryck (2009), who use Belgian firm-level panel data[10], conclude that older workers (>49) are significantly less productive than prime-age workers, particularly in ICT firms.

Using panel data and coping with the endogeneity of the age structure of the workforce has become key in this literature (more in Section 2). Another key distinction in terms of methodology is between studies which only examine productivity and those that simultaneously consider pay or

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[8] While the age of 58 is *a priori* the minimum access age, a lower age of 55, 56 or 57 is possible in some sectors (steel, glass, textile, etc.), presumably reflecting more arduous working conditions. Similar exceptions exist for some workers in the building industry and those who worked shifts. Even more pronounced reductions in the minimum age are possible when the company is recognized as being in real trouble, under which circumstance the age can be brought down to 52 years, or even 50.

[9] The key idea of HN is to estimate a production function (or a labour-cost function), with heterogeneous labour input, where different types (e.g. men/women, young/old) diverge in terms of marginal product.

[10] The Structure of Earnings Survey and the Structure of Business Survey conducted by Statistics Belgium.

labour costs. Economists with a focus on labour demand assess employability by examining the ratio of (or the gap between) individuals' productivity to (and) their cost to employers. This paper analyses the sensitivity of that gap to the workforce structure of firms. Under proper assumptions (see Section 2), this amounts to analysing the sensitivity of the productivity-labour cost gap to the age structure of firms.

One of the first papers that combined the productivity and labour cost dimensions was that of Hellerstein *et al*. (1999). In a recent replication of that seminal analysis using data covering the US manufacturing sector, the authors (Hellerstein & Neumark, 2007) estimate relative productivity of workers aged 55+ is only 0.87 (ref. group <35 =1), whereas relative wages is 1.12. Most papers based on cross-sectional data conclude that firm productivity has an inverted U-shaped relationship with age, while labour costs are either rising with age or flat beyond a certain threshold with a negative impact on the productivity-labour cost ratio after 55 (Grund & Westergård-Nielsen, 2008; Skirbekk, 2004, 2008).

Turning to authors using (*a priori* more trustworthy) panel data, the evidence is mixed. For Belgium, Cataldi, Kampelmann & Rycx (2011)[11] find evidence of a negative effect of older workers on the productivity-labour cost gap. Aubert & Crépon (2003, 2007), observe that the productivity of French workers rises with age until around the age of 40, before stabilizing, a path which is very similar to that of wages. But a negative effect on the productivity-labour cost gap is observed with rising shares of workers aged 55+. On the contrary, the absence of such evidence seems to hold for manufacturing in the Netherlands, as explained by van Ours & Stoeldraijer (2011), and in Portugal for the whole economy, as shown by Cardoso, Guimãraes & Varejão (2011).

Our point is that none of the existing papers has adequately considered the *gender* dimension of ageing, in a context where women are likely to form a growing part of the older labour force. This paper aims at filling that void. We try to assess the current willingness of employers to (re)employ older male and female workers. And we posit that the answer to this question largely depends on how larger shares of older (male or female) workers affect private firms' productivity-labour cost ratio. We assume in particular that a sizeable negative impact of older men/women on that ratio can adversely affect their respective chances of being employed.

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[11] Extending the analysis *of Structure of Earnings Survey* and the *Structure of Business Survey* to examine age-wage-productivity nexus.

In this paper we also use firm-level direct measures of productivity and labour cost. Our Belgian data[12] permit a direct estimation of age-gender/productivity-labour cost ratio profiles, where the parameter estimates associated with the shares of older workers (male and female) in the workforce can be directly interpreted as conducive to weak or strong labour demand or employability (more on this in Section 2). Our measure of firms' productivity (valued added) enhances comparability of data across industries, which vary in their degree of vertical integration (Hellerstein *et al.*, 1999). Moreover, we know with great accuracy how much firms spend on their employees. Some studies use individual information on gross wages, whereas we use firm-level information on annual gross wages *plus* social security contributions and other related costs. Our data also contain information on firms from the large and expanding services industry[13], where administrative and intellectual work is predominant, and where female employment is important. Many observers would probably posit that age and gender matters less for productivity in a service-based economy than in one where agriculture or industry dominates. Finally, it is worth stressing that our panel comprised a sizeable number of firms (9,000+) and covered a relatively long period running from 1998 to 2006.

In this paper, we try to find evidence of a negative (or positive) effect on *i)* average productivity, *ii)* average labour costs and *iii)* the productivity-labour cost ratio[14] of larger shares of older (male and female) workers. We also employ the framework pioneered by HN, which consists of estimating production and/or labour cost functions that explicitly account for labour heterogeneity. Applied to firm-level data, this methodology presents two main advantages. First, it delivers productivity differences across age/gender groups that can immediately be compared to a measure of labour costs differences, thereby identifying the net contribution of an age/gender group to the productivity-labour cost ratio (which can be directly interpreted as conducive to weak or strong employability). Second, it measures and tests for the presence of market-wide impact on the productivity-labour cost ratio that can affect the overall labour demand for the category of workers considered.

The HN methodology is suitable for analysing a wide range of workers' characteristics, such as

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12 The raw firm-level data are retrieved from Bel-first. They are matched with data from Belgian's Social Security register (called Carrefour data warehouse) containing detailed information about the characteristics of the employees in those firms, namely their age.

13 According the most recent statistics of the Belgian National Bank (http://www.nbb.be/belgostat), at the end of 2008 services (total employment – agriculture, industry and construction) accounted for 78% of total employment, which is four percentage points more than 10 years earlier. Similar figures and trends characterize other EU and OECD countries.

14 Strictly speaking the expression "productivity-labour cost ratio" used throughout this paper refers to the ratio of *i)* the difference between a firm's value added (Y) and its labour costs (W), to *ii)* the firm's labour costs, i.e. $(Y-W)/W$.

race, education, gender and marital status, e.g. Hellerstein & Neumark (1999), Hellerstein *et al*.(1999), Vandenberghe (2011b), and richer data sets regarding employees, *e.g.* Crépon, Deniau & Pérez-Duarte (2002). In this paper, we focus exclusively on gender and age.

From the econometric standpoint, recent developments of HN's methodology have tried to improve the estimation of the production function by the adoption of alternative techniques to deal with a potential heterogeneity bias (unobserved time-invariant determinants of firms' productivity that are correlated with labour inputs) and simultaneity bias (endogeneity in input choices in the short run that includes firm's age-gender mix). A standard solution to the heterogeneity bias is to resort to fixed-effect analysis, generally via first-differencing (FD) of panel data.

As to the endogeneity bias, the past 15 years has seen the introduction of new identification techniques.[15] One set of techniques follows the dynamic panel literature (Arellano & Bond, 1991; Aubert & Crépon, 2003; Blundell & Bond, 2000; or van Ours & Stoeldraijer, 2011), which basically consists of using lagged values of (first-differenced) labour inputs as instrumental variables (FD-IV-GMM henceforth). A second set of techniques, initially advocated by Olley & Pakes (1996), Levinsohn & Petrin (2003) (OP, LP henceforth), and more recently by Ackerberg, Caves & Fraser (2006) (ACF henceforth), are somewhat more structural in nature. They consist of using observed intermediate input decisions (i.e. purchases of raw materials, services, electricity...) to "control" for (or proxy) unobserved short-term productivity shocks.

In this paper we use these recent applications of the HN methodology that we apply to panel data that have been first differenced (FD), in order to account for time-invariant unobserved heterogeneity. We also apply two strategies that are aimed at coping with endogeneity/simultaneity. Following many authors in this area (Aubert & Crépon, 2003, 2007; van Ours & Stoeldraijer, 2011; Cataldi, Kampelmann & Rycx, 2011), we first estimate the relevant parameters of our model using FD "internal" instruments (i.e lagged values of endogenous labour inputs) (FD-IV-GMM henceforth). Second, we also implement the more structural approach initiated by Olley & Pakes (1998), further developed by Levinsohn & Petrin (2003) and more recently by Ackerberg, Caves & Frazer (2006) (ACF hereafter), which primarily consists of using intermediate inputs to control for short-term simultaneity bias. Note that we innovate within this stream, as we combine the ACF intermediate-good approach with FD, to better account for simultaneity <u>and</u> firm heterogeneity (FD-

15 See Ackerberg, Caves & Frazer (2006) for a recent review.

ACF henceforth).

Easy access to (early)retirement benefits and the financial disincentives to continue to work at older ages imbedded these regimes are the factors traditionally emphasized by economists to explain the country’s low employment rate among individuals aged 50 and over. This paper contains evidence that the latter could also be demand-driven. Firms based in Belgium face financial disincentives to employing older workers - particularly older women. Our most important results in this respect are those derived from the regression of the productivity-labour cost ratio on the share of older men and women. Using prime-age men as a reference, we show that a 10%-points rise in the share of older men causes a moderate reduction in the productivity-labour cost ratio ranging from 0 to 0.88%. However, the situation is different for older women. Our preferred estimates suggest that a 10%-points expansion of their share in the firm’s workforce causes a 1.8 to 2.1% reduction in the productivity-labour cost ratio; something that is likely to negatively affect their employability. Using prime-age women as a reference, we find that 10%-points expansion of old women’s share causes a contraction of the productivity-labour cost ratio in the range of 1.04 to 2.14%. And these negative effects are even larger when we restrict the analysis to subsamples of firms (i.e. balanced panel, services industry). The ultimate point is that these results raise questions about the feasibility, in the current context, of a policy aimed at boosting the employment rate of older women.

The rest of the paper is organized as follows. In Section 2, our methodological choices regarding the estimation of the production, labour cost and production-labour cost ratio functions are unfolded. Section 3 is devoted to an exposition of the dataset. Section 4 contains the econometrics results. Our main conclusions are exposed in Section 5. That final section also contains a discussion of the various factors that may explain why older women (at least in Belgium) display a larger productivity and employability handicap than older men.

2. Methodology

In order to estimate age-gender productivity profiles, following most authors in this area, we consider a Cobb-Douglas production function (Hellerstein *et al.*, 1999; Aubert & Crépon, 2003, 2007; Dostie, 2011; van Ours & Stoeldraijer, 2011; Vandenberghe, 2011a,b):

$$ln\,(Y_{it}/L_{it}) = lnA + \alpha\, ln\, QL_{it} + ß\, lnK_{it} - lnL_{it} \qquad (1)$$

where: Y_{it}/L_{it} is the average value added per worker (average productivity hereafter) in firm i at time t, QL_{it} is an aggregation of different types of workers, and K_{it} is the stock of capital.

The variable that reflects the heterogeneity of the workforce is *the quality of labour index* QL_{it}. Let L_{ikt} be the number of workers of type k (*e.g.* young/prime-age/old: men/women) in firm i at time t, and μ_{ik} be their productivity. We assume that workers of various types are substitutable with different marginal products. As each type of worker k is assumed to be an input in quality of labour aggregate, the latter can be specified as:

$$QL_{it} = \sum_k \mu_{ik} L_{ikt} = \mu_{i0} L_{it} + \sum_{k>0} (\mu_{ik} - \mu_{i0}) L_{ikt} \qquad (2)$$

where: $L_{it} \equiv \sum_k L_{ikt}$ is the total number of workers in the firm, μ_{i0} the marginal productivity of the reference category of workers (*e.g.* prime-age men) and μ_{ik} that of the other types of workers.

If we further assume that a worker has the same marginal product across firms, we can drop subscript i from the marginal productivity coefficients. After taking logarithms and doing some rearrangements equation (2) becomes:

$$ln\ QL_{it} = ln\ \mu_0 + lnL_{it} + ln\ (1+ \sum_{k>0} (\lambda_k - 1) P_{ikt}) \qquad (3)$$

where $\lambda_k \equiv \mu_k/\mu_0$ is the relative productivity of type k worker and $P_{ikt} \equiv L_{ikt}/L_{it}$ the proportion/share of type k workers over the total number of workers in firm i .

Since $ln(1+x) \approx x$, we can approximate (3) by:

$$ln\ QL_{it} = ln\ \mu_0 + ln\ L_{it} + \sum_{k>0} (\lambda_k - 1) P_{ikt} \qquad (4)$$

And the production function becomes:

$$ln(Y_{it} /L_{it}) = lnA + \alpha\ [ln\mu_0 + ln\ L_{it} + \sum_{k>0} (\lambda_k -1) P_{ikt}] + ß\ lnK_{it} - lnL_{ik} \qquad (5)$$

Or, equivalently, if $k=0,1,\ldots.N$ with $k=0$ being the reference group (*e.g.* prime-age male workers)

$$ln\ (Y_{it} /L_{it}) = B + (\alpha\text{-}1)l_{it} + \eta_1 P_{i1t} + \ldots \eta_N P_{iNt} + ß\ k_{it} \qquad (6)$$

where:

$B=lnA+\alpha\ ln\ \mu_0$

$\lambda_k=\mu_k/\mu_0$ $\qquad$ $k\text{-}=1\ldots N$

$\eta_1 = \alpha\,(\lambda_1 - 1)$
….

$\eta_N = \alpha\,(\lambda_N - 1)$
$l_{it}=lnL_{it}$
$k_{it}=lnK_{it}$

Note first that (6), being loglinear in P, has coefficients can be directly interpreted as the percentage change in the firm's average labour productivity of a 1 unit (here 100 percentage points) change of the considered type of workers' share among the employees of the firm. Note also that, strictly speaking, in order to obtain a type k worker's relative marginal productivity, (*i.e.* λ_k), coefficients η_k have to be divided by α, and 1 needs to be added to the result.[16]

A similar approach can be applied to a firm's average labour cost. If we assume that firms operating in the same labour market pay the same wages to the same category of workers, we can drop subscript i from the remuneration coefficient π.[17] Let π_k stand for the remuneration of type workers ($k=0$ being reference type). Then the average labour cost per worker becomes:

$$W_{it}\,/L_{it}= \sum_k \pi_k\, L_{ikt}\,/\,L_{it} =\pi_0 + \sum_{k>0} (\pi_k - \pi_0)\, L_{ikt}/\,L_{it} \qquad (7)$$

Taking the logarithm and using again $log(1+x)\approx x$, we can approximate this by:

$$ln(W_t\,/L_{it})= ln\,\pi_0 + \sum_{k>0} (\Phi_k - 1)\, P_{ikt} \qquad (8)$$

where the Greek letter $\Phi_k \equiv \pi_k/\,\pi_0$ denotes the relative remuneration of type k workers ($k>0$) with respect to the ($k=0$) reference group, and $P_{ik}= L_{ik}/L_{i0}$ is again the proportion/share of type k workers over the total number of workers in firm i .

The logarithm of the average labour cost finally becomes:

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16 Does all this matter in practice? Our experience with firm-level data suggests values for ß ranging from 0.6 to 0.8 (these values are in line with what most authors estimates for the share of labour in firms' output/added valye). This means that λ_k are larger (in absolute value) than η_k.. If anything, estimates reported in Tables 6-8 underestimate the true marginal productivity difference vis-à-vis prime-age workers.

17 We will see, how, in practice via the inclusion of dummies, this assumption can be relaxed to account for sectoral wage effects.

$$ln\ (W_{it}\ /L_{it})= B^w + \eta^w{}_1\ P_{i1t} + \dots\ \eta^w{}_N\ P_{iNt} \qquad (9)$$

where:

$$B^w = ln\ \pi_0$$
$$\eta^w{}_1 = (\Phi_1\ - 1)$$
$$\dots$$
$$\eta^w{}_N = (\Phi_N - 1)$$

Like in the average productivity equation (6) coefficients $\eta^w{}_k$ capture the sensitivity to changes of the age/gender structure (P_{ikt}).

The key hypothesis test of this paper can now be easily formulated. Assuming spot labour markets and cost-minimizing firms the null hypothesis of no impact on the productivity-labour cost ratio for type k worker implies $\eta_k = \eta^w{}_k$. Any negative (or positive) difference between these two coefficients can be interpreted as a quantitative measure of the disincentive (incentive) to employ the category of workers considered. This is a test that can easily implemented, if we adopt strictly equivalent econometric specifications for the average productivity and average labour cost; in particular if we introduce firm size (l) and capital stock (k) in the labour cost equation (9). Considering three age groups (1=[20-29], 2=[30-49]; 3=[50-64[) and with prime-age (30-49) male workers forming the reference group, we get.

$$ln(Y_{it}/L_{it}) = B + (\alpha-1)l_{it} +$$

$$\eta_{1m}P_{it}^{m18\text{-}29} + \eta_{3m}P_{it}^{m50\text{-}64} + \eta_{1f}\ P_{it}^{f18\text{-}29} + \eta_{2f}\ P_{it}^{f30\text{-}49}{}_{+}\ \eta_{3f}\ P\ {}_{it}^{f50\text{-}64}{}_{+}\ ß\ k_{it} + \gamma F_{it} + \varepsilon_{it} \qquad (10)$$

$$ln\ (W_{it}\ /L_{it}) = B^w + (\alpha^W - 1)l_{it} +$$

$$\eta^W{}_{1m}\ P_{it}^{m18\text{-}29} + \eta^W{}_{3m}P_{it}^{m50\text{-}64} + \eta^W{}_{1f}P_{it}^{f18\text{-}29} + \eta^W{}_{2f}\ P_{it}^{f30\text{-}49}{}_{+}\ \eta^W{}_{3f}P_{it}^{f50\text{-}64} + ß^w\ k_{it+}\ \gamma^W F_{it} + \varepsilon^w{}_{it} \qquad (11)$$

What is more, if we take the *difference* between the logarithms of average productivity (10) and labour costs[18] (11) we get a direct expression of the productivity-labour cost ratio[19] as a linear function of its workforce determinants.

$$Ratio_{it} \equiv ln\ (Y_{it}/L_{it}) - ln\ (W_{it}/L_{it}) = B^R + (\alpha^R - 1) l_{it} +$$

$$\eta^R_{1m} P_{it}^{m18\text{-}29} + \eta^R_{3m} P_{it}^{m50\_64} + \eta^R_{1f} P_{it}^{f18\text{-}29} + \eta^R_{2f} P_{it}^{f30\text{-}49} + \eta^R_{3f} P_{it}^{f50\text{-}64} + ß^R k_{it} + \gamma^R F_{it} + \varepsilon^R_{it} \qquad (12)$$

where: $B^R = B - B^w$; $\alpha^R = \alpha - \alpha^W$, $\eta^R_{1m} = \eta_{1m} - \eta^w_{1m}$; $\eta^R_{3m} = \eta_{3m} - \eta^w_{3m}$; $\eta^R_{1f} = \eta_{1f} - \eta^w_{1f}$; $\eta^R_{2f} = \eta_{2f} - \eta^w_{2f}$; $\eta^R_{3f} = \eta_{3f} - \eta^w_{3f}$; $\gamma^R = \gamma - \gamma^w$ and $\varepsilon^R_{it} = \varepsilon_{it} - \varepsilon^w_{it}$.

It is immediate to see that coefficients η^R of equation (12) provide a direct estimate of how the productivity-labour cost ratio is affected by changes in terms of percentages/shares of employed workers.

Note also the inclusion in (12) of the vector of controls F_{it} . The latter comprises total labour/firm size (l) and the amount of capital (k). In all the estimations presented hereafter F_{it} also contains year X sector[20] dummies. This allows for systematic and proportional productivity variation among firms along these dimensions. This assumption can be seen to expand the model by controlling for year and sector-specific productivity shocks or trends, labour quality and intensity of efficiency wages differentials across sectors and other sources of systematic productivity differentials (Hellerstein & Neumark, 1999). More importantly, since the data set we use do not contain sector price deflators, the introduction of these dummies can control for asymmetric variation in the price of firms' outputs at sector level. An extension along the same dimensions is made with respect to the labour cost equation. Of course, the assumption of segmented labour markets, implemented by adding linearly to the labour cost equation the set of year/sector dummies, is valid as long there is proportional variation in wages by age/gender group along those dimensions (Hellerstein *et al.*, 1999).

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[18] Labour costs used in this paper, which were measured independently of value added, include the value of all monetary compensations paid to the total labour force (both full- and part-time, permanent and temporary), including social security contributions paid by the employers, throughout the year. The summary statistics of the variables in the data set are presented in Table 1.

[19] Measured in %. This is because the logarithms, used in conjunction with differencing, convert absolute differences into relative (i.e., percentage) differences: i.e. $(Y\text{-}W)/W$.

[20] NACE2 level.

It is also worth stressing the inclusion in F_{it} of firm-level information on the (log of) average number of hours worked annually per employee; obtained by dividing the total number of hours reportedly worked annually by the number of employees (full-time or part-time ones indistinctively). The resulting variable is strongly correlated with the intensity of part-time work. Although there is little evidence that older workers more systematically resort to part-time work in Belgium, it seems reasonably to control for this likely source of bias when studying the causal relationship between age-gender and productivity, labour cost or the ratio between these two.

But, as to proper identification of the causal links, the main challenge consists of dealing with the various constituents of the residual ε_{it} of equation (10).[21] We assume that the latter has a structure that comprises three elements:

$$\varepsilon_{it} = \theta_i + \omega_{it} + \sigma_{it} \tag{13}$$

where: $cov(\theta_i, P_{ik,t}) \neq 0$, $cov(\omega_{it}, P_{ik,t}) \neq 0$, $E(\sigma_{it})=0$

In other words, the OLS sample-error term potentially consists of *i)* an unobservable firm fixed effect θ_i; *ii)* a short-term shock ω_{it} whose evolution corresponds to a first-order Markov chain, and is observed by the firm (but not by the econometrician) and (partially) anticipated by the firm, and, *iii)* a purely random shock σ_{it}.

Parameter θ_i. in (13) represents firm-specific characteristics that are unobservable but driving average productivity. For example the vintage of capital in use, the overall stock of human capital[22], firm-specific managerial skills, location-driven comparative advantages.[23] And these might be correlated with the age-gender structure of the firm's workforce, biasing OLS results. Older workers for instance might be overrepresented among plants built a long time ago using older technology. However, the panel structure of our data allows for the estimation of models with firm fixed effects (using FD). FD are good at purging fixed effects and thus at coping with unobserved heterogeneity terms θ_i. The results from the FD estimation can be interpreted as follows: a group (e.g. male or female) is estimated to be more (less) productive than another group if, within firms, a increase of that group's share in the overall workforce translates into productivity gains (loss).

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21 And its equivalent in equation (12).

22 At least the part of that stock that is not affected by short-term recruitments and separations.

23 Motorway/airport in the vicinity of logistics companies for instance.

This said, the greatest econometric challenge is to go around the simultaneity/endogeneity bias (Griliches & Mairesse, 1995). The economics underlying that concern is intuitive. In the short run, firms could be confronted to productivity deviations, ω_{it}; say, a lower turnover, itself the consequence of a missed sales opportunity. Contrary to the econometrician, firms may know about ω_{it}. An anticipated downturn could translate into a recruitment freeze, or, alternatively, into a multiplication of "involuntary" (early) retirements.[24] A recruitment freeze affects youth predominantly, and translates into rising share of older (male/female) workers during negative spells, creating a negative correlation between older workers' share and productivity, thereby leading to underestimated estimates of their productivity (when resorting to OLS or even FD estimates). By contrast, if firms primarily promote early retirements when confronted with adverse demand shocks, we would expect the correlation to be positive, leading to an overestimation of older (male/female) workers' productivity with OLS or FD.

To account for the presence of this endogeneity bias we first estimate the relevant parameters of our model using only "internal" instruments. The essence of this strategy is to use lagged values of endogenous labour inputs as instruments for the endogenous (first-differenced) labour inputs (Aubert & Crépon, 2003, 2007; van Ours & Stoeldraijer, 2011; Cataldi, Kampelmann & Rycx, 2011).[25] Our choice is to instrument the potentially endogenous first-differenced worker shares (ΔP_{it}^{k}) with their second differences (ΔP_{it}^{k} - ΔP_{it-1}^{k}) and lagged second differences (ΔP_{it-1}^{k}- ΔP_{it-2}^{k}) *i.e.* past changes of the annual variations of the worker age/gender mix. The key assumptions are that these past changes are *i)* uncorrelated with current year-to-year changes of the productivity term $\Delta\omega_{it}$, but *ii)* still reasonably correlated with those of the workers' shares ΔP_{it}^{k}.

An alternative to IV-GMM that seems promising and relevant is to adopt the structural approach initiated by Olley & Pakes (1998) (OP hereafter) and further developed by Levinsohn & Petrin (2003) (LP hereafter), and more recently by Ackerberg, Caves & Frazer (2006) (ACF, hereby). The essence of the OP approach is to use some function of a firm's investment to control for (proxy) time-varying unobserved productivity, ω_{it}. The drawback of this method is that only observations with positive investment levels can be used in the estimation. Many firms indeed report no

[24] Dorn & Sousa-Poza (2010) report that, in many Continental European countries, the proportion of involuntary retirement is significantly higher in years with increasing unemployment rates. One explanation for this finding is that firms promote early retirement when they are confronted with adverse demand shocks in an economic recession.

[25] The other key feature of these methods is that they are based on the Generalized Method of Moments (GMM), known for being more robust than 2SLS to the presence of heteroskedasticity).

investment in short panels. LP overcome this problem by using material inputs (raw materials, electricity,...) instead of investment in the estimation of unobserved productivity. They argue that firms can swiftly (and also at a relatively low cost) respond to productivity developments ω_{it}, by adapting the volume of the intermediate inputs they buy on the market. ACF argue that there is some solid and intuitive identification idea in the LP paper, but they claim that their two-stage estimation procedure delivers poor estimates of the labour coefficients and propose an improved version of it.

Simplifying our notations to make them alike those used by ACF, average productivity equation becomes:

$$ln\ (Y_{it}\ /L_{it}) = B + \varphi\ ql_{it} + ß\ k_{it} + \gamma F_{it} + \varepsilon_{it} \quad (14a)$$

with the labour quality index (or vector of labour inputs) equal to:

$$\varphi\ ql_{it} \equiv (\alpha-1) l_{it} + \eta_1 P_{it}^{18\text{-}29} + \eta_3 P_{it}^{50\text{-}64} \quad (14b)$$

and the ACF error term:

$$\varepsilon_{it} = \omega_{it} + \sigma_{it} \quad (14c)$$

Note that the latter does not contain a proper fixed effect θ_i, as we have assumed above, and as is traditionally assumed by the authors using FD-IV-GMM.

Like ACF, we assume that firms' (observable) demand for intermediate inputs (int_{it}) is a function of the time-varying unobserved term ω_{it} as well as (log of) capital, and the quality of labour index ql_{it} and its components:

$$int_{it} = f_t(\omega_{it}\ , k_{it}, ql_{it}) \quad (15)$$

By contrast, LP unrealistically assume that the demand of intermediate goods is not influenced by that of labour inputs.[26]

ACF further assume that this function f_t is monotonic in ω_{it} and its other determinants, meaning that

[26] Consider the situation where ql_{it} is chosen at $t\text{-}b$ ($0<b<1$) and int_{it} is chosen at t. Since ql_{it} is chosen before in_{it}, a profit-maximizing (or cost-minimizing) optimal choice of int_{it} will generally directly depend on ql_{it} (Ackerberg, Caves & Frazer, 2006).

it can be inverted to deliver an expression of ω_{it} as a function of int_{it} , k_{it}, ql_{it}, and introduced into the production function:

$$ln\ (Y_{it}\ /L_{it}) = B + \varphi\ ql_{it} + ß\ k_{it} + \gamma F_{it} + f_t^{-1}(int_{it}, k_{it}, ql_{it}) + \sigma_{it} \quad (16a)$$

We use this strategy here. However - unlike ACF - we do this in combination with first differences (FD) to properly account for firm fixed effects θ_i, meaning that our production function writes

$$ln\ (Y_{it}\ /L_{it}) = B + \varphi\ ql_{it} + ß\ k_{it} + \gamma F_{it} + f_t^{-1}(int_{it}, k_{it}, ql_{it}) + \boldsymbol{\theta_i} + \sigma_{it} \quad (16b)$$

In a sense, we stick to what has traditionally been done in the dynamic-panel literature underpinning the FD-IV-GMM strategy discussed above. We also believe that explicitly accounting for firm fixed effects increases the chance of verifying the key monotonicity assumption required by the ACF approach in order be able to invert out ω_{it} , and completely remove the endogeneity problem. In the ACF framework (similar in that respect to the LP or OP ones), the firm fixed effects are *de facto* part of ω_{it}. Allowing for a time-varying firm effect is *a priori* appealing. For instance, it preserves more identifying variation.[27] On the other hand, the evidence with firm panel data is that fixed effects capture a large proportion (>50%) of the total productivity variation.[28] This tentatively means that, in the ACF intermediate goods function $int_{it} = f_t(\omega_{it}, k_{it}, ql_{it})$, the term ω_{it} can vary a lot when switching from one firm to another and, most importantly, in a way that is not related to the consumption of intermediate goods. In other words, firms with similar values of int_{it} (and k_{it} or ql_{it}) are characterized by very different values of ω_{it}. This is something that invalidates the ACF assumption of a one-to-one (monotonic) relationship, and the claim that the inclusion of intermediate goods in the regression adequately controls for endogeneity/simultaneity. This said, we still believe that intermediate goods can greatly contribute to identification, but conditional on properly accounting for firm fixed effects. In practice, how can this be achieved? The ACF algorithm consists of two stages. We argue that only stage one needs to be adapted.

In stage one, like ACF, we regress average productivity on a composite term Φ_t that comprises a constant, a 3^{rd} order polynomial expansion in int_{it}, k_{it}, ql_{it}., and our vector of controls added linearly. This leads to

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27 Fixed effect estimators only exploit the within part of the total variation.

28 Another illustration of the same idea is that published studies have documented, virtually without exception, enormous and persistent measured (but unexplained) productivity differences across firms, even within narrowly defined industries (Syverson, 2011).

$$ln\ (Y_{it}/L_{it}) = \Phi_t(int_{it}, k_{it}, ql_{it}, F_{it}) + \boldsymbol{\theta_i} + \sigma_{it} \qquad (17)$$

Note that Φ_t encompasses $\omega_{it} = f_t^{-1}(.)$ displayed in (16b) and that φ, $ß$ and γ are clearly not identified yet.[29] The point made by ACF is that this first-stage regression delivers an unbiased estimate of the composite term Φ_{it}^{hat}; i.e productivity net of the purely random term σ_{it}. We argue that this is valid only if there is no firm fixed effect θ_i or if the latter can be subsumed into $\omega_{it} = f_t^{-1}(.)$ - something we believe unrealistic and problematic for the reasons exposed above. Hence, we prefer assuming that fixed effects exist and explicitly account for them; which can easily be done by resorting to first differencing (FD) to estimate equation (17). The FD-estimated coefficients - provided they are applied to variables in levels - will deliver an unbiased prediction of Φ_{it}^{hat}. Specifically, Φ_{it}^{hat}, net of the noise term and firm-fixed effects, is calculated as $\Phi_{it}^{hat} = (\upsilon_{a1})^{FD}\ int_{it} + (\upsilon_{a2})^{FD}\ int^2_{it} + \ldots + (\upsilon_{b1})^{FD}\ k_{it} + \ldots + (\upsilon_{c1})^{FD} ql_{it} + \ \ldots\ + (\upsilon_{d1})^{FD}\ int_{it}k_{it} \ldots$, where $(\upsilon_{a1})^{FD}$, $(\upsilon_{a2})^{FD} \ldots$ represent the first-differenced coefficient estimates on the polynomial terms.

Beyond, we basically argue that their second stage is unaffected by the modifications discussed above. Key is the idea that one can generate implied values for $\boldsymbol{\omega_{it}}$ using first-stage estimates Φ_{it}^{hat} and candidate[30] values for the coefficients φ , $ß$, γ:

$$\omega_{it} = \Phi_{it}^{hat} - ql_{it}\,\varphi - ß\ k_{it} - \gamma F_{it} \qquad (18)$$

ACF assume further that the evolution of ω_{it} follows a first-order Markov process

$$\omega_{it} = E[\omega_{it} | \omega_{it-1}] - \xi_{it} \qquad (19)$$

That assumption simply amounts to saying that the realization of ω_{it} depends on some function g(.) (known by the firm) of *t-1* realisation and an (unknown) innovation term ξ_{it}.

$$\omega_{it} = g(\omega_{it-1}) + \xi_{it} \qquad (20)$$

By regressing non-parametrically (implied) ω_{it} on (implied) ω_{it-1}, ω_{it-2}, one gets residuals that

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29 Note in particular that the non identification of vector φ (ie. labour input coefficients) in the first stage is one of the main differences between ACF and LP.

30 OLS estimates for example.

correspond to the (implied) ξ_{it} that can form a sample analogue to the orthogonality (or moment) conditions identifying φ,$ß$ and γ. We would argue that residuals ξ_{it} are orthogonal to our controls F_{it}

$$E[\xi_{it|} F_{it}]=0 \tag{21a}$$

Analogous to ACF, we would also argue that capital in period *t* was determined at period *t-1* (or earlier). The economics behind this is that it may take a full period for new capital to be ordered and put to use. Since k_{it} is actually decided upon *t-1*, *t-2*…, it must be uncorrelated with the implied innovation terms ξ_{it}:

$$E[\xi_{it|} k_{it}]=0 \tag{21b}$$

Labour inputs observed in *t* are probably also chosen sometime before, although after capital – say in *t-b*, with $0<b<1$. As a consequence, ql_{it} will be correlated with at least part of the productivity innovation ξ_{it}. On the other hand, assuming *lagged* labour inputs were chosen at time *t-b-1* (or earlier), ql_{it-1}, ql_{it-2}… should be uncorrelated with the innovation terms ξ_{it}. This gives us the third (vector) of moment conditions needed for identification of φ:

$$E[\xi_{it|}\ ql_{it-1}, ql_{it-2}\ldots]=0 \tag{22a}$$

or more explicitly, given the composite nature of ql_{it}, we have:

$$E[\xi_{it|}\ l_{it-1}, l_{it-2}\cdots]=0 \tag{22b}$$

$$E[\xi_{it|}\ P^{18\text{-}29}{}_{it-1}, P^{18\text{-}29}{}_{it-2}\cdots]=0 \tag{22c}$$

$$E[\xi_{it|}\ P^{50\text{-}54}{}_{it-1}, P^{50\text{-}64}{}_{it-2}\cdots]=0 \tag{22d}$$

3. Data description

As already stated, we are in possession of a panel of around 9,000 firms with more than 20 employees, largely documented in terms of sector, location, size, capital used, labour cost levels and productivity (value added). These observations come from the Bel-first database. Via the so-called Carrefour data warehouse, using firm identifiers, we have been able to inject information on the age/gender of (all) workers employed by these firms, and this for a period running from 1998 to 2006.

Descriptive statistics are reported in Tables 1-4. Tables 2 and 3 suggest that firms based in Belgium have been largely affected by ageing over the period considered. Table 2 shows that between 1998 and 2006, the mean age of workers active in private firms located in Belgium rose by almost 3 years: from 36.2 to 39.1. This is very similar what has occurred Europe-wide. For instance Göbel & Zwick (2009) show that between 1997 and 2007 the average age of the workforce in the EU25 has risen from 36.2 to 38.9.

Table 3 also shows that, in the Belgian private economy, between 1998 and 2006, the percentage of old male workers (50-65) has risen steadily from 10% to almost 15%. And the proportion of older women has risen even more dramatically, from 2% to 4.1%. While starting from a low level in 1998 (2.13%), the rise of the share of older women has been of more than 96% in cumulative terms. The corresponding figure for older men is only 48 %.

What may explain this gender asymmetry? We would formulate two (non-mutually exclusive) explanations. The first one, already mentioned above, is the "lagged effect" of surge of female participation in the labour market, itself explained by the lowering of the birth rate and a surge in the number of women accessing tertiary education. The second hypothesis is that of the impact of the pension reform that took place in Belgium in 1997. Before 1997, the legal age of retirement was 60 for women, but 65 for men. The European court of Justice considered this as a form of gender discrimination.

The exact timing of gender alignment decided in 1997 is exposed in Table 4. The point is the coincidence between the calendar of the 1997 reform (first step towards alignment in 1997, full alignment in 2007) and that of our panel (1998-2006). Of course, there is no certainty that the increase in the share of older women in our data is primarily due to the reform. But one cannot exclude this hypothesis. What is more, it has some methodological interest as to the econometric identification of the consequences of ageing workforces.

If we assume that at least part of the increase in the share of elderly women can be ascribed to the 1997 reform, then we could argue that we are dealing with a "natural experiment". And the latter could help assess the impact of ageing on firm-level productivity. We will argue hereafter that there a chance that our estimates for older female workers are intrinsically less biased due to selectivity than those obtained for older men. We will elaborate on this in the final section of the paper.

Table 1: Bel-first-Carrefour panel. Main variables. Descriptive statistic.

Variable	**Mean**	**Std. Dev.**
Productivity (ie.value added) per worker (th. €) (log)	4.076	0.565
Labour cost per worker (th. €) (log)	3.706	0.381
Productivity-Labour cost ratio/markup	0.372	0.404
Capital (th. €) (th. €) (log)	6.835	1.752
Number of workers (th. €) (log)	3.937	0.994
Share of 18-29 (Male)	0.287	0.163
Share of 30-49 (Male)	0.309	0.152
Share of 50-65 (Male)	0.122	0.103
Share of 18-29 (Female)	0.137	0.153
Share of 30-49 (Female)	0.115	0.117
Share of 50-65 (Female)	0.031	0.050
Use of intermediate inputs (th. €) (log)	8.939	1.575
Share of blue collar workers in total workforce	0.544	0.351
Share of Manager in total workforce	0.010	0.042
Number of hours worked annually per employee (log)	7.377	0.163
Number of spells	8.730	0.944

Source: Bel-first-Carrefour

Table 2: Bel-first-Carrefour panel. Basic descriptive statistics. Evolution of shares of workers between 1998 and 2006

Year	Mean age (year)	Share of 18-29 (%)	Share of 30-49 (%)	Share of 50-65 (%)
1998	36.15	48.58%	39.35%	12.08%
1999	36.43	46.98%	40.37%	12.67%
2000	36.64	45.84%	40.90%	13.26%
2001	37.00	44.24%	41.77%	14.00%
2002	37.37	42.61%	42.76%	14.64%
2003	37.96	40.64%	43.12%	16.24%
2004	38.33	39.17%	43.77%	17.06%
2005	38.72	37.66%	44.43%	17.91%
2006	39.10	36.33%	44.66%	19.00%

Source: Bel-first-Carrefour

Table 3. Shares of male vs female old workers (50-64). Private sector economy. Belgium. 1998-2006

	Share of old men	Share of old women	Evolution share of old men (1998=100)	Evolution share of old women (1998=100)
1998	9.92%	2.13%	100.00	100.00
1999	10.33%	2.30%	104.08	107.62
2000	10.73%	2.48%	108.13	116.25
2001	11.22%	2.72%	113.06	127.53
2002	11.69%	2.92%	117.76	136.82
2003	12.90%	3.31%	130.02	155.06
2004	13.47%	3.56%	135.75	166.73
2005	14.04%	3.83%	141.43	179.29
2006	14.72%	4.20%	148.31	196.86

Source : Bel-first, Carrefour

Table 4. Pension reform of 1997. Calendar of the alignment of legal age of retirement for women on that of men.

	1996	**1997**	2000	2003	2006	**2009**
Male	65	65	65	65	65	65
Female	60	61	62	63	64	65

Source : www.socialsecurity.be

Intermediate inputs pay a key role in our analysis, as they are central to one of the two strategies we use to overcome the simultaneity/endogeneity bias (see Section 2). The level of intermediate inputs used by a firm is calculated here as the difference between its turnover (in nominal terms) and gross value-added. It reflects the value of goods and services consumed or used up as inputs in production by that firm, including raw materials, services and various other operating expenses.

Figure 1 (left panel) displays how the (log of) average productivity and the (log of) average labour costs evolve with mean age, for the year 2006 subsample. The right panel of Figure 1 corresponds to the difference between these two curves, which is equal to the productivity-labour cost ratio.[31] These stylised facts suggests that, in the Belgian private economy, the productivity-labour cost ratio rises up to the (mean) age of 35-38 where it reaches 40%, but then declines steadily. It falls below 10% when mean age exceeds 55.

Figure 2 is probably more directly echoing the main issue which is raised in this paper. It depicts the relationship between the share or older (50-64) men or women and the productivity-labour cost ratio. It suggests that firms employing shares of older men and women in excess of the 7-8% threshold have a significantly smaller productivity-labour cost ratio. It is also shows that firms employing a given share of older women systematically achieve a lower ratio than firms employing the same share of older men.

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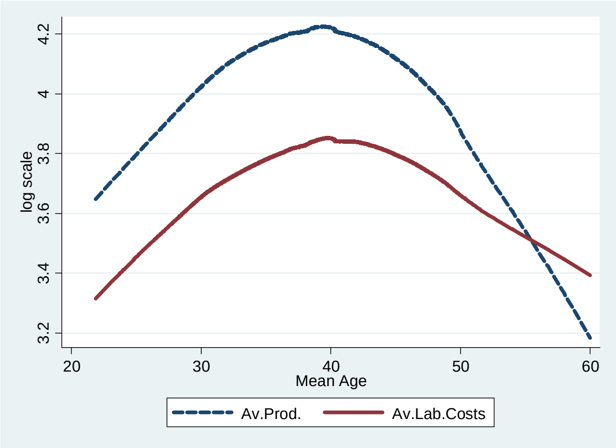
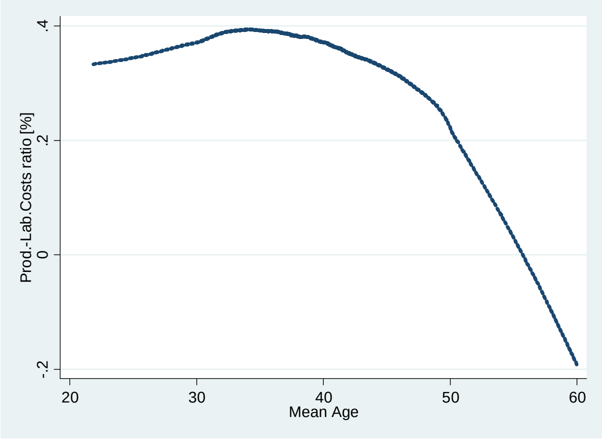
[31] Logarithms, used in conjunction with differencing, convert absolute differences (*Y-W)* into relative differences: i.e. (*Y-W)/W*.

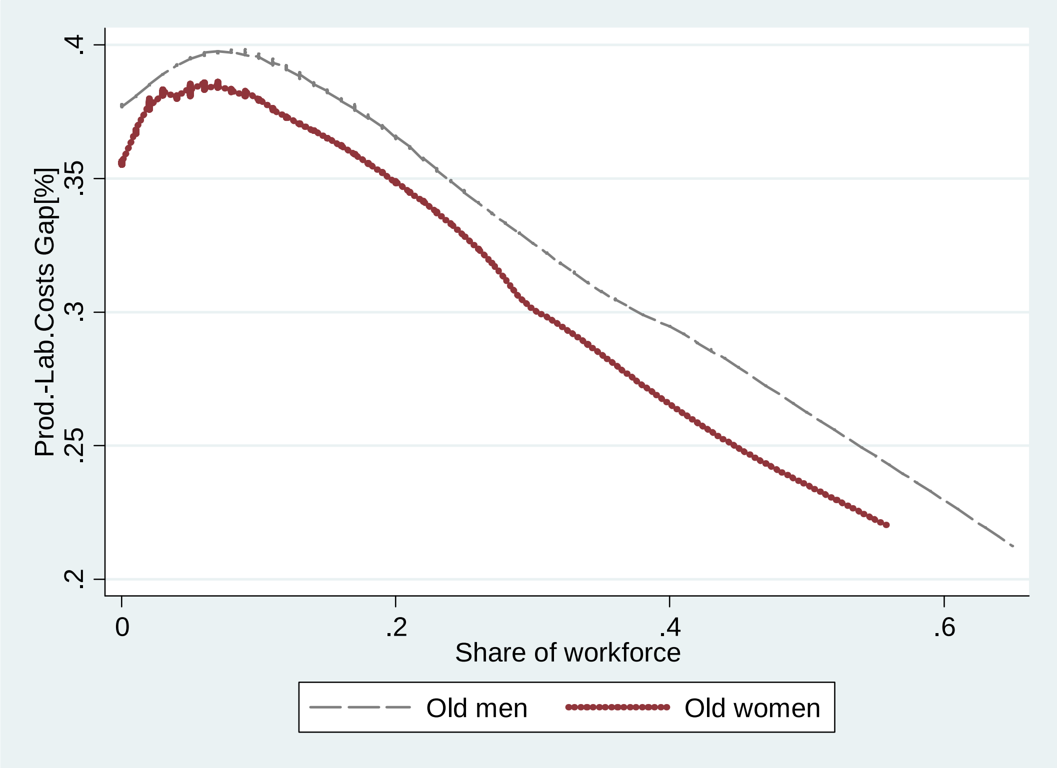
Figure 1: (Left panel) Average productivity and average labour costs. (Right panel) Productivity-Labour cost ratio (%) according to mean age. Year 2006





Curves on display correspond to locally weighted regression of *y* (i.e. log of average productivity, log of average labour cost [left panel] and labour costs ratio [right panel]) on *x* (i.e. mean age). OLS estimates of *y* are fitted for each subsets of *x*. This method does not required to specify a global function of any form to fit a model to the data, only to fit segments of the data. It is thus semi-parametric.

Figure 2: Productivity-Labour cost ratio (in %) according to share of older men or women



Curves on display correspond to locally weighted regression of *y (productivity-labour cost ratio)* on *x (shares).* It does this by fitting an OLS estimate of *y* for each subsets of *x*. This method does not required to specify a global function of any form to fit a model to the data, only to fit segments of the data. It is thus semi-parametric.

A weakness of our dataset is that it does not contain the workers' educational attainment. The point is that younger cohorts are better-educated and, for that reason, potentially more productive than older ones. As we do not control for educational attainment, how large is the risk that our estimates confound age and cohort/education, and consequently exaggerate the age-related productivity handicap?

Not so much, we think, for three reasons. First, although we do not observe education, our vector of controls F_{it} comprises good firm-level proxies for education (i.e. the share or blue-collar workers and the share of managers). Second, in this paper the identification of the effect of age on productivity is driven by younger (and presumably better-educated) cohorts entering the 50-64 age-bracket. With FD, identification comes from the confrontation of production changes recorded between *t* and *t-1* and the simultaneous change (presumably rise) of the share of older workers. But in a panel, cohort/year-of-birth and time of observation are monotonically related: individuals belonging to the 50-64 age-band in *t* are likely to belong to younger (and better-educated) cohorts than those observed in *t-1* in the same age band. In short, with FD identification of the consequence of ageing workforces is driven by better-educated individuals. Sceptics will rightly argue that with FD identification rather comes from the comparison between *i)* productivity gains achieved by firms with rising shares of old (50-64) workers *ii)* and those obtained by firms[32] with no (or less of) such rises. How do the two types of firms compare in terms of cohort (and thus educational) changes between *t* and *t-1*? The workers' average year of birth has probably risen more in the second type of firms, due to a more pronounced propensity to replace older workers by younger (better-educated) ones. This leads us to our third argument. Unobserved asymmetries across firms in terms of cohort (and education) dynamics are unlikely to bias results obtained in an HN framework. This is because, with HN, productivity is measured in *relative* terms. The estimated coefficient for the share of 50-64 workers corresponds to the relative productivity of that group vis-à-vis the reference group (i.e. prime-age workers). If, within each firm, the pace at which younger/better-educated cohorts enter the prime-age and the old age brackets does not vary significantly, firm-specific cohort biases will just cancel out.

4. Econometric results

Table 6 presents the parameter estimates of the average productivity (see equation 10, Section 2), labour costs (equation 11) and productivity-labour cost ratio equations (12), under four alternative econometric specifications. Note that, with equation (12) being the difference between equation (10) and equation (11), it is logical to verify that $\eta\text{-}\eta^{W}\approx\eta^{R}$ for each age/gender category. Standard errors on display have been computed in a way that accounts for firm-level clustering of observations. To get the results on display in Table 5 we use all available observations forming of our (unbalanced) panel.

The first set of parameter estimates comes from OLS, using total variation [1]. Then comes first differences (FD), where parameters are estimated using only within-firm variation [2]. Model [3] combines FD and the IV-GMM approach using internal lagged labour inputs as instruments (FD-IV-

[32] The same reasoning applies to different periods of observation.

GMM). The last model [4] combines FD and the ACF intermediate-goods proxy idea (FD-ACF).[33]

Estimations [3] [4] in Table 6 are a priori the best insofar as *i)* the parameters of interest are identified from within-firm variation to control for firm unobserved heterogeneity, and *ii)* that they control for short-term endogeneity biases either via the use of ACF's intermediate input proxy, or internal instruments.

OLS results suffer from unobserved heterogeneity bias. Even the inclusion of controls in F_{it}, mostly a large set of dummies[34], is probably insufficient to account for firm-level singularities that may affect simultaneously firms' productivity and age structure. First-differencing as done in [2] is still the most powerful way out of this problem. Heterogeneity bias might be present since our sample covers all sectors of the Belgian private economy and the list of controls included in our models is limited. Even if the introduction of the set of dummies (namely year, sector) in F_{it} can account for part of this heterogeneity bias, first-differencing as done in [2], [3] or [4] is still the most powerful way out. But first differences alone [2] are not sufficient. The endogeneity in labour input choices is well documented problem in the production function estimation literature (*e.g.* Griliches & Mairesse, 1995) and also deserved to be properly and simultaneously treated. And this is precisely what we have attempted to do in [3] and [4] by combining first differences with techniques like IV-GMM or ACF.

To assess the credibility of our FD-IV-GMM approach [3] we performed a range of diagnostic tests. First, an Anderson correlation relevance test. If the correlation between the instrumental variables and the endogenous variable is poor (*i.e.* if we have "weak" instruments) our parameter estimate may be biased. The null hypothesis is that the instruments are weak (correlation in nil). Rejection of the null hypothesis (low p-values) implies that the instruments pass the weak instruments test, i.e. they are highly correlated with the endogenous variables. In all our FD-IV-GMM estimates reported in Table 6 our instruments pass the Anderson correlation relevance test. Second, to further assess the validity of our instrument we use the Hansen-Sargan test. – also called Hansen's J test – of overidentifying restrictions. The null hypothesis is that the instruments are valid instruments (i.e., uncorrelated with the error term), and that the instruments are correctly "excluded" from the estimated equation. Under the null, the test statistic is distributed as chi-square in the number of

[33] As suggested in Section 2 (equ. 21, 22 a-d), identification is provided by a set of moment conditions imposing orthogonality between implied innovation terms ξ_{it} and k_{it} ; ξ_{it} and lags 1 to 3 of the labour inputs.

[34] All our models, including OLS, use data in deviations from year interacted with NACE2 industry means. See Appendix 2 for a detailed presentation of the NACE2 classification.

overidentifying restrictions. A failure to reject the null hypothesis (high p-values) implies that the instruments are exogenous. In all our FD-IV-GMM estimates we cannot reject the null hypothesis that these restrictions are valid.

In Table 6, parameter estimates (η) for the average productivity equation support the evidence that older worker (50-65) - both men and women - are less productive than prime-age (30-49) male workers (our reference category). Sizeable (and statistically significant) negative coefficients are found across the range of models estimated. Those from the FD-ACF model [4] suggest that an increase of 10%-points in the share of old male workers depresses productivity by 1.54%-points. Model [3], based on FD-IV-GMM, points at a smaller (not statistically significant) drop by only 0.37%t.

As to old women both FD-IV-GMM [3] and the FD-ACF model [4] deliver large negative estimates of the impact of larger shares of old women on productivity. An increase of 10%-points in the share of older female workers reduces productivity by 2.32% [3] to 3.81% [4].

Turning to the average labour cost coefficients (η^W), we find some evidence of lower labour cost for older men and women. Estimates for model [3] show that a 10%-points rise of the share of older male (female) workers reduces average labour cost by 0.31%-point (0.49%-point respectively). Evidence from model [4] is supportive of wage declines of 0.67% for men, and 2.96 %-points for women. The slightly lower labour costs for older women could reflect the fact that they have accumulated lower tenure in firms; something that, ceteris paribus, may reduce their cost to employ in a country where seniority plays an important role in wage formation (BNB, 2010).

However, regarding the labour demand for older men and women, the most important parameters are those of the productivity-labour cost ratio equation (η^R). Their sign informs as to whether a lower productivity is fully compensated by lower labour costs. Remember that we posit that a negative (and statistically significant) coefficient is a indication that the category of workers is less employable than the reference category. Results for old men are mixed. Model [3] delivers a coefficient that is not statistically different from O. Model [4] suggests that a 10%-points rise of their share causes a modest 0.88% reduction of the productivity-labour cost ratio.

The situation is quite different for old women. Model [3] suggests that a 10%-points expansion of their share in the total workforce causes a 1.8% reduction of the productivity-labour cost ratio. And model [4] points to a 2.11% drop of that ratio.

Table 5- Parameter estimates (*standard errors*[£]). Older (50-64) male/female and prime-age (30-49) female workers productivity (η), average labour costs(η^w) and productivity-labour cost ratio (η^R). Overall, unbalanced panel sample.

	[1]-OLS	[2]-First Differences (FD)	[3]- FD-IV-GMM	[4]- FD + intermediate inputs ACF[$]
		Share of 50-64 (Men)		
Productivity (η_{3m})	-0.218***	-0.071**	-0.037	-0.154***
std error	*(0.024)*	*(0.028)*	*(0.027)*	*(0.034)*
Labour Costs (η^w_{3m})	-0.170***	-0.017	-0.031**	-0.067***
std error	*(0.013)*	*(0.012)*	*(0.015)*	*(0.021)*
Prod.-Lab. Costs ratio (η^R_{3m})	-0.054***	-0.054**	-0.002	-0.088***
std error	*(0.020)*	*(0.027)*	*(0.037)*	*(0.024)*
		Share of 30-49 (Women)		
Productivity (η_{2f})	-0.281***	-0.031	-0.119***	-0.050
std error	*(0.021)*	*(0.032)*	*(0.045)*	*(0.055)*
Labour Costs (η^w_{2f})	-0.347***	-0.043***	-0.037**	-0.081**
std error	*(0.012)*	*(0.014)*	*(0.019)*	*(0.031)*
Prod.-Lab. Costs ratio ($\eta^R_{2}f$)	0.019	0.012	-0.076*	0.003
std error	*(0.017)*	*(0.031)*	*(0.044)*	*(0.044)*
		Share of 50-64 (Women)		
Productivity (η_{3f})	-0.638***	-0.210***	-0.232***	-0.381***
std error	*(0.038)*	*(0.053)*	*(0.070)*	*(0.080)*
Labour Costs (η^w_{3f})	-0.665***	-0.056**	-0.049*	-0.296***
std error	*(0.021)*	*(0.023)*	*(0.029)*	*(0.049)*
Prod.-Lab. Costs ratio (η^R_{3f})	-0.017	-0.153***	-0.180***	-0.211**
std error	*(0.031)*	*(0.051)*	*(0.068)*	*(0.070)*
#Obs.	77,847	67,678	50,176	38,296
Controls	All data are deviations from region+ year interacted with NACE2 industry means. See appendix for NACE2 classification of industries			
	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: **firm**	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: **firm**	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: **firm**
Orthogonality conditions/instruments used to identify endog. labour shares			Second differences and lagged second differences	Innovation in ω_{it}⫫ *lag1-3* labour shares Innovation in ωit⫫ lag1-3 labour shares
Identification tests			**IV relevance**: Anderson canon. corr. LR statistic√ **Overidentifying restriction**: Hansen J statistic √	

a: Average number of hours worked by employee on an annual basis, which is strongly correlated to the incidence of part-time work.
£:Standard errors estimates are robust to firm-level clustering
*p < 0.05, **p < 0.01, *** p < 0.001
[$] Ackerberg, Caves & Frazer

Table 6 contains a series of important results that can be derived from a further analysis of those displayed in Table 5. The first column simply reproduces the estimates for the average productivity and productivity-labour cost ratio equations, using our preferred estimation strategies [3] [4]. The following columns contain the results of three *hypothesis tests* aimed at answering key questions about age and gender. First, are old women (50-64) less productive [and less employable, due to a lower productivity-labour cost ratio] than old men? The question amounts to verifying that $\eta_{3m} > \eta_{3f}$ [$\eta^R_{3m} > \eta^R_{3f}$] in absolute value and testing H0: $\eta_{3m} = \eta_{3f}$ for productivity [H0: $\eta^R_{3m} = \eta^R_{3f}$ for employability]. Results for FD-IV-GMM model [3] point to a 1.95% productivity handicap for old women relative to old men, and an employability handicap of 1.78%. Both estimates are highly statistically significant. They mean that a 10% rise of the share of older women is causing an additional 1.95% [1.78%] reduction of labour productivity [productivity-labour cost ratio], compared with a similar increase of the share of older men.

The second question that can be addressed is whether old women's productivity[employability] handicap relative to old men is driven by more pronounced effects of age on women than on men's productivity[employability].

We can first examine, for each gender separately, how age affects productivity[employability] using the prime-age category as a reference .As already stated above, the evidence for old vis-à-vis prime-age male workers (ie. estimated η_{3m} [η^R_{3m}]) is mixed. Results for the FD-IV-GMM model [3] suggest an absence of significant deterioration of productivity[employability], whereas FD-ACF model [4] is supportive of a small deterioration. A 10%-points rise of the share of old men causes a 1.54% [0.88] decline of productivity[employability].

Assessing the situation of older women relative to prime-age women is less immediate and requires hypothesis testing (ie. rejecting H0: $\eta_{2f} = \eta_{3f}$ [H0: $\eta^R_{2f} = \eta^R_{3f}$]). Results for FD-IV-GMM model [3] points to a 1.1% productivity handicap (not statistically significant at the level of 5 percent) for old women relative to prime-age women. In terms of employability, the handicap is of 1.04% (also not statistically significant). Results with FD-ACF model [4] are larger in magnitude and statistically significant, namely a productivity handicap of 3.31%-, and an employability handicap of 2.14%.

Furthermore, we can test whether age affects more women's than men's productivity[employability] by testing H0: $\eta^R_{3f} - \eta^R_{2f} = \eta^R_{3m}$ [H0: $\eta_{3f} - \eta_{2f} = \eta_{3m}$]. Results point to a 0.7% to 1.77% productivity handicap of women vis-à-vis men in terms of age-related productivity decline, and a 1.02% to 1.26% handicap in terms of employability decline. But none of these estimates are statistically significant at the level of 5 percent.

Table 6 – Parameter estimates (*standard errors*[£]) and hypothesis testing. Older (50-64) male/female and prime-age (30-49) female workers productivity (η), average labour costs(η^{w}) and productivity-labour cost ratio (η^{R}). Overall, unbalanced panel sample.

	Coefficient	**Hyp Test** $\eta_{3f}=\eta_{3m}$ (old women vs old men)			**Hyp Test** $\eta_{3f}=\eta_{2f}$ (old women vs prime-age women)			**Hyp Test** $\eta_{3f}-\eta_{2f}=\eta_{3m}$ (within gender ageing differences)		
		$\eta_{3f}-\eta_{3m}$	**F**	**Prob >F**	$\eta_{3f}-\eta_{2f}$	**F**	**Prob >F**	$(\eta_{3f}-\eta_{2f})-\eta_{3m}$	**F**	**Prob >F**
[3] - FD- IV-GMM										
Productivity										
Men 50-64 (η_{3m})	-0.037									
	(0.027)									
Women 30-49 (η_{2f})	-0.119***	-0.195**	6.67	0.0098	-0.112	2.57	0.1089	-0.075	0.89	0.3452
	(0.045)									
Women 50-64 (η_{3f})	-0.232***									
	(0.070)									
Prod.-Lab. Costs ratio										
Men 50-64 (η^{R}_{3m})	-0.002									
	(0.037)									
Women 30-49 (η^{R}_{2f})	-0.076**	-0.178*	5.91	0.015	-0.104	2.35	0.1257	-0.102	1.72	0.1891
	(0.044)									
Women 50-64 (η^{R}_{3f})	-0.180***									
	(0.068)									
#obs	50,176									
[4]- FD + ACF intermediate inputs LP[$]										
Productivity										
Men 50-64 (η_{3m})	-0.154***									
	(0.034)									
Women 30-49 (η_{2f})	-0.050	-0.227**	6.88	0.0087	-0.331***	11.61	0.0007	-0.177	2.67	0.1022
	(0.055)									
Women 50-64 (η_{3f})	-0.381***									
	(0.080)									
Prod.-Lab. Costs ratio										
Men 50-64 (η^{G}_{3m})	-0.088***									
	(0.024)									
Women 30-49 (η^{G}_{2f})	0.003	-0.123	2.55	0.1106	-0.214*	5.52	0.019	-0.126	1.60	0.2056
	(0.044)									
Women 50-64 (η^{G}_{3f})	-0.211**									
	(0.070)									
#obs	38,296									

Controls: capital, number of employees, hours worked per employee, share of blue-collar workers, share of managers + firm fixed effects. **FD-IV-GMM**: Instruments=second differences and lagged second differences. Tests: IV relevance: Anderson canon. corr. LR statistic √ Overidentifying restriction: Hansen J statistic √. **FD-ACF**: Innovation in $\omega_{it} \perp\!\!\!\perp$ *lag1-3* labour share, innovation in $\omega_{it} \perp\!\!\!\perp$ *lag1-3* labour shares. **£**:Standard errors estimates are robust to firm-level clustering; ***p < 0.1, **p < 0.05, *** p < 0.01**
$$: Ackerberg, Caves & Frazer.

We have undertaken two further steps in our analysis:

i) First, we test whether we reach similar conclusions, with regards to those coming from the unbalanced panel used so far, when we restrict the analysis to the (smaller) *balanced* panel[35] sample. The rationale for doing is at least twofold. First, data quality is likely to be lower with the unbalanced panel. Poor respondents are likely to be overrepresented among short-lived firms forming the unbalanced part of the panel. Second, and more importantly, entering and exiting firms probably have a-typical productivity-age profiles. Entering firms (that tend also to be those exiting the sample due to a high mortality rate among entrants) are usually less productive and employ a younger workforce than incumbents. More to the point, the short-term dynamic of their productivity performance (which matters a lot in an analysis that rests heavily on first-difference estimates) is much less predictable and inadequately captured by the identification strategies mobilised in this paper. Bartelmans & Doms (2000) reviewing the US evidence, explain that a few years after entry a disproportionate number of entrants have moved both to the highest and the lowest percentiles of the productivity distribution.

ii) Second, we examine whether we reach substantially different conclusions, as to the productivity-labour cost ratio gender asymmetry, when we further restrict the sample to the *services industry*. We do this because observers *a priori* posit that age and gender should matter less for productivity in a services-based economy than in one where agriculture or industry dominates.

35 The sample of firms that are observed observed *every* year between 1998 and 2006.

4.1. Balanced vs. unbalanced panel

Our main analysis so far has been based on unbalanced panel data that comprise all firms available in our sample. By way of sensitivity analysis we now present the parameter estimates (for models [3][4] and only for the productivity and productivity-labour cost ratio equations[36]) based on balanced panel data, consisting only of firms surveyed in each of the 9 years between 1998 and 2006. This subset comprises 7,933 firms (vs. approx. 9,000 in the unbalanced sample). On average (see Appendix 1 for the details) they are quite similar to those of the unbalanced set, be it in terms of average value-added, labour cost or size...

If anything, the old worker gender asymmetry highlighted with the unbalanced panel now appears stronger. Parameter estimates are exposed on the right-hand side of Table 7, alongside those of Table 6 for comparison purposes. For old men, productivity-labour cost parameter estimates (η^R) delivered by model [3] are consistently not statistically different from zero, whereas FD-ACF [4] suggests a small negative impact of -0.6% (vs -0.88% with the unbalanced panel. By contrast, for older women, both models deliver coefficients that are larger in magnitude than with the unbalanced panel. FD-IV-GMM [3] shows that a 10%-points expansion of their share in the firm's workforce causes a 2.19% reduction (vs. 1.8% with the unbalanced panel), while FD-ACF model [4] points at 3 % fall (vs. 2.11% with the unbalanced panel).

Table 7 also contains the results of three cross-gender tests of equality. In short, these tend to reinforce the conclusions obtained with the unbalanced panel. First, old women (50-64) appear significantly less productive and less employable than old men. Results for FD-IV-GMM [3] point to a 2.44% productivity handicap (vs. 1.95% with the unbalanced panel) of old women relative to old men. In terms of employability the old women's handicap is of 2.4%- (vs. 1.78% in Table 6). And both estimates are statistically significant at the level of 5 percent. Similar rises of the productivity handicap are observed when using FD-ACF[4].

The other results on display in Table 7, using prime-age women as a reference, confirm that age negatively affects the productivity [employability] of women. Results for FD-IV-GMM [3] point to a, now statistically significant, 1.71% (vs. 1.11 %-points with unbal. data) productivity handicap.. In terms of employability, the handicap rises from 1.04% (unbal.) to 1.64% with the balanced panel, and also becomes statistically significant.. Similar results are obtained with FD-ACF model [4],

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36 Those from the labour cost equation (η^W) can be easily inferred from the relationship $\eta + \eta^W \approx \eta^R$

namely a (highly statistically significance) productivity handicap rising from 3.31% (unbal.) to 4.58%. And an employability handicap going from 2.14% (unbal.) to 3.83%. There is also stronger evidence, based of the "within gender" comparison of coefficients, that age affects more women's than men's productivity[employability]. Results, in the last column of Table 7 show female productivity[employability] handicaps that are systematically above 1.5%. And most of them are now statistically significant at the level of 5 percent.

Table 7 – Parameter estimates (*standard errors*£) and hypothesis testing. Older (50-64) male/female and prime-age (30-49) female workers productivity (η), average labour costs(η^{w}) and productivity-labour cost ratio (η^{R}). Balanced panel sample.

	Coefficient	Coef. (bal.)	Hyp Test $\eta_{3f}=\eta_{3m}$ (old women vs old			Hyp Test $\eta_{3f}=\eta_{2f}$ (old women vs prime-age			Hyp Test $\eta_{3f}-\eta_{2f}=\eta_{3m}$ (within gender ageing		
			$\eta_{3f}-\eta_{3m}$	**F**	**Prob >F**	$\eta_{3f}-\eta_{2f}$	**F**	**Prob >F**	$(\eta_{3f}-\eta_{2f})-\eta_{3m}$	**F**	**Prob >F**
[3] FD- IV-GMM											
Productivity											
Men 50-64 (η_{3m})	-0.037	-0.025									
	(0.027)	*(0.038)*									
Women 30-49 (η_{2f})	-0.119***	-0.098**	-0.244**	9.96	0.0016	-0.171*	5.72	0.0168	-0.146	3.21	0.0734
	(0.045)	*(0.046)*									
Women 50-64 (η_{3f})	-0.232***	-0.269***									
	(0.070)	*(0.072)*									
Prod.-Lab. Costs ratio											
Men 50-64 (η^{R}_{3m})	-0.002	0.022									
	(0.037)	*(0.037)*									
Women 30-49 (η^{R}_{2f})	-0.076**	-0.055	-0.241**	10.26	0.0014	-0.164*	5.58	0.0182	-0.186*	5.52	0.0189
	(0.044)	*(0.045)*									
Women 50-64 (η^{R}_{3f})	-0.180***	-0.219***									
	(0.068)	*(0.070)*									
#obs	50,176	46,882									
[4]- FD + ACF intermediate inputs LP$											
Productivity											
Men 50-64 (η_{3m})	-0.154***	-0.110**									
	(0.034)	*(0.042)*									
Women 30-49 (η_{2f})	-0.050	0.049	-0.299**	8.29	0.004	-0.458***	12.93	0.0003	-0.348*	5.49	0.0191
	(0.055)	*(0.071)*									
Women 50-64 (η_{3f})	-0.381***	-0.409***									
	(0.080)	*(0.092)*									
Prod.-Lab. Costs ratio											
Men 50-64 (η^{R}_{3m})	-0.088***	-0.060*									
	(0.024)	*(0.029)*									
Women 30-49 (η^{R}_{2f})	0.003	0.083	-0.240**	7.10	0.0077	-0.383***	12.78	0.0004	-0.323**	7.03	0.0080
	(0.044)	*(0.055)*									
Women 50-64 (η^{R}_{3f})	-0.211**	-0.300***									
	(0.070)	*(0.078)*									
#obs	38,296	35,776									

Controls: capital, number of employees, hours worked per employee, share of blue-collar workers, share of managers + firm fixed effects. **FD-IV-GMM**: Instruments=second differences and lagged second differences. Tests: IV relevance: Anderson canon. corr. LR statistic √ Overidentifying restriction: Hansen J statistic √. **FD-ACF**: Innovation in $\omega_{it}\perp$ *lag1-3* labour share, innovation in $\omega_{it}\perp$ *lag1-3* labour shares. **£**:Standard errors estimates are robust to firm-level clustering; ***p < 0.1, **p < 0.05, *** p < 0.01**
$$: Ackerberg, Caves & Frazer.

4.2. Balanced panel restricted to the services industry

Secondly, we have re-estimated the average productivity and productivity-labour cost ratio equations (using the balanced panel data), but now isolating the services industry.[37] Remember that we do so because many observers posit that age and gender differences probably matter less for productivity in a service-based economy than in one where industry dominates. Another good reason for focusing on services is that women are overrepresented in that industry, in comparison with construction or manufacturing.

Parameter estimates from models [3] [4] are reported on the right-hand side of Table 8, alongside those presented in Table 6 and Table 7; again to facilitate comparison. The key result is that the important gender asymmetry emerging from the analysis of the panel pooling all sectors is reinforced when using services-only data. For older women, both model [3] and model [4] deliver productivity (η) and employability coefficients (η^R) that are of larger magnitude than those displayed in Tables 6 or 7 (all sectors pooled). FD-IV-GMM [3] shows that a 10%-points expansion of their share in the firm's workforce causes a 3.57% reduction of labour productivity (vs. 2.69% with the bal. & all sectors polled data), whereas FD-ACF model [4] points at a 6.43% reduction (vs. 4.09% with the bal. & all sectors polled data).

Table 8 also contains the results of the three important cross-gender tests of equality. And once again, the previous conclusions get reinforced. First, old women (50-64) appear less productive and less employable than old men. Results for FD-IV-GMM [3] point to a 3.05% productivity handicap (vs. 2.44% with the bal. & all sectors polled data of Table 7) for old women, with respect to their male counterpart. As to employability, the old women's handicap reaches 3.71% (vs. 2.41% in Table 7). The other results displayed in Table 8 also strengthen the idea that age is particularly harmful to women's productivity[employability]. Results for FD-IV-GMM [3] point to a 2.28% (vs. 1.71% when with the bal. & all sectors polled data) statistically-significant productivity handicap for old women relative to prime-age ones. In terms of employability, the handicap rises from 1.64% to 2.45%. Similar results are obtained with ACF model [4]. There is also evidence - though more limited due to less accurate estimates - that age is more of an issue for women's than men's productivity[employability] in the services industry than in the overall private economy.

[37] A detailed in terms of NACE 2 categories is to be found in Appendix 2. Manufacturing and construction are excluded. We also exclude observations from the financial/insurance industry, real estate, utilities and a few other activities that can be associated with the non-profit sector. We do this because the productivity and capital of firms in these service industries are, arguably, hard to measure.

The tentative conclusion is that the (now dominant and highly feminized) services industry does not seem to offers working conditions to older women, mitigating their productivity or employability disadvantage vis-à-vis other categories of workers.

Table 8 - Parameter estimates (*standard errors*£) and hypothesis testing. Older (50-64) male/female and prime-age (30-49) female workers productivity (η), average labour costs(η^{w}) and productivity-labour cost ratio (η^{R}). Balanced panel sample, services industry.

	Coefficient	Coef. (bal.)	Coefficient (bal. SERVICES)	Hyp Test $\eta_{3f}=\eta_{3m}$			Hyp Test $\eta_{3f}=\eta_{2f}$			Hyp Test $\eta_{3f}-\eta_{2f}=\eta_{3m}$		
				$\eta_{3f}-\eta_{3m}$	F	Prob >F	$\eta_{3f}-\eta_{2f}$	F	Prob >F	$(\eta_{3f}-\eta_{2f})-\eta_{3m}$	F	Prob >F
[3] FD- IV-GMM												
Productivity												
Men 50-64 (η_{3m})	-0.037	-0.025	-0.052									
	(0.027)	*(0.038)*	*(0.054)*									
Women 30-49 (η_{2f})	-0.119***	-0.098**	-0.129**	-0.305**	9.13	0.0025	-0.228*	5.93	0.0148	-0.175	2.61	0.1059
	(0.045)	*(0.046)*	*(0.060)*									
Women 50-64 (η_{3f})	-0.232***	-0.269***	-0.357***									
	(0.070)	*(0.072)*	*(0.092)*									
Prod.-Lab. Costs ratio												
Men 50-64 (η^{R}_{3m})	-0.002	0.022	0.037									
	(0.037)	*(0.037)*	*(0.052)*									
Women 30-49 (η^{R}_{2f})	-0.076**	-0.055	-0.089	-0.371***	14.56	0.0001	-0.245**	7.39	0.0066	-0.282**	7.25	0.0071
	(0.044)	*(0.045)*	*(0.058)*									
Women 50-64 (η^{R}_{3f})	-0.180***	-0.219***	-0.334***									
	(0.068)	*(0.070)*	*(0.089)*									
#obs	50,176	46,882	23,574									
[4]- FD + ACF intermediate inputs LP$												
Productivity												
Men 50-64 (η_{3m})	-0.154***	-0.110**	-0.224**									
	(0.034)	*(0.042)*	*(0.082)*									
Women 30-49 (η_{2f})	-0.050	0.049	-0.173	-0.418*	4.65	0.031	-0.470*	4.21	0.0403	-0.246	0.84	0.3597
	(0.055)	*(0.071)*	*(0.120)*									
Women 50-64 (η_{3f})	-0.381***	-0.409***	-0.643***									
	(0.080)	*(0.092)*	*(0.169)*									
Prod.-Lab. Costs ratio												
Men 50-64 (η^{R}_{3m})	-0.088***	-0.060*	0.011									
	(0.024)	*(0.029)*	*(0.073)*									
Women 30-49 (η^{R}_{2f})	0.003	0.083	-0.237*	-0.387*	4.02	0.0451	-0.139	0.27	0.603	-0.150	0.27	0.6007
	(0.044)	*(0.055)*	*(0.116)*									
Women 50-64 (η^{R}_{3f})	-0.211**	-0.300***	-0.377**									
	(0.070)	*(0.078)*	*(0.171)*									
#obs	38,296	35,776	18,265									

Controls: capital, number of employees, hours worked per employee, share of blue-collar workers, share of managers + firm fixed effects. **FD-IV-GMM**: Instruments=second differences and lagged second differences. Tests: IV relevance: Anderson canon. corr. LR statistic √ Overidentifying restriction: Hansen J statistic √. **FD-ACF**: Innovation in $\omega_{it}\perp\!\!\!\perp$ *lag1-3* labour share, innovation in $\omega_{it}\perp\!\!\!\perp$ *lag1-3* labour shares.
£:Standard errors estimates are robust to firm-level clustering; ***p < 0.1, **p < 0.05, *** p < 0.01**
$$: Ackerberg, Caves & Frazer.

5. Final comments

As a socio-economic phenomenon, population ageing in Europe will affect more than its welfare systems, as it will also affect the age structure of the *workforce*. In particular, the share of older workers (aged 50+) will rise significantly due to demographics. And this trend will be reinforced by policies aimed at maintaining more of those older individuals in employment. Another point we highlight in this paper is that a greying European workforce should also become more female. There is indeed robust evidence that older women are still under-represented in employment in comparison with older men. But this should change due to the combined effect of two elements. First, participation rates in the 50-60 age range will partially align with those currently observed in some Nordic countries (Sweden, Iceland), because successive cohorts of women with an increasing history of youth and prime-age participation are reaching older ages. Second, labour policy will try to close the gender participation gap that persists beyond 50, independently of the above-mentioned trend.

Optimists may believe that an ageing and feminized workforce will have only a minimal impact on firms' performance and on labour markets. This paper contains evidence, based on the analysis of private-economy firm-level panel data, suggesting the opposite. We show that the age/gender structure of firms located in Belgium is a key determinant of their productivity-labour cost ratio. Employing a larger share of female workers aged 50-64 could translate *ceteris paribus* a lower markup between productivity (ie value added) and labour cost.

Our results show that, using prime-age men as a reference, an increase of 10%-points in the share of older female workers (50-64) depresses firms' productivity-labour cost ratio by 1.8 to 2.1%, depending on the estimation method and the sample chosen. The equivalent results for old men a moderate reduction in the productivity-labour cost ratio ranging from 0 to 0.88%. A closer look at the results reveals three important things.

First, the handicap of old female workers vis-à-vis old male workers is driven by a lower productivity that is not compensated for by lower average labour costs.

Second, older women are collectively less productive and employable than prime-age women.

Third, some of our results – obtained when focussing on balanced panel data and the service industry data - also support the idea that age affects women's productivity[employability] more than men's. In short, older women's employability handicap vis-à-vis older men stems from a productivity handicap caused by a more pronounced effect of age, which is not compensated by lower labour costs.

There is no doubt that welfare institutions played a role in lowering the country' supply of old labour, and have contributed to its low employment rate, singularly amongst women. According to Eurostat, in the first quarter of 2010, only 36% of individuals aged 55-64 were employed; which is 11.1%-points lower than the European average (EU 15). What is more, old women's employment rate (barely 30%) lags behind that of men (44%). In Belgium, qualifying for early retirement benefits is indeed relatively easy by international standards. While the age of 58 is *a priori* the minimum access age, a lower age of 55, 56 or 57 is possible in some sectors (steel, glass, textile, etc.). Even more pronounced reductions in the minimum age are possible when the company is recognized as being in financial trouble, under which circumstance the age can be brought down to 52 years, or even 50.

These social welfare determinants of the supply of old labour have traditionally been emphasized by economists to explain the country's particularly low employment rate among individuals aged 50 and over. Our main point is that this paper contains evidence that the latter could also be demand-driven. Firms based in Belgium face financial disincentives to employing older workers - particularly older women.

We would like to also briefly mention some elements that should be held in mind when interpreting our results. First, only "average firm profiles" are calculated, which may imply that we overlook the capacity of some firms to neutralize the effect of age and gender on productivity, by implementing *ad hoc* measures that compensate for the age/gender-related loss of performance.

Second. This paper is focused on the ratio between labour productivity and labour costs which is, without doubt, an important metric for employers. However, many observers would rightly argue that ultimately employers will care about financial survival and profits. Can it be the case that firms can employ older workers, singularly older women, and still make a profit or simply survive? First of all, remember that what is at stake here is not the financial survival of firms. All that we show in that paper is that firms employing older women (and to a lesser extent older men) have to live with a lower (but still positive) markup between *i)* what they manage to produce per worker and *ii)* how much they spend to remunerate them. Beyond, how does this ultimately translate in terms of profits (i.e. return on capital)? The answer depends on the amount of capital in use per capita in firms with larger shares of older female workers. If it is the same as in other firms employing a younger or more masculine workforce, then returns will be lower, and this will further entice firms to reduce their demand of older female workers. Alternatively, these firms could operate with a lower capital base, in order to maintain returns. That could somehow preserve labour demand, but implies than an older and more feminized workforce will lead to the expansion of activities than are intrinsically less capital-intensive. This raises important issues (e.g. the degree of complementarity between young/old labour and capital) that go beyond the scope of this paper, but certainly call for more research by economists with an interest in ageing.

Third. The worker sample that used in this paper might not be representative of the entire population of older individuals aged 50-64. This means that there is a risk of a *selection bias*, in particular due to early ejection from the workforce of less productive/motivated older (male or female) workers. To the extent that this selection bias is an issue, we could view our estimated coefficients for older workers' productivity as lower boundaries (in absolute value). In other words, we potentially *underestimate* the productivity (and possibly also the employability) handicap of older workers.

To conclude, we would like to elaborate on some of the reasons that could explain the old female (relative) handicap highlighted in this paper, particularly the factors driving their apparent productivity handicap.

Selectivity bias could be less pronounced for older women. Our data show that in Belgium, between 1996 and 2006, there has been a more pronounced rise of employment among older women than older men. If only a fraction of that extra rise can be ascribed to the 1997 reform, then part of their productivity handicap, as identified it in this paper, could be the consequence of a exogeneous "natural experiment". Consequently, the tendency of our coefficients to *underestimate* the productivity handicap of older individuals could be less pronounced for older women than older men. Simply said, our estimates of the firm-level performance of older female workers could better reflect the actual productivity performance of older individuals than the estimates we get from the observation of older male workers.

Gender health gap could also be an issue (van Oyen *et al.*, 2010; Case & Paxson, 2004). Women in Belgium – as in the US and many other advanced economies - have worse self-rated health, visit

GPs more often, and have more hospitalization episodes than men, from early adolescence to late middle age[38]. This said, the existing evidence suggests that this health gender gap tends to shrink when individuals turn 50 and more.

Lastly, in Belgium, like throughout much of the OECD, more and more people aged 50-64 need to provide informal care to their old parents aged 70+[39] while, perhaps, they are still intensively supporting their children who, for example, need baby-sit help. The point is that informal carers are predominantly female aged 50-64 (OECD, 2011). Caring responsibilities may cause burnout and stress, and lead to a lower attachment to the labour force, that is not properly captured by our data. All this could ultimately translate in to lower firm-level productivity.

38 But they are less likely to die at each age.

39 Which is, incidentally, another clear manifestation of ageing.

Appendix

Appendix 1: Bel-first-Carrefour panel. Main variables. Descriptive statistics.

Variable	Mean	Std. Dev.
Productivity (ie.value added) per worker (th. €) (log)	4.078	0.546
Labour cost per worker (th. €) (log)	3.698	0.366
Productivity-Labour cost markup (ratio)	0.381	0.392
Capital (th. €) (th. €) (log)	6.875	1.707
Number of workers (th. €) (log)	3.948	0.982
Share of 18-29 (Male)	0.286	0.160
Share of 30-49 (Male)	0.311	0.150
Share of 50-65 (Male)	0.124	0.102
Share of 18-29 (Female)	0.133	0.150
Share of 30-49 (Female)	0.114	0.116
Share of 50-65 (Female)	0.031	0.049
Use of intermediate inputs (th. €) (log)	8.974	1.542
Share of blue collar workers in total workforce	0.555	0.345
Share of Manager in total workforce	0.010	0.042
Number of hours worked annually per employee (log)	7.378	0.154
Number of spells	9.000	0.000

Source: Bel-first-Carrefour

Appendix 2 : Sectors/Industries and NACE2 codes/definitions

NACE2 code		Industry
10 to 12	Manufacturing	Manufacture of food products, beverages and tobacco products
13 to 15	Manufacturing	Manufacture of textiles, apparel, leather and related products
16 to 18	Manufacturing	Manufacture of wood and paper products, and printing
19	Manufacturing	Manufacture of coke, and refined petroleum products
20	Manufacturing	Manufacture of chemicals and chemical products
21	Manufacturing	Manufacture of pharmaceuticals, medicinal chemical and botanical pro
22 + 23	Manufacturing	Manufacture of rubber and plastics products, and other non-metallic
24 + 25	Manufacturing	Manufacture of basic metals and fabricated metal products
26	Manufacturing	Manufacture of computer, electronic and optical products
27	Manufacturing	Manufacture of electrical equipment
28	Manufacturing	Manufacture of machinery and equipment n.e.c.
29 + 30	Manufacturing	Manufacture of transport equipment
31 to 33	Manufacturing	Other manufacturing, and repair and installation of machinery and e
35	Utilities	Electricity, gas, steam and air-conditioning supply
36 to 39	Utilities	Water supply, sewerage, waste management and remediation
41 to 43	Construction	Construction
45 to 47	Services	Wholesale and retail trade, repair of motor vehicles and motorcycles
49 to 53	Services	Transportation and storage
55 + 56	Services	Accommodation and food service activities
58 to 60	Services	Publishing, audiovisual and broadcasting activities
61	Services	Telecommunications
62 +63	Services	IT and other information services
64 to 66	Finance/insurance	Financial and insurance activities
68	Services	Real estate activities
69 to 71	Services	Legal, accounting, management, architecture, engineering, technical
72	Services	Scientific research and development
73 to 75	Services	Other professional, scientific and technical activities
77 to 82	Services	Administrative and support service activities
90 to 93	Services	Arts, entertainment and recreation
94 to 96	Services	Other services
97 to 98	Non-profit	Activities of households as employers; undifferentiated goods
99	Non-profit	Activities of extra-territorial organisations and bodies

References

Acherberg, D.A, Caves, K. and Frazer, G. (2006), 'Structural Identification of Production Functions', Department of Economics, Working Paper, UCLA.

Arellano, M. and S. Bond (1991), 'Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations', *Review of Economic Studies*, 58, pp. 277-297.

Aubert, P. and B. Crépon (2003). 'La productivité des salariés âgés : une tentative d'estimation', *Economie et Statistique*, 368, pp. 95-119.

Aubert, P. and B. Crépon (2007), Are older workers less productive. Firm-level evidence on age-productivity and age-wage profiles, *mimeo*, (French version published in *Economie et Statistique*).

Bartelmans, E. J. and M. Doms (2000), 'Understanding productivity: lessons from longitudinal microdata', *Journal of Economic Literature*, Vol. 38(3), pp. 569-594.

Blöndal, S. & S. Scarpetta (1999), 'The Retirement Decision in OECD Countries', *OECD Economics Department Working Papers*, No 202, OECD, Economics Department, Paris.

Blundell, R. and Bond, S. (2000), 'GMM Estimation with Persistent Panel Data: An Application to Production Functions', *Econometric Reviews*, 19(3), pp. 321-340.

Cardoso, A., P. Guimarães and J. Varejão (2011), Are Older Workers Worthy of Their Pay? An Empirical Investigation of Age-Productivity and Age-Wage Nexuses, *De Economist*, 159(2): 95-111.

Case, A.C. and Ch. Paxson (2004), Sex Differences in Morbidity and Mortality, *NBER Working Papers*, No 10653, National Bureau of Economic Research, Ma.

Cataldi, A., S. Kampelmann and F. Rycx (2011), Productivity-Wage Gaps Among Age Groups: Does the ICT Environment Matter?, *De Economist*, 159(2):193-221

Crépon, B., N. Deniau, et S. Pérez-Duarte (2002), 'Wages, Productivity, and Worker Characteristics: A French Perspective', *Série des Documents de Travail du CREST*, Institut National de la Statistique et des Etudes Economiques.

Dorn, D. and A. Sousa-Poza, (2010), 'Voluntary and involuntary early retirement: an international analysis', *Applied Economics*, 42(4), pp. 427-438

Dostie, B. (2011), Wages, Productivity and Aging, *De Economist*, 159(2), pp. 139-158.

Fitzenberger, B. & R. Schnabel and G. Wunderlich, (2004), 'The gender gap in labour market participation and employment: A cohort analysis for West Germany', *Journal of Population Economics*, 17(1), pp. 83-116.

Göbel, Ch. and Th. Zwick (2009), Age and productivity: evidence from linked employer-employee data, *ZEW Discussion Papers*, No 09-020, ZEW, Mannheim.

Griliches, Z. and J. Mairesse (1995), Production functions: the search for identification, *NBER working paper*, No 5067, NBER, Ma.

Grund, Ch. and N. Westergård-Nielsen (2008), 'Age structure of the workforce and firm performance', *International Journal of Manpower*, 29(5), pp. 410-422.

Hellerstein, J.K. and D. Neumark (1995), Are Earning Profiles Steeper than Productivity Profiles: Evidence from Israeli Firm-Level Data, *The Journal of Human Resources*, 30(1), pp. 89-112.

Hellerstein, J.K., D. Neumar, and K. Troske (1999), 'Wages. Productivity. and Worker Characteristics: Evidence from Plant-Level Production Functions and Wage Equations', *Journal of Labour Economics*, 17(3), pp. 409-446.

Hellerstein, J. and D. Neumark (2007), Production Function and Wage Equation Estimation with Heterogeneous Labor: Evidence from a New Matched Employer-Employee Data Set, in *Hard-to-Measure Goods and Services: Essays in Honor of Zvi Griliches*, Ernst R. Berndt and Charles R. Hulten **(**editors).

Jousten, A., M. Lefèbvre, S. Perelman and P. Pestieau (2008), The Effects of Early Retirement on Youth Unemployment: The Case of Belgium, *IMF Working Paper*, 08/30, IMF, Washington.

Kalwij, A. and F. Vermeulen (2008), 'Health and labour force participation of older people in Europe: what do objective health indicators add to the analysis?', *Health Economics*, 17(5), pp. 619-638.

Lallemand, T. & F. Rycx (2009), 'Are Young and Old Workers Harmful for Firm Productivity?', *De Economist*, 157, pp. 273-292.

Levinsohn, J. and A. Petrin (2003), 'Estimating production functions using inputs to control for unobservables', *Review of Economic Studies*, 70(2), pp. 317-341.

Malmberg, B., T. Lindh. T and M. Halvarsson (2008), Productivity Consequences of Workforce Ageing: Stagnation or Horndal Effect?, in: Prskawetz, A., D. Bloom, W. Lutz (eds.): *Population Aging, Human Capital Accumulation and Productivity Growth*, Population and Development Review, Supplement to Vol. 34, pp. 238-256.

Mitchell, O.S. and G. S. Fields (1984), The Economics of Retirement Behavior, *Journal of Labour Economics*, 2(1), pp. 84-105.

OECD (2011), *Help Wanted? Providing and Paying for Long-Term Care*, OECD, Paris

Olley, G.S, and A. Pakes (1996), 'The Dynamics of Productivity in the Telecommunications Equipment Industry', *Econometrica*, 64(6), pp. 1263-1297.

Peracchi, F. and F. Welch (1994), 'Trends in Labour Force Transitions of Older Men and Women', *Journal of Labour Economics*, 12(2), pp. 210-242.

Pozzebon, S & Mitchell, O.S, (1989), 'Married Women's Retirement Behavior', *Journal of Population Economics*, 2(1), pp. 39-53.

Saint-Paul, G. (2009), Does Welfare State Make Older Workers Unemployable, *CEPR Discussion Paper*, No. 7490, London.

Skirbekk, V. (2004), Age and individual productivity: a literature survey, in: Feichtinger, G. (eds): *Vienna yearbook of population research 2004*. Vienna: Austrian Academy of Sciences Press, pp. 133-153.

Skirbekk, V. (2008), 'Age and productivity capacity: Descriptions, causes and policy options', *Ageing Horizons*, 8, pp. 4-12.

Syverson, C. (2011), What Determines Productivity?, *Journal of Economic Literature*, 49(2), pp 326–365.

van Ours, J.C. and L, Stoeldraijer (2011), 'Age, Wage and Productivity in Dutch Manufacturing', *De Economist*, 159(2), pp. 113-137.

van Oyen, H., P. Deboosere, V. Lorant and R. Charafeddine (2010), *Les inégalités socials de santé en Belgique*, BELSPO, Bruxelles.

Vandenberghe, V. (2011a), Boosting the employment rate of older men and women. An empirical assessment using Belgian firm-level data on productivity and labour costs, *De Economist*, 159(2), pp. 159-191.

Vandenberghe, V. (2011b), Firm-level Evidence on Gender Wage Discrimination in the Belgian Private Economy, *Labour: Review of Labour Economics and Industrial Relations,* forthcoming

Weaver, D. (1994), The Work and Retirement Decision of Older Women: A Literature Review, *Social Security Bulletin*, 57(1), pp. 1-24.

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