Industrial restructuring and the challenge of an ageing workforce

An empirical assessment using Belgian firm-level data on productivity and labour costs*

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Abstract

Over the past 3 decades, industrial restructuring (IR) has become a structural feature of the economic landscape in Europe and elsewhere, with a quasi-permanent re-orientation of activities towards more value adding activities, and a relentless quest for productivity gains. Many economists argue that the recent financial crisis will act as a strong catalyst of IR over the coming years. The purpose of this paper is to draw the attention of decision makers on the fact that this will take place in a context synonymous with ageing workforces. So far, this phenomenon has received little attention. Many studies have looked at the consequences of *ageing population,* in terms of higher dependency rates and rising social security costs. Another strain of the literature has examined the retirement behaviour of older individuals and its determinants (e.g the role pre-retirement benefits). But that literature primarily covers the supply side of the old-age labour market. The consequences of an *ageing workforce* from the point of view of firms, forming the demand side of the labour market, has been overlooked, singularly in Belgium. In our work we ask whether employers in Belgium are *a priori* willing to employ (more) older workers. We posit that their willingness is driven by the ratio of older workers' productivity to their cost to employers (ie. the relative labour cost per unit of output). Our main results indicate a negative impact of larger shares of older men on the productivity-labour cost ratio. An increment of 10%-points of their share causes a 0.17 to 0.69% contraction of that ratio. The equivalent handicap with older women is even larger, ranging from 1.3 to 2.0%. *Ceteris paribus*, ageing workforces could thus hinder IR.

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* This paper draws heavily on Vandenberghe, V. (2011a).
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Introduction

In most EU countries, demographics (ageing populations[1]) and public policy[2] (reforms aimed at raising the employment rate of older individuals) will combine to increase the share of older workers in the labour force. Across the EU, there is also the fact that older women are clearly less present in employment than older men.[3] But this should change.

The first focal point of our work on ageing (Vandenberghe, 2011a; 2011b, 2011d; Vandenberghe & Waltenberg, 2010, 2011) is 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)[4] 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.

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, 1983) 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[5] and high replacement rates (Blondäl & Scarpetta, 1999; Lefèbvre, 2008; Jousten *et al.*, 2008) have played a significant role in the drop in the employment rate among older individuals since the mid 1970s. 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. Several authors have examined the relationship between age and productivity at the level where this matters most: firms. They estimate production functions expanded by the specification of a labour-quality index à la Hellerstein & Neumark (1999) (HN henceforth).[6] 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. Similarly, the analysis of German data by Göbel & Zwick (2009) produces little evidence of an age-related productivity decline. 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. Finally, Lallemand & Ryck (2009), using Belgian firm-level survey data,[7] show that older workers (>49) are

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1 For instance Göbel and Zwick (2009) show that between 1987 and 2007 the average age of the workforce in the EU25 has risen from 36.2 to 38.9. 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 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.

5 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.

6 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 productivity.

7 The *Structure of Earnings Survey* and the *Structure of Business Survey* conducted by Statistics Belgium.

significantly less productive than prime-aged workers, particularly in ICT firms.

But, to adequately assess the effect of age on labour demand, one needs to focus simultaneously on firm-level productivity and pay (or labour costs). Under proper assumptions (see Section 2), this amounts to analysing the sensitivity of the productivity-labour cost ratio 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). These authors estimated productivity and wages equations (using American firm-level data that included information on the age structure of the workforce) and found that both wages and productivity tend to increase with age. Aubert & Crépont (2004, 2007), in turn, observed 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 ratio is observed with rising shares of workers aged over 55. The majority of papers based on firm-level 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 (Myck, 2010), with a negative impact on the productivity-labour cost ratio after 55 (Skirbekk, 2004, 2008). However, van Ours & Stoeldraijer (2011), in their recent analysis of Dutch manufacturing firm-level data, find little evidence of much age-related negative impact on the productivity-labour cost ratio.

The second point we raise in our work is that a greying workforce will also become more female (Vandenberghe, 2011a). Two elements combine in support of this prediction. The first one is the lagged effect[8] of the rising overall female participation in the labour force (Peracchi & Welch, 1994).[9] 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[10] (Fitzenberger *et al.*, 2004). 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. Our work, summarized her below, 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. Alternatively, this can hinder the capacity of firms employing them to successfully restructure, i.e. improve productivity and profitability.

In our work, we use firm-level direct measures of productivity and labour cost. Our Belgian data[11] 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[12], where

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8 Also referred to as a cohort effect.

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

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

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

12 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.

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 the paper underpinning this communication (Vandenberghe, 2011a), 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 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 race, education, and marital status, e.g. Hellerstein & Neumark (1999), Hellerstein *et al*.(1999), or gender e.g. Vandenberghe (2011c), and richer data sets regarding employees, e.g. Crépon, Deniau & Pérez-Duarte (2002). We focus here 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). For example the vintage of capital in use, the overall stock of human capital , firm-specific managerial skills, location-driven comparative advantages. 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. A standard solution to the heterogeneity bias is to resort to fixed-effect analysis (FE henceforth), be it via first-differencing or mean-centring of panel data.

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, say, a lower turnover, itself the consequence of a missed sales opportunity. Contrary to the econometrician, firms may know about these. An anticipated downturn can translate into a recruitment freeze. Since the latter predominantly affects youth, we should expect that the share of older (male/female) workers to increase during negative spells, and decrease during positive ones. This would generate negative correlation between the share of older (male/female) workers and the productivity of firms, thereby leading to underestimated estimates of their relative productivity when resorting to standard techniques. As to the endogeneity bias, the past 15 years has seen the introduction of new identification techniques.[13] One set of techniques follows the dynamic panel literature (Arellano & Bond, 1991; Aubert & Crépon, 2003; Blundell & Bond, 2000; Göbel & Zwick, 2009; or van Ours & Stoeldraijer, 2011), which basically consists of using lagged values of labour inputs as instrumental variables (IV henceforth). A second set of techniques, initially advocated by Olley & Pakes (1996) or more recently by Levinsohn & Petrin (2003) (LP 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 Vandenberghe (2011a), we follow these most recent applications of HN's methodology. We combine and compare all the above-mentioned econometric techniques (FE, IV, OP-LP). Our main results are all based on within-firm variation that we derive from the use of FE (namely first differences). What is more, to control

[13] See Ackerberg, Caves & Frazer (2006) for a recent review.

for the potential endogeneity of the share of old men and women employed by firms, in our preferred estimation methods we combine first differences with *i)* IV techniques and *ii)* the LP intermediate-goods proxy approach, which we implement using information on firms' varying level of intermediate consumption.[14]

The lax rules in terms of access and relatively high replacement rates characterizing the Belgian (pre)pension regimes are traditionally emphasized to explain the country's low employment rate among individuals aged 50 and over. Our work (Vandenberghe, 2011a; Vandenberghe & Waltenberg, 2010) contains evidence that the latter could also be demand-driven. *Ceteris-paribus*, 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 modest 0.16 to 0.69% reduction in the productivity-labour cost ratio. 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 1.3 to 2%- reduction in the productivity-labour cost ratio; something that negatively affects 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 1.1 to 1.24%. 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. Section 2 is devoted to an exposition of the dataset. Sections 3 and 4 contain the results and main conclusions respectively.

2. 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.

A weakness of our dataset is that is 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 much is this likely to bias our productivity-by-age (and gender) estimates? Not so much, we think, for two 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, as stated above, we identify the effect of age on productivity from within-firm variation of age/gender shares over (panel/observation) time. With first differences, identification 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 with no (or less of) such rises. How do the two types of firms compare in terms of cohort changes between t and $t+1$? By definition, the average year of birth rose in both types of firms. In a panel, cohort/year-of-birth and time of observation are monotonically related: individuals belonging to a particular age band in $t+1$ are more likely to belong to younger cohorts than those observed in t in the same age band. Still, 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 ones. But even so, we would argue that the resulting asymmetries in terms human capital dynamics (not captured by the firm-level proxies mentioned above) are unlikely to correlate with short-term productivity differences

[14] It is calculated here as the differences between the firm's turnover (in nominal terms) and its net value added. It reflects the value of goods and services consumed or used up as inputs in production by enterprises, including raw materials and services bought on the market.

across the two types of firms. This is because it probably takes time for firms to mobilise the extra (general) human capital younger cohorts bring along.

Descriptive statistics are reported in Table 1. They suggest that firms based in Belgium have been largely affected by ageing over the period considered. Table 1 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 1987 and 2007 the average age of the workforce in the EU25 has risen from 36.2 to 38.9. Table 1 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%.

Intermediate inputs play a key role in our analysis, as they are central to one of the two strategies we use overcome the simultaneity or endogeneity bias. The level of intermediate inputs used by a firm is calculated here as the difference between its turnover (in nominal terms) and net 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 (see 4th column from the right in Table 1 for descriptive statistics).

Table 1: Belfirst-Carrefour unbalanced panel. Basic descriptive statistics: mean (Standard deviation)

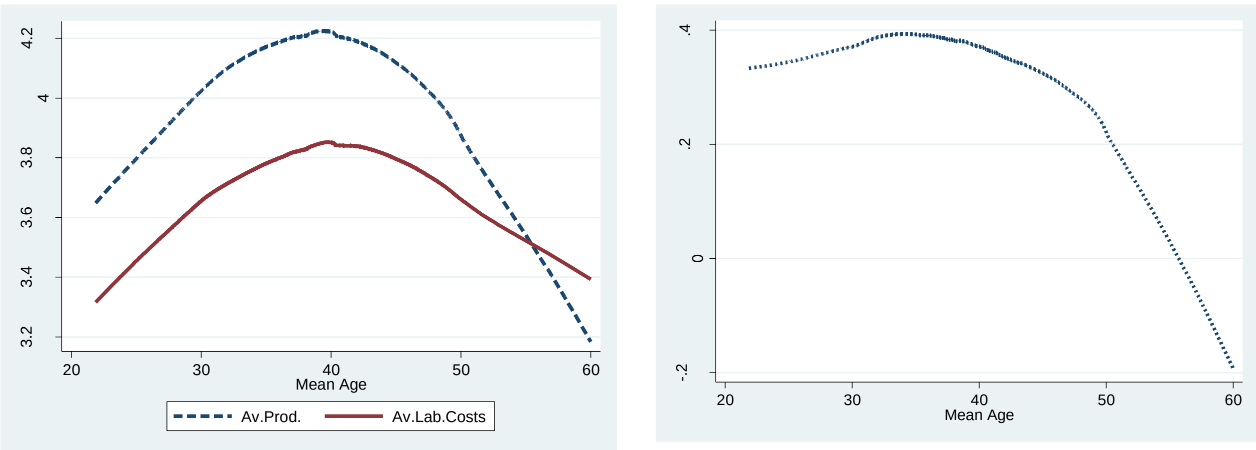
Year	Firms	Productivity (i.e. value-added) per worker (in th. €)	Labour cost per worker (in th. €)	Product.-Lab. cost ratio (%)	Firm size (# workers)	Capital (in th. €)	Mean age	Shares (male) 18-29	Shares (male) 30-49	Shares (male) 50-64	Shares (female) 18-29	Shares (female) 30-49	Shares (female) 50-64	Intermediate goods cons. (in th. €)	Share of blue-collar workers	Share of managers	Hours worked annual per worker
1998	8265	66.03	39.01	0.40	107.86	6402	36.16	0.338	0.298	0.100	0.147	0.095	0.021	27991	0.57	0.01	1661.07
		(106.59)	(26.81)	(0.40)	(474.31)	(95642)	(4.29)	(0.18)	(0.16)	(0.09)	(0.17)	(0.11)	(0.04)	(158639)	(0.35)	(0.05)	(270.46)
1999	8431	69.10	40.29	0.40	111.05	6561	36.44	0.326	0.303	0.105	0.144	0.100	0.022	28466	0.57	0.01	1659.24
		(182.35)	(23.94)	(0.42)	(474.76)	(99485)	(4.24)	(0.17)	(0.15)	(0.09)	(0.16)	(0.11)	(0.04)	(162346)	(0.35)	(0.04)	(272.37)
2000	8624	69.46	41.26	0.39	113.75	6843	36.65	0.315	0.305	0.109	0.143	0.104	0.024	34447	0.56	0.01	1639.33
		(110.10)	(22.91)	(0.42)	(471.75)	(107777)	(4.21)	(0.17)	(0.15)	(0.09)	(0.16)	(0.11)	(0.04)	(222657)	(0.35)	(0.05)	(252.62)
2001	8825	69.47	42.73	0.37	121.06	7424	37.01	0.303	0.310	0.114	0.139	0.109	0.026	35869	0.55	0.01	1623.49
		(99.05)	(23.95)	(0.40)	(511.26)	(114725)	(4.19)	(0.16)	(0.15)	(0.10)	(0.15)	(0.11)	(0.05)	(256231)	(0.35)	(0.04)	(257.45)
2002	8966	71.96	44.67	0.35	127.59	7960	37.39	0.291	0.315	0.118	0.134	0.113	0.028	37472	0.54	0.01	1611.62
		(189.14)	(34.31)	(0.39)	(689.97)	(125480)	(4.16)	(0.16)	(0.15)	(0.10)	(0.15)	(0.11)	(0.05)	(271372)	(0.35)	(0.04)	(253.42)
2003	9051	73.19	45.47	0.35	127.35	8390	37.99	0.277	0.316	0.131	0.128	0.115	0.032	38153	0.54	0.01	1597.14
		(101.82)	(23.95)	(0.39)	(643.51)	(133174)	(4.26)	(0.15)	(0.15)	(0.10)	(0.14)	(0.11)	(0.05)	(254540)	(0.35)	(0.04)	(228.56)
2004	9060	76.49	46.95	0.37	129.36	8725	38.35	0.267	0.320	0.137	0.123	0.119	0.034	42160	0.54	0.01	1611.07
		(91.16)	(26.27)	(0.38)	(644.25)	(141718)	(4.28)	(0.15)	(0.15)	(0.11)	(0.14)	(0.12)	(0.05)	(296393.55)	(0.35)	(0.03)	(226.40)
2005	9036	78.86	48.26	0.36	131.55	7976	38.73	0.258	0.323	0.142	0.117	0.122	0.037	47597	0.53	0.01	1594.23
		(101.11)	(28.32)	(0.40)	(644.64)	(60537)	(4.24)	(0.15)	(0.15)	(0.11)	(0.13)	(0.12)	(0.05)	(416162)	(0.35)	(0.04)	(228.21)
2006	8936	81.10	49.31	0.37	133.41	8155	39.11	0.249	0.322	0.149	0.113	0.125	0.041	52837	0.52	0.01	1572.85
		(96.90)	(30.24)	(0.41)	(638.59)	(59825)	(4.25)	(0.14)	(0.14)	(0.11)	(0.13)	(0.12)	(0.06)	(510248)	(0.35)	(0.04)	(211.68)

Source: Bel-first/Carrefour data warehouse panel, our calculus

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.[15] 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 the 10% threshold when mean age exceeds 55.

Figure 2 is probably more directly echoing the main issue 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.

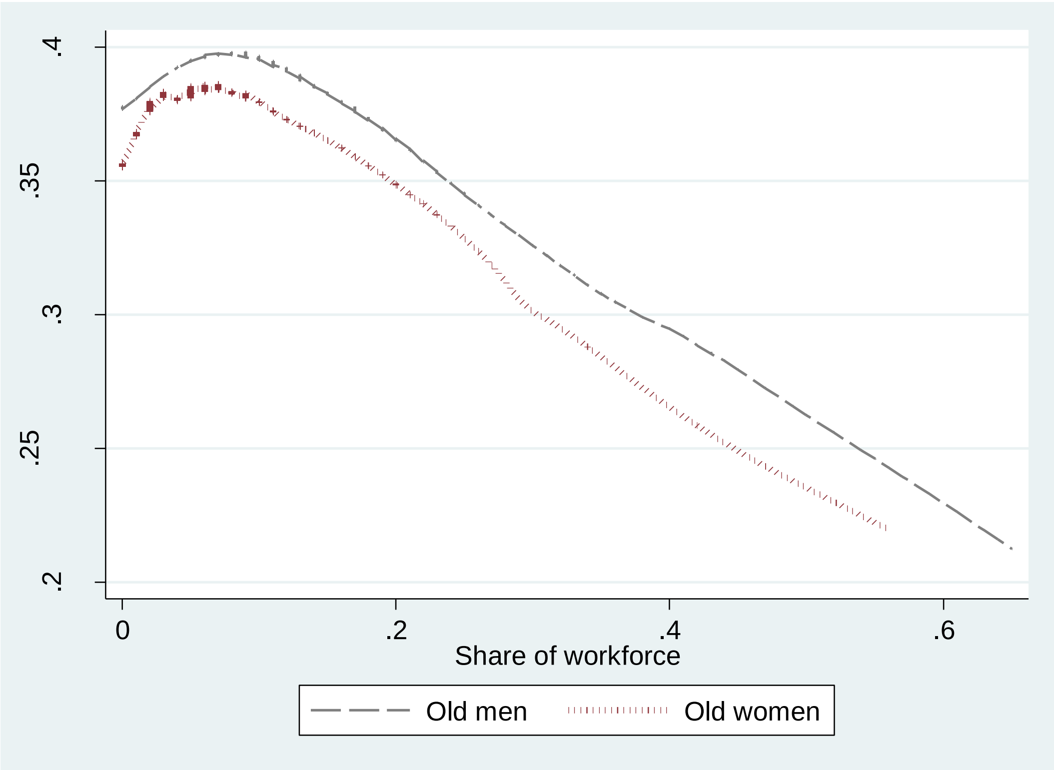
Figure 1: (Left panel) Average productivity and average labour costs. (Right panel) Productivity-Labour cost ratio (%) according to mean age. Year 2006



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.

15 Logarithms, used in conjunction with differencing, convert absolute differences into relative differences.

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 require 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.

3. Econometric results

Table 2 presents the parameter estimates of the average productivity, labour costs and productivity-labour cost ratio equations, under four alternative econometric specifications. Note that, the third equation being the difference between the two previous ones, it is logical to verify that $\eta\text{-}\eta^{W}\approx\eta^{G.}$ 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 2 we use all available observations forming of our (unbalanced) panel.

The first set of parameter estimates come from OLS, using total variation [1]. Then come first differences (FD), where parameters are estimated using only within-firm variation [2]. The next strategy [3] consists of using first-differenced variables and instrumenting the workforce share first differences with second differences and lagged second differences. The last model [4] combines first differences and the LP intermediate-goods proxy idea.

Although they come at the cost of reduced sample sizes, estimations [3] [4] in Table 2 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 LP's intermediate input proxy, or internal instruments (second differences, lagged second differences). In the latter case, note that we estimate the relevant parameters of our model using the General Method of Moments (GMM), known for being more robust to the presence of heteroskedasticity.[16]

[16] Our estimates are based on Stata's "ivreg2" suite, with the "gmm" option

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 and region) in our list of controls 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 LP.

To assess the credibility of our 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 GMM estimates reported in Table 2 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 overidentifying restrictions. A failure to reject the null hypothesis (high p-values) implies that the instruments are exogenous. In all our IV-GMM estimates we cannot reject the null hypothesis that these restrictions are valid.

In Table 2, 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 LP model [4] suggest that an increase of 10%-points in the share of old male workers depresses productivity by 1.15%. Model [3], based on IV-GMM, points at a smaller (not statistically significant) drop by only 0.39%.

As to old women both IV-GMM [3] and the LP 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 2.52% [3] to 2.5% [4].

Turning to the average labour cost coefficients (η^W), we see that those for older men and women are very similar once we control for firm heterogeneity and/or simultaneity [3][4]. They are negative but of small magnitude, although often statistically significant at the 10% level. Estimates for model [4] show that a 10%-points rise of the share of older male (female) workers reduces average labour cost by 0.46% (1.2% respectively). In short, particularly for men we do not find strong evidence of age-related decline of average labour costs in the Belgian private sector economy; something that accords relatively well with the country well-established tradition of seniority-based wage progression.

However, regarding the labour demand for older men and women, the most important parameters are those of the productivity-labour cost ratio equation (η^G). 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 negative but not statistically significant results. Model [4] suggests that a 10%-points rise of their share causes a modest 0.69% reduction of the productivity-labour cost ratio. Those for model [3] are not statistically significant.

The situation is completely different for old women. Model [3] suggests that a 10%-points expansion of their share in the total workforce causes a 2% reduction of the productivity-labour cost ratio. And model [4] points to a 1.3% drop of that ratio.

Table 2 - 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^G). Overall, unbalanced panel sample.

	[1]-OLS	**[2]-First Differences**	**[3]-First Differences+ IV-GMM**	**[4]- First Differences + intermediate inputs LP[$$]**
		Share of 50-64 (Men)		
Productivity (η_{3m})	-0.233***	-0.095***	-0.039	-0.115***
std error	*(0.023)*	*(0.028)*	*(0.038)*	*(0.035)*
Labour Costs (η^w_{3m})	-0.176***	-0.023*	-0.020	-0.046***
std error	*(0.013)*	*(0.012)*	*(0.016)*	*(0.014)*
Prod.-Lab. Costs ratio (η^G_{3m})	-0.063***	-0.071***	-0.016	-0.069**
std error	*(0.020)*	*(0.027)*	*(0.037)*	*(0.034)*
		Share of 30-49 (Women)		
Productivity (η_{2f})	-0.293***	-0.035	-0.114**	-0.034
std error	*(0.021)*	*(0.033)*	*(0.046)*	*(0.040)*
Labour Costs (η^w_{2f})	-0.351***	-0.042***	-0.033*	-0.027*
std error	*(0.012)*	*(0.014)*	(0.019)	*(0.016)*
Prod.-Lab. Costs ratio ($\eta^G{}_{2}f$)	0.053***	0.005	-0.081*	-0.006
std error	*(0.018)*	*(0.032)*	*(0.045)*	*(0.040)*
		Share of 50-64 (Women)		
Productivity (η_{3f})	-0.610***	-0.229***	-0.252***	-0.250***
std error	*(0.039)*	*(0.053)*	*(0.071)*	*(0.063)*
Labour Costs (η^w_{3f})	-0.643***	-0.060***	-0.052*	-0.120***
std error	*(0.022)*	*(0.023)*	*(0.029)*	*(0.025)*
Prod.-Lab. Costs ratio (η^G_{3f})	0.022	-0.169***	-0.201**	-0.130**
std error	*(0.033)*	*(0.052)*	*(0.070)*	*(0.061)*
Controls	capital, number of employees,hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: year, nace2, region	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: year, **firm**	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: year, **firm**	capital, number of employees, hours worked per employee[a], share of blue-collar workers, share of managers + fixed effects: year, **firm**
Test			Instruments: second differences and lagged second differences. **IV relevance**: Anderson canon. corr. LR statistic√ **Overidentifying restriction**: Hansen J statistic √	
Nobs.	76,341	66,383	49,207	52,160

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
[$] Levinsohn and Petrin

Table 3 contains a series of important results that can be derived from a further analysis of those displayed in Table 2. 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 $\eta_{3m} > \eta_{3f}$ [$\eta^{G}_{3m} > \eta^{G}_{3f}$] in absolute value and testing H0: $\eta_{3m} = \eta_{3f}$ for productivity [H0: $\eta^{G}_{3m} = \eta^{G}_{3f}$ for employability]. Results for IV-GMM model [3] point to a 21.3% productivity handicap for old women relative to old men. In terms of employability their handicap is of 18.4%. Both estimates are highly statistically significant.

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]. To that purpose we can first check whether age negatively affects the productivity[employability] of men and women separately. As already stated above, the evidence for old vis-à-vis prime-age male workers (ie. estimated η_{3m} [η^{G}_{3m}]) is mixed. Results for the IV model [3] suggest an absence of significant deterioration of productivity[employability], whereas LP model [4] is supportive of such a deterioration: -11% in terms of productivity and -6.9% in terms of employability. Assessing the situation of older women is less immediate and requires hypothesis testing (ie. rejecting H0: $\eta_{2f} = \eta_{3f}$ [H0: $\eta^{G}_{2f} = \eta^{G}_{3f}$]). Results for IV model [3] point to a 13.8% statistically-significant productivity handicap for old women relative to prime-age women. In terms of employability, the handicap is of 11.9%. Similar results are obtained with LP model [4], namely a productivity handicap of 21.7%, and an employability handicap of 12%. Furthermore, we can test whether age affects more women's than men's productivity[employability] by testing H0: $\eta^{G}_{3f} - \eta^{G}_{2f} = \eta^{G}_{3m}$ [H0: $\eta_{3f} - \eta_{2f} = \eta_{3m}$]. Results point to a 9 to 10% handicap of women vis-à-vis men in terms of age-related productivity decline, and a 5.4 to 10% handicap in terms of employability decline. But none of these estimates appear statistically significant.

Table 3 – 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^G). Overall, unbalanced panel sample.

	Coefficient	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] - First Differences+ IV-GMM$										
Productivity										
Men 50-64 (η_{3m})	-0.039 *(0.038)*	-0.213***	7.75	0.0054	-0.138*	3.75	0.059	-0.099	1.47	0.2256
Women 30-49 (η_{2f})	-0.114** *(0.046)*									
Women 50-64 (η_{3f})	-0.252*** *(0.071)*									
Prod.-Lab. Costs ratio										
Men 50-64 (η^G_{3m})	-0.016 *(0.037)*	-0.184**	6.11	0.0135	-0.119*	2.94	0.0863	-0.103	1.68	0.1955
Women 30-49 (η^G_{2f})	*-0.081** *(0.045)*									
Women 50-64 (η^G_{3f})	-0.201** *(0.070)*									
[4]- First-Differences + intermediate inputs LP$$										
Productivity										
Men 50-64 (η_{3m})	-0.115*** *(0.035)*	-0.135*	3.78	0.0518	-0.217***	11.72	0.0006	-0.101	1.91	0.1668
Women 30-49 (η_{2f})	-0.034 *(0.040)*									
Women 50-64 (η_{3f})	-0.250*** *(0.063)*									
Prod.-Lab. Costs ratio										
Men 50-64 (η^G_{3m})	-0.069** *(0.034)*	-0.061	0.80	0.3698	-0.124**	4.01	0.045	-0.054	0.58	0.4470
Women 30-49 (η^G_{2f})	-0.006 *(0.040)*									
Women 50-64 (η^G_{3f})	-0.130** *(0.061)*									

£:Standard errors estimates are robust to firm-level clustering

*p < 0.05, **p < 0.01, *** p < 0.001

$:IV-GMM: Instruments: second differences and lagged second differences. Tests: IV relevance: Anderson canon. corr. LR statistic √ Overidentifying restriction: Hansen J statistic √

$$: Levinsohn &. Petrin

In Vandenberghe (2011a), we have undertaken two further steps in our analysis: 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[17] sample.[18] 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.

In short, results are that the old worker gender asymmetry highlighted with the unbalanced panel appears stronger with the balanced panel, and even more when restricting the analysis to the service industry. 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.

4. Concluding remarks

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* and influence both firms and labour markets.

Optimists believe that an ageing and feminized workforce will have only a minimal impact on labour markets and on firms' performance or their ability to restructure. For instance, Cardoso, Guimaraes & Verajao (for Portugal) and van Ours & Stoeldraijer (for the manufacturing sector in the Netherlands) find little evidence of a large age-related negative impact on the productivity-pay ratio.

But these Portuguese and Dutch results contrast with the results of many slightly older international studies reviewed by Skirbekk (2004, 2008), or the recent results by Hellerstein *et al.* (2007) for the US; whose most common finding is a hump-shaped relationship between productivity and age, while labour costs are either rising with age or flat beyond a certain threshold. More to the point, they also contrast with the Belgian evidence presented here, and that found by Cataldi, Kampelmann & Rycx (2011) who use different firm-level panel data than ours.

Interestingly, Cataldi, Kampelmann & Rycx (2011) show that the age-related productivity handicap in Belgium does not seem to depend on how ICT-intensive firms are. Our work in progress (Vandenberghe & Waltenberg, 2011) also suggests, for the Belgian private economy, an absence of mechanical positive relationship between the overall propensity of firm to spend money on training[19] and the (relative) productivity of their older employees. One possible explanation could be that Belgian firms concentrate training efforts on young or prime-age workers.

Finally, the cross-country differences mentioned here (Belgium vs. Portugal or the Netherlands) with regard

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

18 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.

19 Which, as such, seems to have a positive impact on the *overall* labour productivity of large Belgian firms (Konings & Vanormelingen, 2011).

to how age[gender], productivity and pay are related could be due to data specificities or to econometric issues. But one cannot reject the hypothesis that they point to “country effects”. It could be, for instance, that the way age affects productivity is partially dependant on the set of labour-market institutions present in one country. Some of these institutions may be conducive to greater investment (from both employers and employees), combating or compensating age-related productivity declines, whereas others may have the opposite effect. The issue remains open for discussion and calls for more research.

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