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Gender and age diversity of the workforce. Does it matter for firms' performance?

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Gender and age diversity of the workforce. Does it matter for firms' performance?[1]

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Abstract

We explore the link between the firm's workforce composition in terms of female, young and senior workers and its performance. Despite extensive research, the impact of age and gender workforce diversity on firms' growth and performance remains theoretically and empirically inconclusive. We consider two types of approaches. We question the complementarity of considered working populations (female / male workers; young and older workers; senior and younger workers) estimating elasticity of substitutions in the framework of CES production functions. Then, we evaluate the effects of diversity in terms of those three working populations on firm labor productivity using a non-linear approach, using an original instrumental variable identification strategy to cope with endogeneity of diversity. Our econometric estimates, based on administrative data from French companies (2009-2015), highlight several results. First, female and male workers are at least partly complements; the same holds for young workers and other workers, and to a lesser extent between senior workers and other workers. Second, increasing diversity in terms of female, young or old workers is associated to greater productivity and generates often productivity gains; in particular, productivity gains decrease as the share of female or young workers is close to the diversity situation, confirming inverse *U*-shaped relation between productivity and the share of the given employed population. Third, this positive relation between female and young workers diversity and productivity is mainly attributable only to some industries, where the share of given working population is below or above the diversity situation. Consequently, this article seems to indicate robust findings to inspire public policy actions in favor of diversity in terms of female, young or old workers.

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Keywords*: female, young or old workers; firm performance; public policy; instrumental variables.*

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1. Introduction

We focus on the relation between diversity of the workforce in terms of gender or age and the firm performance. There is no shortage of calls for gender diversity in the labor market, whether promote the integration of young people, to guarantee equal access for men and women to jobs, functions and all levels of the hierarchy, to prevent discrimination based on origin, or to include people with disabilities in the workplace. Every time, corporate social responsibility is at stake. Managing the diversity of human resources in all these dimensions has become a real challenge for private and public organizations. Indeed, for at least the past ten years, numerous reports have emphasized the central role that workforce diversity and diversity within management teams play in firms' growth and performance. For instance, McKinsey Global Institute mentions that companies in the top quartile for gender or racial and ethnic diversity are more likely to have financial returns above their national industry medians; on the other hand, companies in the bottom quartile in these dimensions are statistically less likely to achieve above-average returns (Hunt *et al.*, 2015). As well, Hunt *et al.* (2018) highlight the role of diversity as a driver of firms' success. Companies in the top-quartile for gender diversity on executive teams were 21% more likely to outperform on profitability and 27% more likely to have superior value creation. The importance of diversity for firm performance seems to hold not just in terms of gender, but also ethnic and cultural, or LGBTQ+ or age/generation in (large) companies across multiple industries. Overall, companies in the bottom quartile for both gender and ethnic/ cultural diversity were 29% less likely to achieve above-average profitability than were all other companies. In short, not only were they not leading, they were lagging. Laws to increase quotas for certain population groups were thus introduced in many countries to promote diversity.

From this perspective, crucial questions are the following. What are the effects of greater diversity, notably in terms of gender or age, on business performance? Namely, to what extent female and male workers, or young and older workers, are complements in the production activity and as such contribute to output growth? Is it costly to diversify human resources considering these two criterions? In particular is there any (non-linear) trade-off between age or gender diversity and productivity in companies?
Research in the social sciences, psychology and management does not provide definitive answers to these questions, which could inform the choices of human resources managers and public decision-makers. From a theoretical point of view, the mixing of work teams is associated with both the best and the worst. For some, it is a source of creativity, resilience and innovation. For others, it is a breeding ground for conflict and division in organizations. From an empirical point of view, studies emphasize the relative nature of this relationship by showing that the effects of diversity on performance also depend on the nature, variety and difficulty of tasks, as well as work contexts, the size of teams and companies, and the type of business sector. On all these topics, the management science literature, which has reportedly doubled in size every five years since the late 1980s, has not produced consistent results and has even been accused of being "weak, inconsistent, or both" (Harrison and Klein, 2007). While there is a very large number of publications on the association between age or gender diversity and company performance, only a small proportion of them is based on explicit empirical strategies that make it possible to account for the endogenous nature of gender diversity in top performing companies. Some of these publications focus on the effects of diversity on firm performance by exploiting laws introduced to promote diversity as natural experiments. A lot of them aimed at analyzing feminizing boards and management teams.

Feminization of boards and management teams (*e.g.*, Adams and Ferreira, 2009; Ahern and Dittmar, 2012; Azmat (2014); Bear *et al.*, 2010; Campbell and Minguez-Vera, 2008; Carter *et al.*, 2003; Dale-Olsen *et al.*, 2013; Erhard *et al.*, 2003; Green and Homroy, 2018; Solakoglu, 2013; Ben Slama *et al.*, 2019). There is no unequivocal effect on firms' economic and financial performance, although the proportion of women in the executive ranks of large companies does affect governance and decision-making (Adams and Ferreira, 2009). Few articles also deal with age diversity in boards (Darmadi, 2011; Petersson and Wallin, 2017). Far fewer works deal with the consequences of greater diversity in the overall workforce, either in terms of age (De Meulenaere *et al.* (2016); Garnero *et al.*, 2014; Grund and Westergaard-Nielsen, 2008; Ilmakunas and Ilmakunas, 2011; Lovasz and Rigo (2013); Parrotta *et al.*, 2014; Zelity, 2023), gender (Apesthegia *et al.,* 2012; Garnero *et al.,* 2014; Parrotta *et al.*, 2014) or both (Vandenberghe, 2013). Results are still inconclusive. In this article, another strand of literature is also of interest to us. Indeed, when studying the effects of diversity in terms of gender or age, a closely related issue concerns the complementarity of certain categories of workers in the production process: female and male, younger and older workers, as well as seniors and younger employees. A wide set of articles consider the production function framework (either CES of Translog) to estimate the elasticity of substitution between two populations of workers, and more and less macro sectoral or firm data. The aim is to assess the extent to which the complementarity of production factors contributes to growth. With regards to gender, a set of articles (Acemoglu *et al.* (2004); Bargain and Lo Bue (2022); Ghosh (2018); Ostry *et al.* (2018); Pellizari *et al.* (2014)) show that there is no perfect substitution between female and male workers. The same holds, but to a lesser extent, when elasticities of substitution are estimated between different categories of workers that differ by age (Arntz and Gregory (2014); Card and Lemieux (2001); Fitzenberger and Kohn (2006); Grant and Hamermesh (1981); Hebbing (1993); Peters (2015); Welch (1979)). Thus, previous macroeconomic models that consider perfect substitutability between different categories of workers therefore underestimate the impact of gender diversity on growth, inappropriately attributing a part of growth to unknown factors (broadly interpreted as technological change) rather than to its real cause — past increases of the participation to the labor market of a given category of workers. Our article lies at the intersection of these two strands of the literature.

Despite extensive research, the impact of age and gender workforce diversity on firms' performance remains theoretically and empirically inconclusive. We consider two complementary approaches to analyze the link between the firm's workforce composition and firm performance. First, we analyze to what extent female and male workers, on the one hand, and workers by age, on the other hand, are complements in the production process. Second, we consider an original econometric approach to evaluate the impact of gender and age diversity on firm labor productivity. To this end, we rely on French firm tax and accounting databases with exhaustive coverage between 2009 and 2015, and two complementary econometric approaches that make it possible to overcome usual identification troubles. In particular, we question the complementarity of female / male workers (respectively of young (less than 30) and older workers; or of senior (older than 49) and younger workers) in a production function framework; we evaluate elasticities of substitutions on a sectoral panel (built at a two digits SIC level) estimating CES production functions with nonlinear least squares (for instance, Ostry *et al.*, 2018); we thus do not suppose that firms pay workers their marginal productivity and allow for potential discriminating behavior of firms (Altonji and Blank, 1999; Jarrell and Stanley, 2004). Moreover, we evaluate the effects of diversity in terms of female, young and old workers on firm labor productivity using a non-linear approach (Chetty *et al.*, 2014; Dahl and De Leir, 2008); on this occasion, we use an original instrumental variable identification strategy to cope with endogeneity and overcome reverse causality of performance in relation to age or gender diversity, but also unobserved heterogeneity and potential error measurement, considering as an instrument a kind of push and pull factor adapted to the context of our study, namely the diversity index for the given working population (female, young or old workers), computed on the workforce composition of the other firms in its four-digit SIC code (Hanlon *et al.*, 2003; Lev and Sougianis, 1996). Our results are fourfold. First, female and male workers are at least partly complements; the same holds for workers less than 30 and older workers, and to a lesser extent for workers older than 49 and other workers. Second, increasing diversity in terms of female, young or old workers is associated to greater productivity gains and generates often productivity gains. Third, productivity gains decrease as the share of female, young or old workers is close to the diversity situation, either in terms of female or young workers employed in the company, confirming observed inverse *U*-shaped relation between labor productivity and the share of the given employed population. Fourth, this positive relation between female and young workers diversity and productivity is mainly attributable to only some industries: trade and accommodations (female / young workers, young female workers), transportation and communications (female or old female workers), construction (old workers), manufacturing (old female workers) or education and social activities (female workers); real estate-rental-business services and manufacturing industries; namely these correspond to business sectors where the share of the given working population is below the diversity situation (transportation and communications for female workers or old female workers), or where it is above it (trade and accommodation for female / young workers education and social activities for female workers, construction for old workers, and manufacturing for old female workers).

This article contributes to the literature on the relation between workforce diversity in terms of gender and age and firm performance in several ways. To our knowledge, our paper is the first to combine two complementary approaches to analyze the effect of gender and age workforce diversity. One is based on evaluating to what extent production factors are complements in the production process, considering nonlinear least squares estimation of CES production functions and evaluating to what extent complementarity contributes to output growth. The other approach focuses on analyzing impacts of diversity on labor productivity, allowing us to explore for potential non linearities in the relation between diversity and productivity (like in Chetty *et al.*, 2014). This method provides a common framework allowing to estimate the impact of age or gender (young, old workers) diversity on the company's performance, both on the distribution tails or along the distribution of the proportions of young / old people or female workers, while it does not make any assumptions about the presence and form of nonlinearity since it is based on estimates by quantile of the given share. Another important contribution of our paper is that we study the age diversity not along the whole age distribution, but considering a particular sub-group, that of workers younger than 30 years old. We also address the potential endogeneity of our diversity indicators and to cope with reverse causality; in particular, we distinguish an original instrument of the type push and pull adapted to firm studies like in Garnero *et al.* (2016), Hanlon *et al.* (2003), or Lev and Sougianis (1996). In the end, we also study the relation between workforce diversity at the industry level; we investigate to what extent the findings for the overall economy rely on industries, considering six main business sectors. We relate our econometric results both with the composition of the given industry in terms of the given working population and with observed relation between labor productivity and the share of the considered population.

In the second section we present an overview of the literature on the associations between the gender and age composition of a company's employment and its productivity. The third section is devoted to the presentation of the methods used to evaluate the effects of age and gender diversity on business performance. The fourth section presents the data. The fifth displays results and discuss them. In the sixth section, we present extensions and robustness checks. The last section concludes.

2. Literature review

In the economic literature that analyzes the link between diversity of the labor input and firm performance, we can distinguish (at least) two kinds of strand of literatures, one that relates complementarity of production factors to output growth and another that relates diversity to (labor) productivity. In what follows, we review the two strands of the literature, focusing successively on workforce heterogeneity along gender and age dimensions.

2.1. Complementarity of production factors and growth

A first strand of literature copes with the link between heterogeneity of production factors and output growth.

2.1.1. Female and male workers

The economic literature mentions a long-term relationship between economic development and female labor force participation. Countries in their late development stages are supposed to mature into modern economies where fertility rates decline, female education rates increase, and female employment expands, notably in the service sector (Goldin, 1990, 1995).

In spite of lots of efforts from public authorities, female labor force participation (FLFP) remains still low (Ostry *et al.*, 2018). However, efficient arguments have been put forward to militate in favor of policies that could improve women's position in the labor market. First, there is the detrimental effect of gender employment gaps on the overall productivity and growth potential of emerging economies (Klasen and Lamanna, 2009). Second, women's labor may provide a competitive advantage in early development stages if it is cheaper than men's (Seguino, 2008). Third, increasing women's bargaining power at home makes them more able to invest in health and education (Cavalcanti and Tavares, 2016). Fourth, the economy may simply benefit from larger pools of workers and talents (Kan and Klasen, 2018; Klasen, 2018).

What about a complementarity between female and labor workers in the production process? Women bring different skills and ideas to the economy. Reducing the participation gaps between women and men should lead to significant economic gains (Acemoglu *et al.* (2004); Ostry *et al.*, 2018; Pellizzari *et al.*, 2014).

This expected effect is obtained through two mechanisms: the improvement of gender diversity through the increase of the gender mix of the labor force, and the job reallocation, both within and across industries. The idea is that women bring new skills, have different attitudes towards risk, different social preferences or attitudes towards a competitive environment and modes of cooperation and different responses to incentives and modes of socialization (Alesina and La Ferrara, 2005).

Finally, increasing female participation in the labor market should also increase the diversity of production factors and thus increase output more strongly than an equivalent increase in male employment.

From an empirical point of view, the importance of gender complementarity for economic growth is often evaluated through the (estimation of the) elasticity of substitution (*ES*) between women and men. When the *ES* is very high (technically, when it is infinite—the usual assumption in macro models), there are no benefits from diversity and firms can substitute one worker (female or male) for another with no effect on the level of output, however initially scarce women are. When the *ES* is zero, a fixed proportion of women and men is always optimal, and any deviation from this proportion is pure waste. The economically relevant range turns out to be one of partial substitutability, or, equivalently, partial complementarity. Estimates of ES considering CES production functions are given by a wide range of values considering the kind of data at hand: clustered below 1 with macro data (Ostry *et al.*, 2018), between 1 and 2 with sectoral data (Bargain and Lo Bue (2022: around 2), Ostry *et al.* (2018: about 1.6 to 2.4), between 2 and 3 with firm-level data (Ostry *et al.* (2018: about 1.9 to 3.3). However, there is a great variability with wage and econometric specification (Acemoglu *et al.*, 2004; Pellizari *et al.*, 2014).[6] As to economic growth, these findings provide evidence that previous models therefore underestimate the impact of gender diversity on growth, inappropriately attributing a part of growth to unknown factors (broadly interpreted as technological change) rather than to its real cause — past increases in women's participation.

Besides, the literature report positive aspects of sectoral reallocation. Services tend to be more gender equal in employment (Weinberg, 2000; Borghans *et al.*, 2014). This is due to the evolution in the economic history of countries. As they develop, agriculture' share in employment declines, while services' share rises: a substantial share of past increases in FLFP can be explained by the employment growth of the services sector. Since households become wealthier during the process of economic development, the demand for services increases and labor is reallocated to this growing sector. As time progresses, the development process will gradually incorporate more women into the labor force. The argument then proceeds on the assumption that services are more egalitarian in terms of employment than other sectors so that economies become mechanically more inclusive (*i.e.* tertiarization leads to more gender balance in the labor market).

However, there may be a slowdown of this process. Barriers to FLFP (which include tax distortions, discrimination, and social/cultural factors) slow this process, reducing output and welfare. Thus, reducing barriers to FLFP leads to a more efficient allocation of labor and to gains in both measured marketable output and welfare (Ostry *et al.*, 2018). Therefore, a large heterogeneity of these gains is found. While output and welfare effects are moderate in relatively gender-equal economies, potential gains are much larger in more unequal countries.

2.1.2. Young vs medium or old workers

As to heterogeneity of the labor workforce in terms of age, and distinguishing young and old workers, the question is to know where are the most productive firms.

According to decremental theory, abilities decline as workers age (Shock, 1962; Welford, 1977). But there are examples of different jobs where older workers surpassed younger (Giniger *et al.*,1983). Therefore, reduced signal-to-noise ratio in the brain and progressive loss of body cells is not a sufficient condition that older employees are necessarily less productive.

Otherwise, there is an incomplete information about employees' abilities at the beginning of their career. Thus, young employees exert efforts in order to suggest high abilities levels. Employees may avoid working together with weaker colleagues (Akerlof, 1976), or try to increase future

[6] With wage data, slightly similar results are found: Acemoglu *et al.* (2004; about 3); Ghosh (2018: about 1.7); Pellizari *et al.* (2014: 1.0-1.4).

earnings, and the external labor market takes the work result as a measure for unknown talent (Fama, 1980; Holmström, 1982-1999). In this way, firms with young employees are more productive.

Exploring the effects of age complementarity implies analyzing the link between an homogenous vs. an heterogenous workforce and productivity, while considering skill complementarities (human capital).

According to Lazear (1998, 1999), young workers have new ideas and skills in new technologies, but also better cognitive and physical abilities. On the other hand, old workers have knowledge about intra-firm structures and the relevant markets and networks, as well as abilities to grasp difficult situations as well as to use and apply existing skills (Börsch-Supan, 2013; Lazear, 1998, 1999). Usually, both kinds of human capital are necessary for firm productivity. Hence, a mixture of age groups seems to be beneficial.

Empirical evidence examines the degree of substitution between age groups of workers. The evaluation is often done considering three categories of workers: young, medium-aged and old ones. Considering a CES production function, Welch (1979) shows that workers of different age are imperfect substitutes, and Hebbing (1993) that young and old workers are complements. Grant and Hamermesh (1981) provide evidence for complementarities between young workers and different types of older workers, although no strong relationship seems to exists. According to Card and Lemieux (2001), cohort-specific relative supplies of college-equivalent labor is one driving force of a relative rise in college wage premium for younger workers. Fitzenberger and Kohn (2006) find that employees of different age but same skill level are imperfect substitutes. More recently, translog functions were considered while estimating *ES* elasticities. Arntz and Gregory (2014) find that younger and older workers are complements in the knowledge production process, although the degree of complementarity between younger and medium aged and between medium aged and older workers is rather low.[7] Peters (2015) shows that workers who belong to different age groups are indeed complements and that the degree of complementarity differs across the considered age groups and by skill level.

Focusing on the relation between homogenous vs. heterogenous workforce according to age of workers and productivity relies on the research on demographic diversity in teams and organizations. Including age diversity builds on two competing theoretical perspectives. On the one hand, to the extent that age diversity creates a pool of complementary age-specific knowledge and skill-based differences, potential synergies can be realized (Horwitz and Horwitz, 2007; Lazear, 1999; Williams and O'Reilly, 1998). According to the information/decision-making perspective, mixing people of different ages could stimulate employee creativity, problem-solving capacity, decision-making quality, employee productivity, and ultimately organizational performance. Based on theories of social similarity and categorization, demography researchers have argued that age diversity may also entail differences in values, which might hamper cohesion, social integration, and cooperation among employees (Byrne, 1971; Carton and Cummings, 2012; van Dijk and van Engen, 2013), ultimately reducing organizational performance.

2.2. Diversity of workforce and labor productivity

A second strand copes with effects of workforce diversity on labor productivity.

[7] Note that complementarities are not analyzed within groups of workers with a comparable skill level as suggested by Card and Lemieux (2001).

Alesina and La Ferrara (2005) provide micro foundations to the relation between diversity and firm performances. One way is to consider a heterogeneous population. If the individual preferences are increased by joining a group populated by individuals of its own type and decreasing by joining a group composed of individual of other types then the preferences for homogeneous group involve a negative relationship between diversity and firm performances. Another channel through which diversity can affect firm performance is strategic behavior. In case of market imperfections and in the absence of a preference for or against diversity it may be optimal from an efficiency perspective to prefer to interact with members of the same type. In this case the diversity has a negative impact on the firm performances. A last way to describe the relationship between diversity and firm performances is through the production function. Lazear (1999) describe how heterogeneity in skill can increase the productivity. He shows that the communication cost related to language, cultural, generational, educational differences can involve a tradeoff between firm performance and diversity.

2.2.1. Gender diversity

Several factors may explain relation between heterogenous workforce in terms of gender and labor productivity. Mixed-gender groups can foster the impact of group efficacy on performance according to Lee and Farh (2004). Indeed, the authors argue that gender diversity is likely to increase the heterogeneity in the values, beliefs, and attitudes of the members of a group, which in turn may stimulate critical thinking. On the other hand, Akerlof and Kranton (2000) introduce the concept of identity – which corresponds to a person's sense of self – into an economic model; they consider gender as an illustration of identity. The authors point out that social categories such as "men" and "women" are associated with prescribed behaviors and physical prescribed behaviors and ideal physical characteristics. As a result, women in male-dominated jobs may experience strong hostility and discrimination from their male counterparts. They predict that increasing gender diversity can have a negative impact on business performance, especially if men are a socially "dominant" group.

Corresponding empirical evidence is rather limited. In fact, the effect of gender diversity on the economic and financial performance of companies has been extensively studied empirically with regard to the composition of boards of directors and management teams, which is one of the area's best covered in the literature (Adams and Ferreira, 2009; Ahern and Dittmar, 2012; Bear *et al.*, 2010; Campbell and Minguez-Vera, 2008; Carter *et al.*, 2003; Dale-Olsen *et al.*, 2013; Darmadi, 2011; Erhard *et al.*, 2003; Green and Homroy, 2018; Solakoglu, 2013). One of the most widely cited studies is that of Adams and Ferreira (2009), which indicates that the proportion of women in the executive ranks of large companies changes governance and decision-making, without having an unequivocal effect on their economic and financial performance. This is because the statistical methods used take into account the reverse causality of performance towards gender diversity. The reader is also referred to the evaluation of the effects of the feminization of boards of directors and management teams carried out by Solakoglu (2013), who uses data from large Turkish companies.

Among the studies that rely on a research strategy to analyze the causal effect of gender diversity on performance, the contribution of experimental economics should also be mentioned. Several studies have proposed laboratory experiments making it possible to link the composition of work teams by gender and age with the functioning and efficiency of these teams. These experiences are based on a large strand of literature in psychology that highlights individual psychological traits and preferences that differ by gender and age. For example, Azmat and Petrongolo (2014) show women are more altruistic and do not value competitive contexts as much as men. Therefore, the gender composition of teams is a potential explanatory factor for team decisions, and their performance and is a subject of study for laboratory experiments. As well, Apesteguia *et al.* (2011) consider a business game, played in groups of three teams in which each group takes the role of general manager. Their finding is that teams formed by three women are significantly outperformed by all other gender combinations. The reason is the following: three-women teams are less aggressive in their price strategy, invest less in research and development, and invest more in social sustainability initiatives than does any other gender combination.

One of the rare articles that focus on this matter is that from Garner *et al.* (2014). The authors examine the effects of gender, age, and educational attainment on productivity (value added per hour worked), wages, and firm profitability, using Belgian individual data covering the period 1999-2006. As to gender, the authors show that mixed results: the feminization of the workforce produces beneficial effects in high-tech intensive business sectors but negative effects in more traditional industries. More precisely, they found a difference in the result, depending on whether the variable is introduced as an average or as a dispersion. Thus, high average age has a positive effect on a company's productivity, while age dispersion has a negative effect, as does gender dispersion. For an increase of one standard deviation, productivity decreases by 4% on average. Gender diversity is beneficial only in high-tech sectors (from + 2.5% to 6% increase in productivity). Parrotta *et al.* (2014) use Danish data sources that provide information on all companies from private business industries to form a panel for the period 1995-2005. They show there seems to be no association between the demographic index (built from the intersection of age and gender quartiles/quintiles) and total factor productivity.

2.2.2. Age diversity

Unlike gender, there is a link between age and productivity. Productivity evolves according to the life cycle on an inverted U pattern: increase at the beginning of a career, stagnation, then decrease at the end of a career. Activities involving experience and verbalization are less subject to a decrease in productivity at the end of a career compared to activities requiring a good capacity for problem-solving, learning or even speed. Young workers are assumed to learn faster (Skirbekk, 2004) and have better cognitive and physical skills (Hoyer and Lincourt, 1998) than their elders. However, age is also positively correlated with work experience and knowledge of intra-firm structures, markets and relevant networks (Grund and Westergaard-Nielsen, 2008; Leonard and Levine, 2003).

In a macroeconomic overlapping generation model, Zelity (2023) studies the role of age diversity in determining aggregate productivity and output, and determines an optimal amount of age diversity. Indeed, the author shows age diversity has two conflicting effects on output. Due to skill complementarity across different cohorts, age diversity may be beneficial. On the other hand, rapid skill-biased technological change makes age diversity costly as up-to-date education tends to be concentrated among younger cohorts. Investigation of whether changing age diversity can have important macroeconomic effects. The benefit of age diversity comes from the fact that education and experience are complementary inputs into production. This means that firms need both factors in order to maximize output. Increasing age diversity ensures that both factors are available in the desired quantities. On the cost side, age diversity can be detrimental because education and experience need not be equally productive. This implies that there is an optimal amount of education and experience that maximizes output depending on the weight of each factor. The co-existence of a cost and a benefit to age diversity implies a hump-shaped relationship between age diversity and output per capita. Increasing age diversity is beneficial up to a point, but is detrimental beyond that.

From an empirical point of view, up to now, the related literature exhibits inconclusive results. Considering linked employer-employee data of Danish private-sector firms employing at least 20 employees, Grund *et al.* (2008) provide evidence for a pyramidal or inverse *U*-shaped interrelation is found between mean age and standard deviation of age and value added per employee, respectively. Ilmakunnas and Ilmakunnas (2011) uses data from Finnish plants belonging to mining, manufacturing and construction industries over the period 1990-2004, and analyze the relation between age-education diversity and productivity or wages. In particular, they show a positive (respectively a negative) link between age (respectively education) diversity in the company and total factor productivity, labor productivity or wages. The dispersion of age also has a positive effect in that people of different ages can perform the same task if they have the same level of education. Garnero *et al.* (2014) examine the effects of gender, age, and educational attainment on productivity, wages, and firm profitability, using Belgian individual data covering the period 1999-2006. They show that the variety of ages reduces wages and productivity, which is strictly the opposite of the results of Ilmakunnas and Ilmakunnas (2011). Moreover, they find a difference in the result, depending on whether the variable is introduced as an average or as a dispersion. High average age has a positive effect on a company's productivity, while age dispersion has a negative effect. Using Belgian data, De Meulenaere *et al.* (2016) find that the effect of age diversity depends on the shape of the age distribution: positive when it is heterogeneous (*i.e.*, variety) and negative when it is polarized (*i.e.*, polarization). They thus unravel previous ambiguous effects suggested by previous literature, namely both positive or negative impacts.[8]

3. Identifying the effects of gender and age diversity of workforce

In the current study, we focus on diversity considering the composition of the salaried workforce of companies in terms of female and young workers. Two types of complementary approaches. First, question the complementarity of some production factors; to proceed, we estimate the elasticity of substitution between production factors through the estimation of a production function: female VS. male workers; young VS. medium-aged / old workers or old workers VS. young-medium aged workers. We then can analyze the impact of complementarity of categories of employees on output growth. Second, we focus on the impact of diversity on labor productivity, using a nonlinear approach, à la Chetty *et al.* (2014). It allows measuring locally, per quartile of firms, the impact of an additional diversity on labor productivity and evaluating marginal effects of a gain of one percentage point or of one position (in the ranking of firms) for the employment category (female; young or old workers).

3.1. Complementarity of categories of workers

In a first approach, we want to evaluate the elasticity of substitution (*ES*) between gender groups, or different age groups of workers. Indeed, people may differ in their productive skills and

[8] To our knowledge, few works also deal with age diversity in boards (Dagsson and Larsson, 2011; Darmadi, 2011; Petersson and Wallin, 2017). Results seem to be also inconclusive.

cognitive abilities in their interpretation of information and problem solving (Alesina and La Ferrara, 2005). Our analytical framework is in line with that of the classical growth model (Solow, 1956). We consider a Cobb Douglas technology:

$$Y = AK^{1-\alpha}L^{\alpha} \quad (1)$$

with *A* being the total factor productivity, *K* the capital factor, *L* the labor factor, and α is the share of employment in total output *Y*. *L* is specified as a constant elasticity of substitution composite of the considered population of interest, *T* that represents the employment of female workers (respectively young workers, less than 30; respectively old workers, more than 49) and its complement *N* to overall workforce (*N*=*L*-*T*):

$$L = \left(\delta T^{\rho} + N^{\rho}\right)^{1/\rho} \quad (2)$$

where *T* = *F, Y, O* stands for Female, Young and Old workers, *N* = *M, MO, YM* for Male, Medium-aged / Old and Young/ Medium-aged workers. $\sigma = 1/(1-\rho)$ represents the degree of substitutability between the category of workers of interest and other workers. It ranges from 0 (as ρ goes towards minus infinity) - perfect complementarity - and infinity (as ρ goes towards infinity) - perfect substitution.

Log-linearizing the complete production function $Y = AK^{1-\alpha}\left(\delta T^{\rho} + N^{\rho}\right)^{\alpha/\rho}$ we get the empirical model:

$$\ln Y_{it} = \left(1-\alpha\right)\ln K_{it} + \frac{\alpha}{\rho}\ln\left(\delta T_{it}{}^{\rho} + N_{it}{}^{\rho}\right) + \Gamma Z_{it} + \varepsilon_{it} \quad (3)$$

The *i* index represents the unit of observation, which can be a country, sector, or firms. The *t* index represents the year the unit is observed. Z_{it} includes individual (firm, regional, industry) fixed effects, and year fixed effects (Bargain and Lo Bue, 2025); ε_{it} is the usual error term.

Up to now, at least two kinds of estimation methods can be considered to estimate (Ostry *et al.*, 2018). The first applies standard linear regression model by linking the theoretical expression for growth:

$$\Delta \ln Y = \alpha\left(\mu \Delta \ln T + \left(1-\mu\right)\Delta \ln N\right) + \left(1-\alpha\right)\Delta \ln K + \Delta \ln A,$$

where $\mu = F(\partial L / \partial F) / L = \delta F^{\rho} / L^{\rho}$ is the share of *T*'s income (4)

To its empirical counterpart:[9]

$$\Delta \ln Y_{it} = \beta_K \Delta \ln K_{it} + \beta_T \Delta \ln T_{it} + \beta_N \Delta N_{it} + \Gamma Z_{it} + \varepsilon_{it} \quad (5)$$

Thus:

$$\beta_T / \beta_N = \mu / (1-\mu) \Rightarrow 1 - 1/\sigma = \ln(\beta_T / \beta_N) / \ln(dT / N) \quad (6)$$

However, proceeding as such assumes that firms pay workers their marginal productivity, which is not consistent with potential discriminating behavior of employers (Altonji and Blank, 1999; Jarrell and Stanley, 2004) and thus with non-competitive markets. In the framework of our article, it is important to allow for this. We thus prefer estimating *ES* thanks to nonlinear least squares applied to (3).

[9] This also requires to use the Taylor approximation of μ related to an elasticity of substitution of 1 (that is, for values of ρ close to 0), that is (Ostry *et al.*, 2018): $\mu \approx \delta / \left(1+\delta\right)\left[1 - \rho\delta \ln(T / N)\right]$.

3.2. Impact of workforce diversity on labor productivity

A second approach consists in evaluating the effects of workforce diversity on firm productivity. As mentioned above, corresponding studies are less common than those and remain overall inconclusive. Research on the subject is confronted with three series of methodological issues, which it overcomes to differing degrees.

One problem deals with the definition considered for diversity and the kind of indicator we use to measure diversity. The first part of this sub section deals with that matter, by surveying the related literature.

A second issue lies in the heterogeneity of firms' situations. There is a very wide variety of business situations in terms of the composition of the workforce by age and gender, and there is also a wide variety of situations in terms of work organization, technology or market context. To produce general knowledge that is representative on the scale of the productive fabric of a national economy, it is important to use statistical approaches based on large matched samples of data from companies and employees.

A third issue lies in the potentially endogenous nature of the diversity, which may be due at least in part to companies' performance. Beyond the heterogeneity in the observable characteristics of companies and employees, a difficulty relates to the effects of unobserved determinants of company performance, which can sometimes be correlated with the greater or lesser diversity of their human resources. To control for the effect of this unobservable heterogeneity, the most classic approach is to use panel data and estimates with company effects that are fixed across time, which requires a sufficiently long-term dimension. Moreover, the researcher who wishes to identify the causal impact of age or gender diversity on productivity must guard against the feedback effect of productivity on age or gender diversity (reverse causality). Because a highly efficient company generates high profits and is able to offer attractive remuneration, it may choose a proactive policy to promote diversity. It may then automatically attract particular profiles of job applicants most interested in these elements, who may be over-represented in certain socio-demographic groups, leading to a statistical bias in the estimates. This is an example of one of several mechanisms that lead to the existence of a reverse causality from performance to age or gender diversity, the existence of which requires the researcher to implement a particular data processing strategy to offset this type of bias (instrumental variable methods in particular).

Only a very small number of studies have faced these three difficulties head-on, using large samples of matched employer-employee panel data, with a time dimension long enough to neutralize unobservable heterogeneity using company fixed effects, and with an explicit identification strategy to deal with endogeneity bias.

3.2.1. Concepts and measurements

In their article and within the context of residential segregation, Massey and Denton (1988) consider five dimensions for diversity. According to them, diversity is a multidimensional phenomenon varying along with five axes. First, evenness compares the relative size of the groups across geographical units, is not measured in an absolute sense but is scaled relative to some other group; in this case, the dissimilarity index is advised as a measurement. Second, there is the degree of potential contact, *i.e.* the possibility of interaction between minority and majority groups within a geographic area, what the authors refer as to exposure; isolation and interaction indices are recommended. Third, Massey and Denton (1988) consider the relative amount of physical space occupied by a minority group, that is called concentration; relevant measurements are relative concentration index or spatial measures. Fourth, a group may be located spatially near the center of an urban area (centralization); the absolute centralization index may be used as a measurement. Fifth and last, minority groups are distributed in a 'contiguous and closely packed' way, creating a single ethnic or racial enclave, what is called clustering; corresponding measurement is the index of spatial proximity.

Following the five considered dimensions, various indicators are suggested. The share of the given population, for instance that of foreign-born in the total population; however, this seems unlikely to be a true measure of diversity because within-group homogeneity is supposed. The fractionalization index takes account for within-group heterogeneity: it is informative both in terms of evenness (equiprobability/uniform) and richness (number of different diversity types). The following indicator is proposed (Alesina *et al.*, 2003):

$$Diversity_{it} = 1 - \sum_{g=1}^{n} share_{git}^{2} \tag{7}$$

To take account for the size of dominant groups (Dawson, 2012), two modified version of the fractionalization index were proposed. Alesina *et al.* (2016) remove the influence of the dominant group but also within group heterogeneity. Kahane *et al.* (2013) include a relative share variable, constructed by the share of the non-dominant group.

Otherwise, the Shannon-Weaver entropy index was proposed, based on information theory (Shannon, 1949; Shannon-Weaver, 1963; Theil, 1967). It allows calculation of the frequency of each group, and also weights each group according to its frequency (Parrotta *et al.* (2014), Ostergaard *et al.* (2011):

$$Shannon_{it} = -\sum_{g=1}^{n} share_{git} \ln(share_{git}) \tag{8}$$

This index is more robust to extreme values, but less sensitive to intermediate values (Jost, 2007).

3.2.2. Nonlinear approach

In a widely cited article that relate to the concept of diversity is that of Harrison and Klein (2007). The authors stress the need to conceptually distinguish between different approaches, and propose to consider three types of diversity. Separation refers to the diversity of points of view and systems of attitude. Variety expresses the diversity in the nature of experiences and expertise. Disparity refers to differences in level of experience and expertise. In the current study, we adopt a more restrictive definition of diversity by considering only the composition of the salaried workforce of companies in terms of considered category of workers (namely: female, young and old workers). We use the term "age-gender diversity" to qualify this composition.

The methodology must be adapted to the particularities of these two variables. Gender is a dichotomous variable, summarized at the company level by the proportion of women in the workforce. In addition, gender is generally assumed to be independent of productivity. Age is a continuous variable, which can also be expressed as an ordered polytomous qualitative variable. The age distribution may be imperfectly summarized by the share of those under 30, for example. Unlike gender, age is correlated with productivity (Lazear, 1976). Because of these differences, identification is carried out separately for age and sex. In this article, the methodology is first applied to female workers and then transposed to the case of workers under 30 ("young workers"), and then to female workers younger than 30.

We measure business performance, considering a single synthetic indicator, the company's apparent labor productivity. Given the high sensitivity of this indicator to the economic situation, we assess it on average over the duration of a business cycle.

In our article, we consider an original approach, that is inspired by Chetty *et al.* (2014). Quoting Dahl and De Leir (2008), the authors use a nonlinear approach to analyze intergenerational social mobility between parents and their children in the US.
Our aim it to measure locally, per quartile of firms as to the share of given employed population in overall, the impact of an additional diversity on labor productivity. We focus on the marginal effects of a gain of one percentage point for the employment category (female, young or old workers).

We proceed in two steps. Before implementing our method, a first step consists in purging or netting out the empirical distributions of the share of female, young or old workers in the company's workforce, to account for factors related to productive choice or organizational choice not directly related to the diversity. In fact, firms gradually build up their workforce through hiring and firing. Even if they have no particular bias in favor of a particular structure in terms of female, young or old workers, they hire people from employment pools whose structure varies over time and space. In these different recruitment pools, the proportion of women is not the same over time (due to the increasing numbers of women in the workforce), and location (due to a specific geography of female activity), and depending on the industry and profession (in a context marked by phenomena of gendered educational orientation, school segregation and occupational segregation of women). The same holds also for young or old workers, which is variable in the temporal (aging workforce) and spatial dimensions.
Our first step therefore consists in neutralizing all the gender or age determinants of professional structures which could explain the differences between companies. For example, the proportion of women differs from one profession to another and companies recruit from various professional structures. To neutralize these differences, *ceteris paribus*, it is important to reconstruct the proportion of women in each company, by controlling all of its determinants: technological and organizational choices, job structure by qualification, etc. It is a question of netting out the empirical distributions of the firm workforce by sex or age. To do so, we have regressed at the level of each company the average share (in the time dimension) of women on the average age of the firm, its average capital intensity, and its average wage share in value added. We also take into account the structure of jobs by adding, in the explanatory variables, the average shares of blue-collar workers, intermediate occupations and executive workers. We include the dummies corresponding to industries to which the company belongs (French NAF2003-rev. 2, disaggregation according to the nomenclature in 31 levels; NAF2003). Finally, we take into account the size of the company's workforce by considering 7 size ranges (20-50, 50-100, 100-250, 250-500, 500-1000, 1000-2000, 2000-5000, 5000 workers and more).
Thus, the estimated model stands as follows:

$$\overline{\text{share}_i} = \alpha_0 + \alpha_1 \overline{\text{firm\_age}_i} + \alpha_2 \overline{\text{CI}_i} + \alpha_3 \overline{\text{s\_wages}_i} + \alpha_4 \overline{\text{s\_blue-collar}_i} + \alpha_5 \overline{\text{s\_inter\_occup}_i} + \alpha_6 \overline{\text{s\_excutives}_i}$$
$$+ \alpha_7 \overline{\text{s\_full\_time}_i} + \sum_{b=1}^{B} \beta_b \text{business}_{b,i} + \sum_{s=1}^{S} \beta_s \overline{\text{firm\_size}_{s,i}} + \sum_{r=1}^{R} \beta_r \overline{\text{s\_region}_{r,i}} + u_i \qquad (9)$$

where $\overline{\text{share}_i}$ is the average (in the time dimension) share of female (or young, or old) workers; $\overline{\text{firm\_age}_i}$ refers to the average age of the firms over the period considered, $\overline{\text{CI}_i}$ to the average

capital intensity and $\overline{\text{s\_wages}}_i$ to the average share of wages in value added; $\overline{\text{s\_blue\_collar}}_i$, $\overline{\text{s\_inter\_occup}}_i$, $\overline{\text{s\_executives}}_i$, and $\overline{\text{s\_full\_time}}_i$ to the average shares of different job categories in the workforce of the given company; the dummies $\text{business}_{b,i}$ and $\overline{\text{firm\_size}}_{s,i}$ correspond respectively to the business sector *b* and to the size group *s* of company *i* (on the basis of average workforce over the considered time period); $\overline{\text{s\_region}}_{r,i}$ the share of jobs in company *i* located in region *r*. In the equation for the share of female workers we add the share of those workers older than 49, and in those relating to young or old workers we add the share of women. u_i is the error term, that is averaged in the time dimension.
This equation is estimated at the level of the economy as a whole, and for each business sector (considering six main industries). It allows us to obtain a distribution of the variables of interest (female, young or old workers' share) that excludes technological choices, employment structure and company size. For the remainder of the study, as a variable of interest, we use the estimated error term $\hat{u}_i$, which is by definition independent of all the explanatory variables describing the organization of the company. We call it "fixed effect" and denote it as share_i. The latter corresponds to the average share of female, of young or old workers in the company, which is not correlated to any of the determinants of the share of female, of young or old workers that appear in the estimated equation. It is a measure of the average (over time) residual share of female, of young or old workers in the company.

The second step enables us to assess the marginal impact of a diversity supplement on productivity while allowing this effect to vary along the distribution of companies in terms of gender diversity. As noted above, this measure is inspired by the indicators used by Chetty *et al.* (2014) in their study on intergenerational social mobility in the United States.
This method provides a common framework that makes it possible to estimate the impact of age or gender diversity on the company's performance, both on the distribution tails or along the distribution of the proportions of young / old people or women employed. Second, it does not make any assumptions about the presence and form of nonlinearity since it is based on estimates by percentile of female, of young or old workers.
The "fixed effect" of companies (for the proportion of female, of young or old workers) is broken down into quartiles. In practice, for each quartile q_j ($j = 1, \dots, 4$), we estimate the following equation:

$$\ln(\overline{\text{lab\_prod}}_i) = \gamma_0 + \gamma_1 \text{share}_i + \sum_{b=1}^{B} \beta_b \text{business}_{b,i} + \sum_{s=1}^{S} \delta_s \overline{\text{firm\_size}}_{s,i} + \sum_{r=1}^{R} \lambda_r \overline{\text{s\_region}}_{r,i} + \beta.\overline{\text{firm\_age}}_i + \varepsilon_i, \text{ for } i \in q_j \qquad (10)$$

However, the potential nonlinearity detected during these regressions may be contingent on the chosen specification and therefore on the interpretation of the coefficient (proportion, semi-elasticity, for instance).
To reason in terms of semi-elasticity, the outcome variable is considered as a logarithm. However, estimating the relationship between atypism (or diversity) and company performance by taking the logarithm of productivity leads to the exclusion of companies with zero productivity. Moreover, it is not necessarily the difference between the proportion of workers between two companies that explains the difference in performance, but rather the fact that one company employs a higher

proportion of women than another company. In other words, the relationship between atypicality or diversity and performance is not necessarily cardinal but could be rather ordinal.
Rank regressions then make it possible to estimate the link between the rank of the company in terms of share of a category of workers and the rank in terms of performance, without excluding firms with zero productivity. In addition, they make it possible to account for an ordinal relationship between the shares of female, of young or old workers in a company's workforce and the company's performance. The considered equation is then:

$$\text{rang}\left[\text{lab\_prod}_i\right] = \gamma_0 + \gamma_1 rang\left[\text{share}_i\right] + \sum_{b=1}^{B} \beta_b \text{business}_{b,i} + \sum_{s=1}^{S} \delta_s \overline{\text{firm\_size}}_{s,i} + \sum_{r=1}^{R} \lambda_r \overline{\text{s\_region}}_{r,i} + \beta.\overline{\text{firm\_age}}_i + \varepsilon_i \text{ , for } i \in q_j \quad (11)$$

The estimated coefficient $\hat{\gamma}_1$ is plotted for each quartile (or rank quartile). For a company *i* belonging to the quartile (or rank quartile) q_j, $\hat{\gamma}_1$ measures within the quartile q_j the "effect" on productivity of increasing the proportion of the job category by one percentage point (or by one position when considering the rank regression). We can then see how this association is distorted when we move from one quartile (or rank quartile) to another. For example, if it is positive and decreasing with quartiles (or rank quartiles), the sequence of $\hat{\gamma}_1$, is symptomatic of a decrease in productivity gains as the share of the job category increases. Conversely, if it is negative and decreasing with quartiles, the sequence of $\hat{\gamma}_1$ is symptomatic of a decrease in productivity loss as the share of the job category decreases.

3.2.3. Association VS. causal effect

Presentation
Two estimation methods are used. One is estimation through multiple regression analysis using ordinary least squares. The other is estimation through instrumental variables.
Ordinary least squares provide us with associations between gender / age diversity and productivity. We regress productivity on diversity while controlling for a set of variables to take account of technological and organizational choices, and job structure by qualification, as well as for a (potentially large) set of dummies (firm size, industries, firm location). These variables may be correlated both with diversity and labor productivity. allows to reason *ceteris paribus*. It represents a first way to analyze the link between diversity and firm performance.
On the contrary, instrumental variable estimation aims at evaluating the causal effect of diversity on firm performance. This strategy tries to take account for endogeneity of the diversity. It requires to find an exogenous variation in diversity, *ie.* at least one (or several) instrumental variable(s), a variable that is correlated with diversity, but not with the error term of our labor productivity equation. It is designed to isolate the effect of gender or age diversity (in terms of young or old workers employed) on labor productivity. Thus, the choice of an instrument is based primarily both on the results of standard statistical tests of weak instruments (Stock and Yogo, 2005), in turn supported by theoretical and / or factual arguments. Therefore, the choice of instruments is an important step that should be discussed. In this article, we wish here to highlight the potential effects of gender and age diversity of the workforce on labor productivity.

Potential bias while evaluating the impact of diversity

Biases may arise from estimating our equations through OLS if we try to uncover causal effect of diversity thanks to multiple regression analysis.
First, we may have to account for unobserved heterogeneity related to both diversity and firm performance (omitted variable bias). The diverse composition of firms may correlate with unobserved factors that affect the economic performance of these cities and firms. Investment in state-of-the-art machinery by a firm's management may improve the productivity of both firms and workers and could potentially correlate with the diversity of the firm workforce (Ozgen, 2021).
Second, we may face reverse causality (simultaneity bias). Usually, larger companies with high productivity are more concerned with corporate social responsibility and thus take care for the composition of their labor force (especially high skilled workers). Better work conditions in performing firms may attract diverse groups of workers, while diverse workforce can affect the level of productivity in firms through diversity of knowledge and creativity.
Third, we may have to cope with potential error measurement. Our interest variables (residual shares) are estimated and thus induce attenuation bias.

What kind of instrument can we consider?
To face reverse causality between productivity and gender / age diversity, and as mentioned above, we have to consider as instruments variables for which we hope to have good properties: both exogeneity and correlation with the proportion of female, young or old workers in the firm workforce.
In the literature that focuses on the choice for such instrumental variables, and within the residential segregation context, Card (2001) mention that the most commonly used instruments to-date is the historical share of immigrants. The idea is that existing groups of immigrants attract newcomers from the same group of origin. To the extent that the existing country fellows attracting the newcomers correlate with the increase in diversity, rather than with location-specific productivity shocks, the effect of diversity is interpreted as causal (Ottaviano and Peri, 2005). The initial share of immigrants by country of origin in a given region by a lagged period is used to calculate the growth rate of each group within the whole country for the entire study period. However, such an instrument may be invalid instrument if current economic circumstances continue to adjust to past immigration flows or shocks. In this situation, past immigration would continue to correlate with the current outcomes, for example wages (Jaeger *et al.*, 2018). This issue is less of a concern though when home country-related push factors (*e.g.* wars or forced migration) are the driving force behind the inflow of immigrants rather than the economic cycles of the host country (*e.g.* Edo, 2020). Moreover, the past economic conditions that determined the location choice of immigrants are serially correlated over time (Lewis and Peri, 2015). The use of deeper lags can help to reduce the correlation with current economic outcomes.[10]
A generalization of such a strategy is suggested in meso-level analyses. At the cities or regions level, analyses frequently make use of instrumental variable estimations in which push or pull factors are used as instruments for the level of diversity, where push factors refer to characteristics of the sending countries (*e.g.* geographical and/or cultural distance between the sending and the receiving countries), and pull factors to those of the receiving countries (*e.g.* number of immigrants already residing in the receiving countries, multicultural level in the cities or regions).

[10] Alternative instruments were thus suggested, like policy reforms. For instance, using the British Household Panel Surveys, Longhi (2013) addresses the self-selection of migrants to neighborhoods by using 'The New Deal Programme' of the British government as an instrument.

Such kind of instruments is also widely used in firm-level analyses. In a first case, one considers as an instrument the diversity index calculated at the geographical level, like in Parrotta *et al.* (2014a,b). In this article, for diversity at the firm level, indices of workforce diversity in cultural background, education and demographic characteristics, computed at the commuting area where the firm is located (Andersen, 2002; Nevo, 2000) are considered. In a second case, diversity is computed at the industry level. For instance, to instrument the R&R expenditures at the firm level, Lev and Sougianis (1996) consider for the given firm the average level of R&D expenditures (deflated by sales) of the other firms in its four-digit SIC code. It grounds on the fact industry R&D level is obviously unaffected by firm idiosyncratic shocks (*e.g.*, a specific managerial strategy or a corporate control change affecting the firm's cost of capital), thereby considerably limiting its correlation with the original regression error term. Strong reasons to believe that the correlation between a given firm's R&D expenditures (the original variable) and the industry average (the instrument) is generally high. Corporate activities are often evaluated by investors and financial analysts against industry norms, deterring managers from significantly deviating from them. Another example is given in the article by Hanlon *et al.* (2003). The average employee stock option (ESO) grant value of other firms in the same four-digit SIC code is the instrument for ESO grant values for a given firm. It is an appealing instrumental variable because it is unlikely to be affected by firm-specific shocks such as a shift in the firm's corporate strategy to respond to an increase in firm-specific product demand. Moreover, the industry-average ESO grant value is likely to be highly associated with a firm's ESO grant value because option grants in one firm are likely to be influenced by industry-wide option granting practices (Murphy, 1999).
Based on those examples, what kind of instrument could we consider as to diversity of the workforce? Garnero *et al.* (2016) consider the workforce composition of the other firms in the same industry excluding the focal firm to instrument the diversity index value at the firm level. When defining its workforce, a firm is to some extent constrained by its own technology and work content that might require younger or more experienced workers, skilled or unskilled workers, more men or more women.
Therefore, in context of our article, two kinds of instruments are considered for diversity index in terms of gender or age: a diversity index computed on the workforce composition of the other firms at the same location (city or French department) as the considered firm; a diversity index computed on the workforce composition of the other firms in its four-digit SIC code.

What is the effect identified by our IV estimates?

- the share of female or young people among part-time employees in the company? Is it an average effect, or is it a local effect, *i.e.* on a particular group of firms with female or young workers?

The instrument may only allow us to identify the effect of diversity for a sub-group of firms for which a change in the share of female (or young workers) employed part-time (instrument) implies an increase in the diversity of female (or young workers) which is a potentially endogenous variable. In this case, it is more a question of a local effect contingent on these particular firms (the "compliers" according to Angrist *et al.* (1996)).
In our case, when firms increase part-time employment, the "compliers" correspond to firms which recruit mainly women or mainly men on a part-time basis (polarized recruitment policy). In this case, they also change the share of women in the firm. On the other hand, if a firm recruits the same proportion of men and women part-time, the share of women will not be affected. We can see that the first type of company corresponds more to atypical companies, whereas the second type refers to companies that are more diversified in terms of their workforce composition (female, young workers).

As a consequence, the effect measured with this instrument is rather specific to the group of companies with a polarized recruitment policy, *i.e.* "atypical" companies. The effect is then qualified as the local average treatment effect (LATE) and does not correspond to the average treatment effect (ATE) for the entire population of firms.

4. Data

4.1. Basic statistical sources

We consider data from two different administrative sources available at INSEE (the French national institute of statistics) over 1995-2015. The first data source is the DADS (*Déclarations Annuelles de Données Sociales*), which is a matched employer-employee longitudinal data source, constructed from companies' reports to the French administration collecting the social contributions, URSSAF-ACOSS. The second source is another administrative source called FARE (*Fichiers Approchés des Résultats d'Esane*)-FICUS (*FiChiers Unifiés de Suse*), which gives us measures of sales, value-added and other economic outcomes for most French companies.

The DADS data source includes data on all workers employed in private and semi-public establishments. INSEE receives information from URSSAF-ACOSS in order to compile statistics on employment and wages in France. This file is exhaustive and has been available from 1995. However, the source has grown richer over time (addition of information, number of companies, industries represented) and has undergone several format changes, notably between 2001 and 2002, then between 2008 and 2009, when the current format was implemented. Therefore, we use this exhaustive data aggregated at the company level – for the years 2009 to 2015. For each year, we have a sample of approximately 1,300,000 firms. Individual wages, employment periods, age, gender, and the skill level of the workers are available. We thus can compute proportions of female, young and old workers in each company.

The FARE-FICUS dataset gives information at the firm level about the parent company to which subsidiaries belong. It results from a comparison between tax sources and the results of annual business surveys. This information is available for all firms that are subject to the two major tax regimes. These regimes cover virtually the entire productive system, representing roughly 95 percent of taxable companies in terms of sales. As with the DADS (French Annual Social Data Declarations), the data source underwent format changes, particularly between 2007 and 2008-2009, when the original FICUS source was replaced by FARE; the 2008 version thus contained significantly fewer variables than before and after 2008. The scope of the survey was also broadened during the implementation of FARE. The survey was stabilized in 2009. Therefore, the data were kept for the period 2009-2015. For each year, we have a sample of approximately 2,500,000 companies. They mostly contain various economic indicators, such as value-added, capital investment, and profits. In particular, they allow us to measure the labor productivity, capital intensity and the labor share income of companies.

4.2. Final samples

The preliminary stage consists in netting out the share of female, young or old workers. To obtain our study sample, we follow several steps.

First, we assume that companies' choices regarding gender and age employment structure – apart from technological considerations, distributions by qualification and company size – vary little over a short time period. This hypothesis requires a time dimension long enough to estimate the effects of diversity *i.e.* to get a sample characterized by a homogeneous economic situation. Given that DADS and FICUS data are available in a stable manner between 2009 and 2015, this is the study period that we will consider for our analysis. Second, one drawback of considering all firms, even small ones, is the potential indivisibility of the employment categories in small firms. To avoid this, we consider only companies with 20 workers at least.

Third, we restrict our sample to firms from non-farm and non-financial private businesses. We therefore exclude firms from Agriculture, hunting and forestry, aquaculture and fishing industries, because they are associated with industries that are not very competitive and are highly regulated. Since they do not belong to the private business sectors, we drop from our sample all firms from the public administrations . As well, we do not keep information that deal with household activities or extra-territorial activities where we do not have all the information on labor in the DADS. Finally, financial industries where labor productivity is not the most appropriate indicator to measure the company's performance are also excluded.

Fourth, since we are working with companies over the period 2009-2015, we can use a stable sample of companies over time by considering established companies with 20 or more employees (a so-called balanced sample). However, such a strategy implies removing from the sample companies for which information is not available for the entire period (due to new businesses or bankruptcies, for example), due to company demographics, and in particular companies employing a small number of employees. It thus may introduce a potential attrition bias in the estimations. Considering the sample—the so-called balanced sample—containing information on all companies present over the 2009-2015 period, and not just those established over the period, allows us to circumvent this problem, even if the information does not necessarily relate to the same companies from year to year. This is why we will conduct our analysis by distinguishing the two types of balanced and unbalanced samples: the first contains 56,620 firms, and the second 124,295 firms.

Fifth and finally, the reverse causality between age or gender diversity and labor productivity could be linked to the social dimension of corporate social responsibility (CSR; Liu *et al.*, 2018; Non *et al.*, 2022). This mainly concerns large companies, which are the most productive and also the most concerned about their image and public relations. Beyond their legal obligations, these companies can thus adopt a proactive diversity policy and increase the proportion of female, young or old workers in the most visible positions (management teams, senior executives, boards of directors). These positions are the most highly skilled and are generally full-time, unlike less visible jobs, which are consequently less skilled and much more often part-time. To avoid having to deal with this type of bias or wrongly attributing an effect of diversity rather than CSR policy to our results, we exclude companies that have undertaken such initiatives.

In the end, our samples include 56,269 firms for the balanced one, and 111,248 for the unbalanced one.

Appendix A display basic descriptive statistics on all variables for the balanced panel (Table A1). It also includes features concerning our variables of interest: it contains shares of female workers, of young workers (less than 30), old workers (more than 49), young and old female workers, for the overall economy, as well as for six main industries: manufacturing; construction; trade and accommodations; transportation and communication; real estate, rental and business services;

education, health and social assistance (Tables A2 and A3).[11] Both panels exhibit similar statistics.[12]

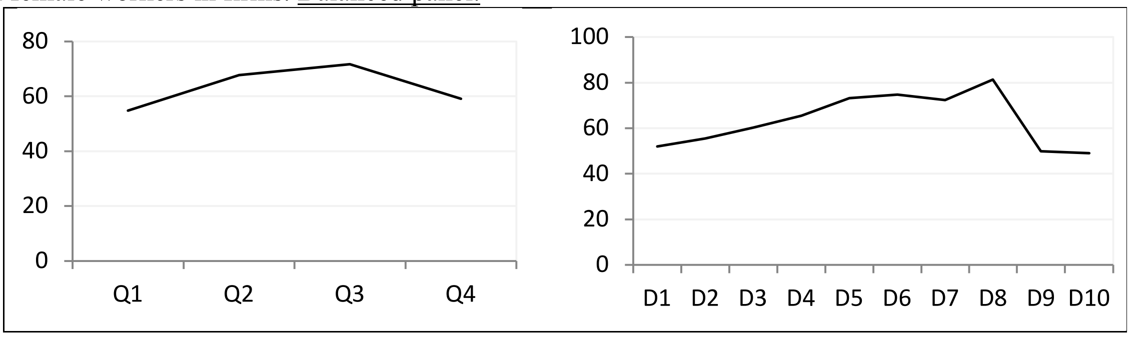
4.3. Descriptive statistics

We present some stylized facts on the relation between labor productivity and the distribution of labor in terms of women, young, seniors, and for the intersections (young women and senior women). We represent labor productivity against the share of the given category of workers on average over our 2009-2015 panel of firms, for the overall economy, and by industry.[13]

4.3.1. Overall economy

Graphs 1a plots labor productivity against deciles or quartiles of the share of female workers in the company's workforce. The relationship between labor productivity and the proportion of female workers in firms in the balanced sample takes the shape of an inverted *U*-curve, suggesting that productivity is higher in firms with greater gender diversity. Productivity reaches its maximum between the second and the third quartiles (sixth and eight deciles). It means that firms employing a small or large proportion of female workers are characterized by low labor productivity. By contrast, productivity is highest for companies whose proportion of female workers is located in the neighborhood of the average proportion of female workers in our sample of companies. The same kind of shapes are observed for the unbalanced panel.[14]

Graph 1a. Gender composition of firm workforce. Labor productivity against quartiles or deciles of the share of female workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of female workers in the firm's workforce.

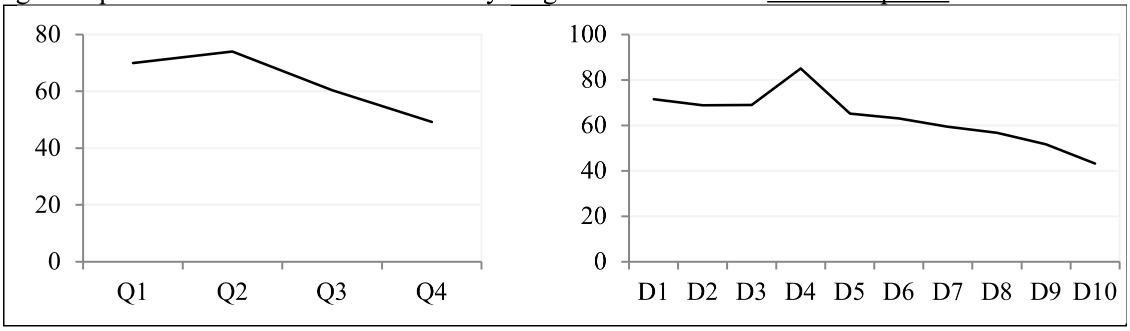
Focusing on the share of young workers (employed people under 30), the relation between labor productivity and the proportion of young workers (under 30) in firms in the balanced sample also

[11] For both panels, we only keep firms that operate in the same industry over time. Nevertheless, this does lead to drop only a small number of firms.
[12] Corresponding composition of the workforce is similar for the unbalanced panel. It is available on request.
[13] Appendix A displays basic descriptive statistics concerning our variables of interest, *i.e.* the average composition of the firm workforce for the considered sample. It contains shares of female workers, of young workers (less than 30) and old workers (more than 49), for the overall economy. We also include the same shares in six main industries: manufacturing; construction; trade and accommodations; transportation and communication; real estate, rental and business services; education, health and social assistance. Finally, we add shares of young and old female workers.
[14] Corresponding graphs are available on request.

takes the shape of an inverted *U*-curve, suggesting that productivity is higher in firms with a more balanced age composition in terms of young workers, but with a maximum for the second quartile or the third-fourth deciles (Graph 1b[15]).

[15] We get almost the same findings considering the unbalanced panel. Corresponding graphs are available on request.

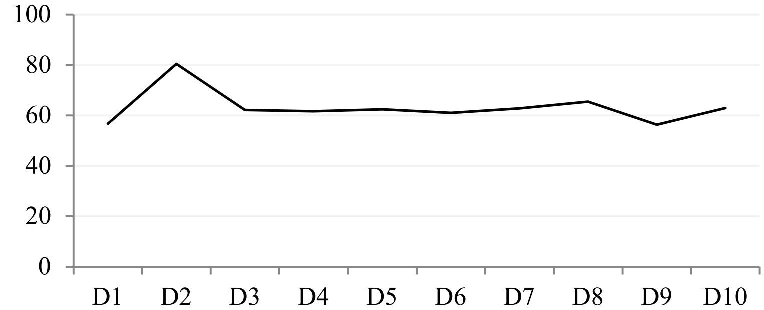
Graph 1b. Composition of firm workforce in terms of workers younger than 30. Labor productivity against quartiles or deciles of the share of young workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of workers younger than 30 in the firm's workforce.

Concerning old workers (more than 49), things are less clear-cut. However, productivity peaks in the second decile, and is lower in particular in the first and last decile.[16]

Graph 1c. Composition of firm workforce in terms of workers older than 49. Labor productivity against deciles of the share of old workers in firms. Balanced panel.

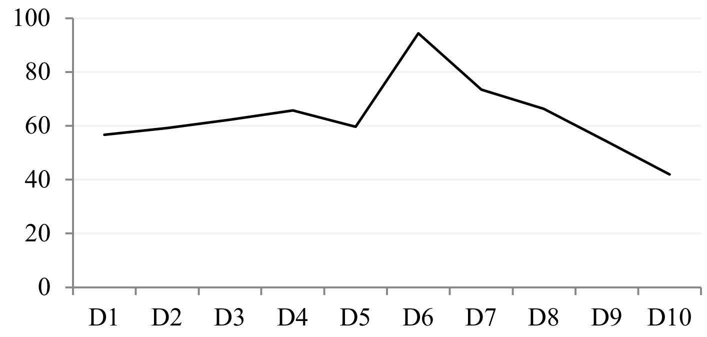


Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given decile of firms in terms of the share of workers older than 49 in the firm's workforce.

Finally, we combine the two criteria of gender and age. We thus consider young female and old female workers. For these two categories of workers, we find the same type of stylized facts. The relation between productivity and the share of young female workers also takes shape of an inverted *U*-curve, similar to that observed for female workers in general. Productivity peaks at the second-third (or sixth decile, see Graph 1d).

[16] The same holds with the unbalanced panel.

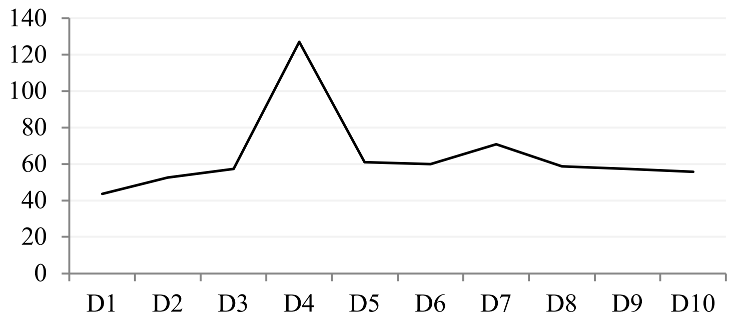
Graph 1d. Composition of firm workforce in terms of female younger than 30. Labor productivity against deciles of the share of young female workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given decile of firms in terms of the share of young female workers in the firm's workforce.

Besides, the relation between productivity and the proportion of senior female workers in firms in the balanced sample also shape of an inverted *U*-curve, suggesting that productivity is higher in firms with a more balanced share of senior women (peaking in fourth quartile).[17]

Graph 1e. Composition of firm workforce in terms of female older than 49. Labor productivity against deciles of the share of old female workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given decile of firms in terms of the share of old female workers in the firm's workforce.

In the end, for female, young or old (even if less clear-cut) workers, if we control for firm size and capital intensity, there appears to be an inverted *U*-shaped relationship between labor productivity in the firm and the share of the female, or young (resp. to a lesser extent old) worker. Therefore, companies with the lowest productivity are characterized by a small or large proportion of female or young workers. Companies in-between, with greater workforce diversity, are associated with greater labor productivity levels.

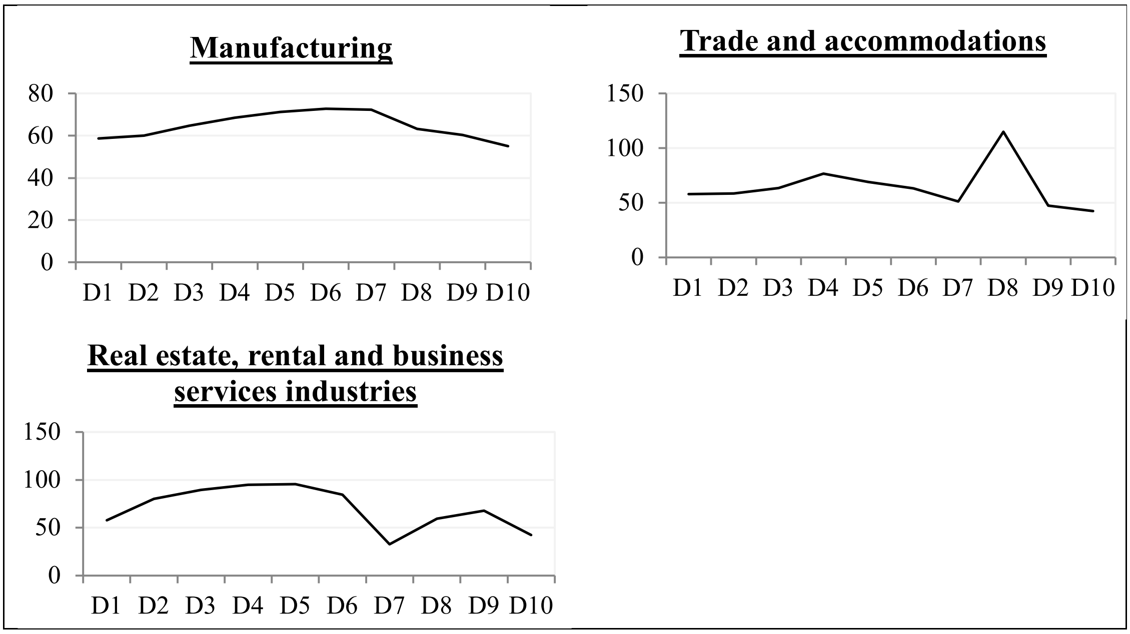
[17] The unbalanced panel exhibit the same kind of features, as do graphs plotting labor productivity against quartiles of the share of the given working population (young or old female workers).

4.3.2. By industry

What is observed at the level of the whole economy is a reflection of what is observed at the industry and can at least be explained or corroborated by what is observed at the sectoral level. In what follows, we focus on the balanced panel.

As to gender composition of the workforce, the economy-wide (56,269 firms) productivity maximum observed in deciles five to seven seems to be driven by the industries that carry the greatest weight in the economy (67% of the firms in the sample), namely manufacturing (13,460 firms; peak in deciles six to eight), trade and accommodations (15,285 firms; peak in decile eight), and real estate or business services (9,272 firms; peak in deciles five-six). Compared with the economy as a whole (36.68% female workers in firms employing at least workers), these industries include both those with relatively fewer women (manufacturing; 28.82%) and those with substantially more (trade, 43.71%; real estate, 48.5%).

Graph 2a. Labor productivity against deciles of the share of female workers in firms. Balanced panel.

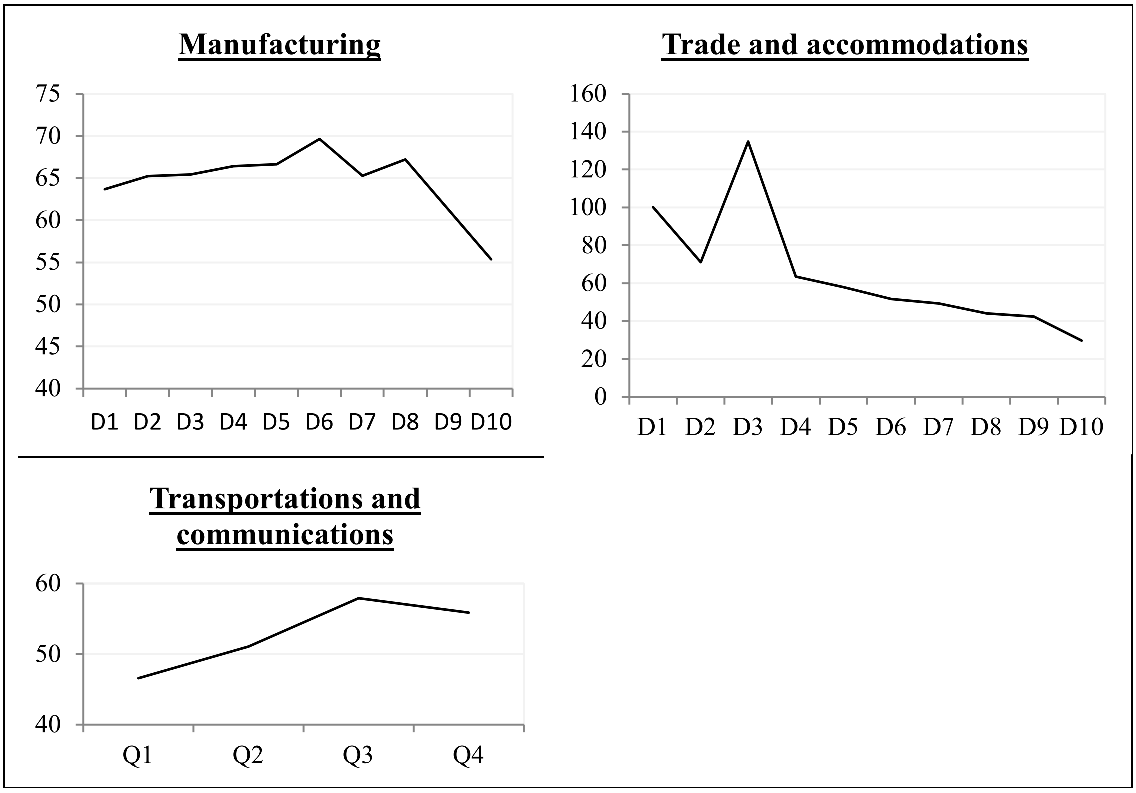


Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of female workers in the firm's workforce.

Focusing on the working population represented by workers younger than 30, the productivity maximum for the economy as a whole in Q2 / D3 is driven by industries that carry the greatest weight in the economy (59% of the firms in the sample), namely: manufacturing (peak in sixth decile), trade and accommodations (third decile), and transportation (third quartile). Compared with the overall economy (26.14% young workers), these industries include both those with a lower share of young employees (industry: 18.51%; transportation: 16.98%) and those with a much higher share (commerce: 36.10%).

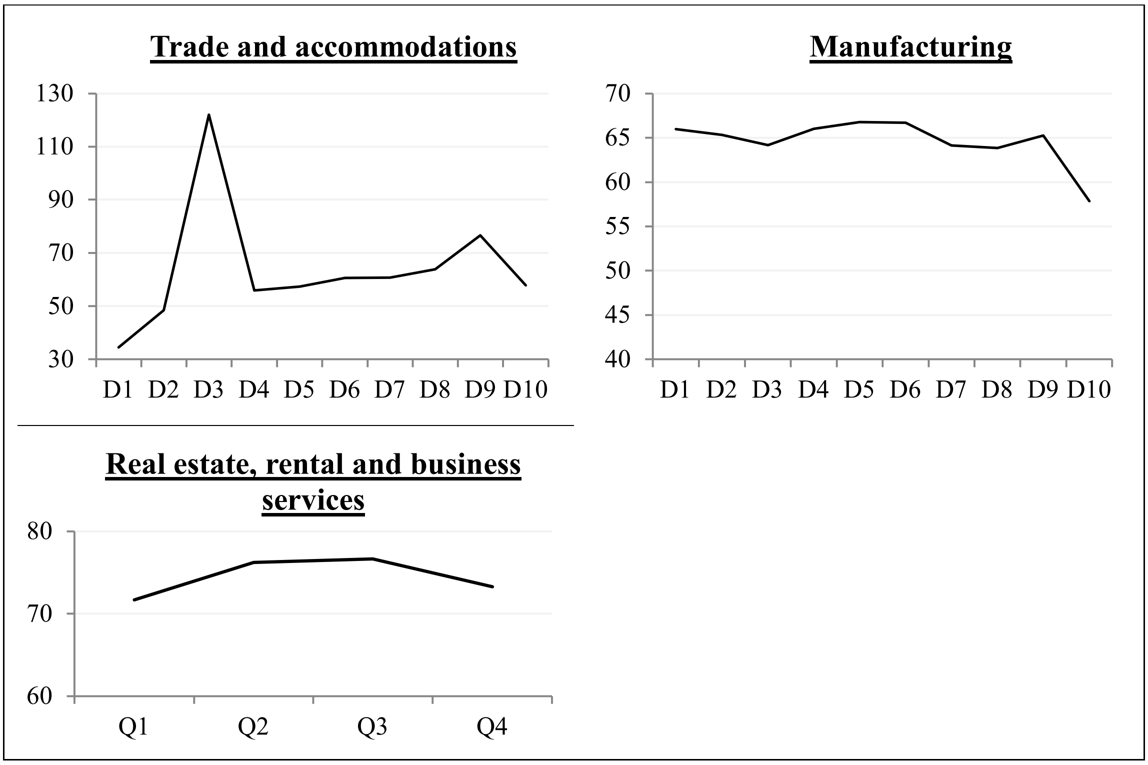
For senior workers, the productivity maximum for the economy as a whole (56,269 firms, about 22% senior workers) in second decile is driven by the dominance of the commerce industry (26% of the sample; peak in third decile). However, the other industries that display a bell-shaped curve (manufacturing, 24%; real estate/business services, 16%), the distribution is rather flat (a "slight" peak in fifth decile for manufacturing, with 27% senior workers; likewise, in second-third quartiles for real estate/business services, with 20% senior workers).

Graph 2b. Labor productivity against deciles or quartiles of the share of young workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of young workers in the firm's workforce.

Graph 2c. Labor productivity against deciles or quartiles of the share of old workers in firms. Balanced panel.

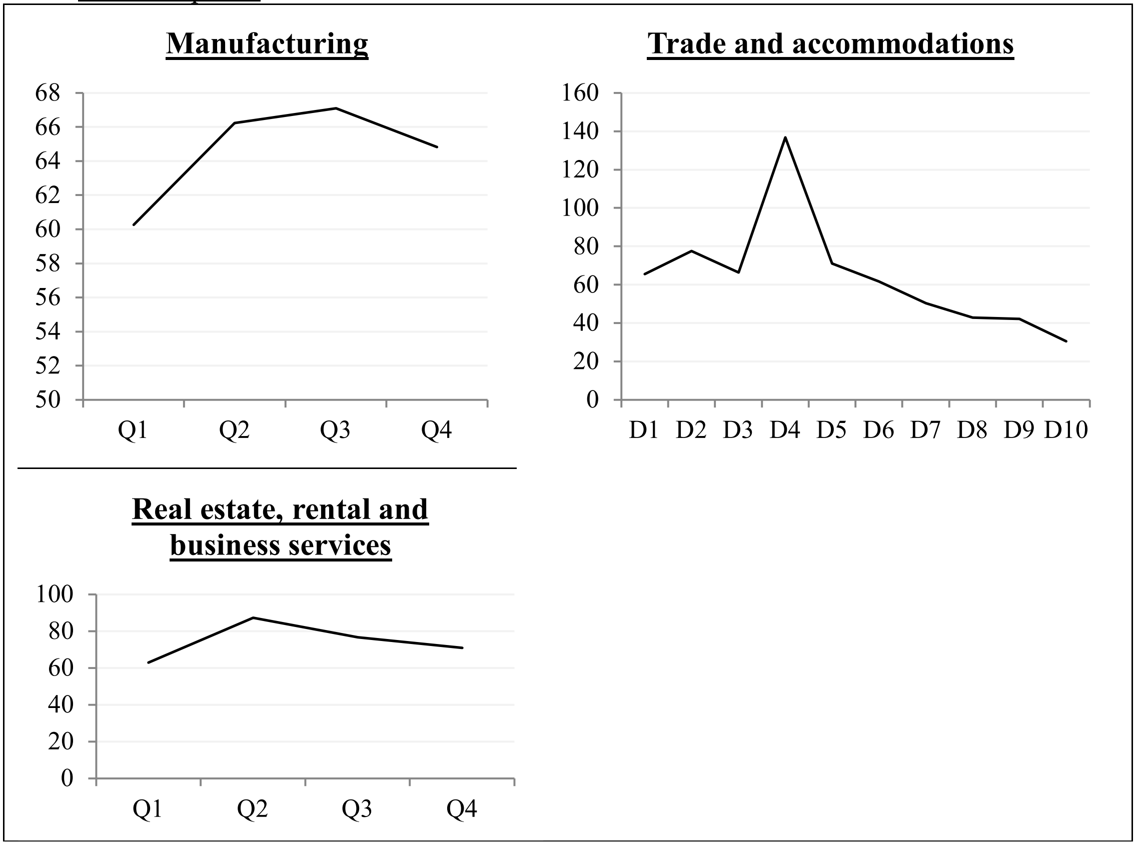


Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of old workers in the firm's workforce.

Finally, if we look at what happens when the employed population is young female or old female workers, we observe the same type of inverted *U*-shaped relationship as at the level of the whole economy in a small number of industries. Indeed, the peak in labor productivity for the economy as a whole in third quartile / sixth decile is driven by industries that carry the greatest weight in the economy (68% of the firms in the sample), namely manufacturing (peak in Q2–Q3), trade and accommodations (peak in D4), and real estate (peak in Q2). Compared with the economy as a whole (10.49% young women), these industries include both those with a lower share of young women (industry: 5.05%) and those with a much higher share (commerce: 17.40%; real estate: 12.18%). As well, for old female workers, the highest labor productivity level in the economy as a whole in Q2 / D5 is driven by the industries that carry the greatest weight in the economy (68% of the firms in the sample), namely manufacturing (peak in D6), trade and accommodations (D4), and real estate (D6). Compared with the economy as a whole (7.24% senior women), these industries include both those with a lower share of senior female workers (trade: 6.38%) and those with a much higher share (manufacturing: 7.79%; real estate: 8.24%).[18]

[18] The unbalanced panel gives rise to the same kind of features.

Graph 2d. Labor productivity against deciles or quartiles of the share of young female workers in firms. Balanced panel.

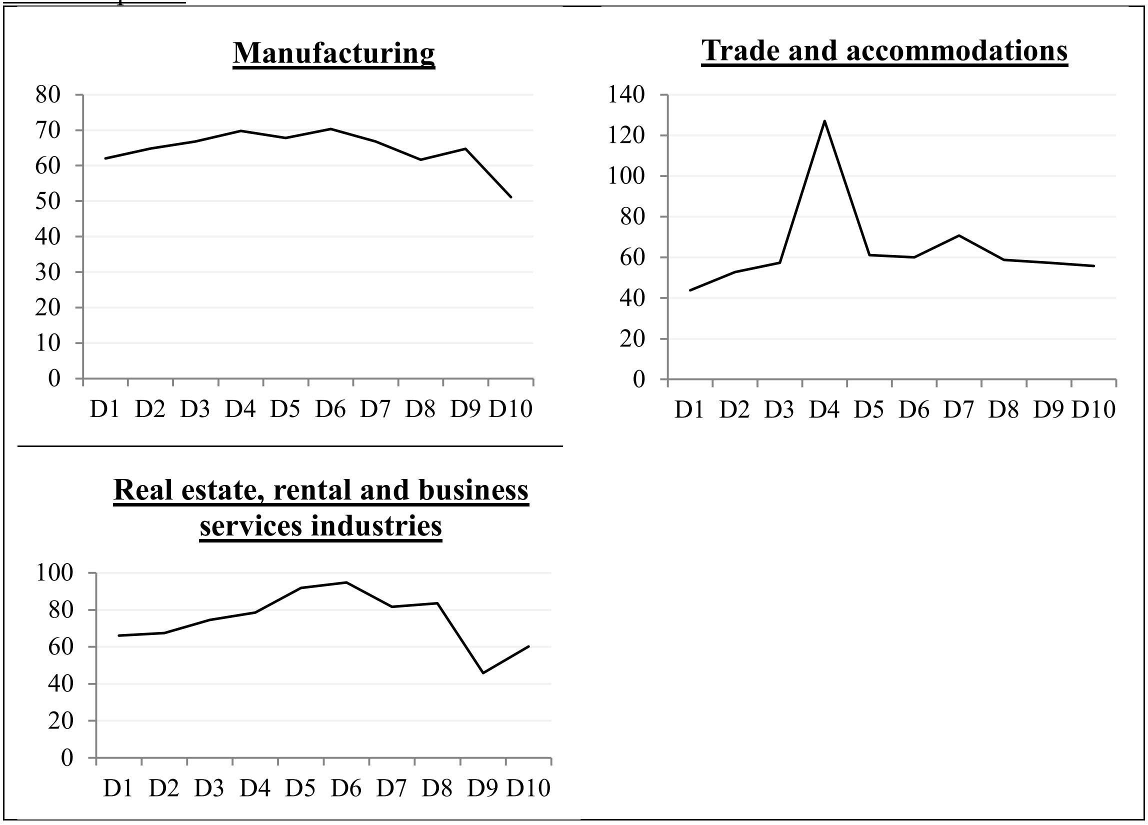


Sources: DADS (Insee) and FARE (Insee).

Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.

Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of young female workers in the firm's workforce.

Graph 2e. Labor productivity against deciles or quartiles of the share of old workers in firms. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: for each point, the figure on the Y-Axis is the average labor productivity corresponding to the given quartile or decile of firms in terms of the share of old female workers in the firm's workforce.

In the end, for female, young or old (even if less clear-cut) workers, if we control for firm size and capital intensity, there appears to be an inverted *U*-shaped relationship between labor productivity in the firm and the share of the female, or young (resp. to a lesser extent old) worker. Therefore, companies with the lowest productivity are characterized by a small or large proportion of female or young workers. Companies in-between, with greater workforce diversity, are associated with greater labor productivity levels.

5. Results

In this Section, we provide our findings for the approaches we consider to analyze the impact of diversity of the workforce on the firm performance. First, we deal with complementarity of considered working populations with regards to the two dimensions that are gender and age using a production function approach. Second, we evaluate the relation between diversity and labor productivity, considering the non-linear approach (à la Chetty *et al.* (2014), distinguishing associations using ordinary least squares, and then the causal effects using instrumental variable estimates.

5.1. Analyzing the substitutability of working populations in the production function framework

In this part, we quantify the degree of substitutability in the production between: Female and male workers; Junior workers (younger than 30) and other workers; Senior workers (older than 49) and other workers. We also discuss the matter for Young female workers and other workers (female workers older than 30 and male workers), as well as for Old female workers and other workers (female workers younger than 50 and male workers).

5.1.1. Presentation

To proceed, we estimate five set of CES production functions. We use a dataset resulting from the merge of 1/12th DADS data source and ALISSE data (aggregation of FARE files at two digits SIC level) and consider a sectoral balanced panel, composed of 38 industries, with the exception of farming and financial industries, over 2009-2015. Proceeding in this way, rather than considering a panel at the firm level, avoids problems related to firm demographics (bankruptcy, mergers, new business). However, as discussed in the literature on estimating degrees of substitutability between factors of production, the resulting elasticities of substitution are mechanically of smaller size.[19]

As usually done in the literature, we then use nonlinear least squares (NLLS) applied to equation (3), where index *i* refers to the given industry in our case. As mentioned in Section 4, this allows to take account for potential discriminating behavior of firms (Altonji and Blank, 1999; Jarrell and Stanley, 2004). Z_{it} includes industry dummies, and year dummies.

As initial values for NLLS, we use OLS estimates provided by the estimation of (5), notably for the labor share (α) and μ parameter. Moreover, over the period 2009-2015, the ratio of the number of workers in the target population to that of the complementary population to the overall employed population (*T/N*), as well as δ, *i.e.* the ratio of monthly hours of work in the target population to that of the complementary population to the overall employed population are computed on the basis of employment and working hours statistics reported in Appendix B (Tables B1 to B5). For instance, over the whole 2009-2015 time period and the overall economy (except farming and financial industries), considering firm year-end employment, companies employing at least 20 workers and focusing on female / male substitutability, *T/N=F/M* is equal to 0.67 and the women's working hours to men's is 0.87[20].

For the second non-linear approach, we consider firms employing at least 20 workers or more and all workers (year-end employment level), whatever their hours of work. While exploring the complementarity between production factors, we consider this case, but also distinguish three other sets of estimates corresponding to year-end employment in all firms whatever the size of their workforce, as well as full time equivalent workforce, either in all firms or in firms employing at least 20 workers. Besides, for the capital stock (*K*), we consider tangible assets.

[19] This is likely due to the fact that intra-industry heterogeneity is not taken into account (Ostry *et al.*, 2018).

[20] This ratio is close to that found in Bargain and Lo Bue (2025) with Morocco data, *δ=0.83*, or Ostry *et al.* (2018), *δ=0.85*, with OECD data. Otherwise, across all companies, regardless of the number of employees, Ostry et al. (2018) report *F/M=0.77*, to be compared with what we find on the same type of company (0.67 considering physical people; 0,97 considering full-time equivalent workers).

5.1.2. Findings

Considering women VS. men substitutability in the production process, we consider a production function where labor is specified as a composite factor comprising female employment *F* and male employment *M*. Corresponding results are reported in Table 1. First, labor share is estimated to about 70 to 90 percent, following we consider all firms or only those employing at least 20 workers; but it does not depend on the type of employment (year-end or full-time equivalent workers). Second, according to Table 1, since female and male workers are characterized by an ES of about 0.78 – that is significantly different from 0 – they are imperfect substitutes and thus partly complementary. The elasticity of substitution is comparable to those other studies using panels at industry level (thus smaller than what is found using firms' data, like in Bargain and Lo Bue, 2025).

Table 1. Estimated elasticities of substitution between female and male workers through the estimation of a CES production function.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.7969**	0.7957**	0.7805**	0.7381**
	(0.0378)	(0.0897)	-0.0397	(0.0969)
	[0.7223;0.8714]	[0.6188; 0.9726]	[0.7021;0.8590]	[0.5470; 0.9292]
Labor share α	0,6813**	0.8919**	0.7063**	0.9335**
	(0.0511)	(0.1026)	-0.0537	(0.1055)
	[0.5805; 0.7822]	[0.6894; 1.0943]	[0.6003;0.8124]	[0.7254; 1.1416]
Average female to male employment (*F/M*)	0,673928536	0,692157703	0,604161532	0,620561576
Ratio of women to men working hours δ	0,874304817	0,870146505	0,975267263	0,970538026

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Focusing on age complementarity, Table 2 reports estimates when labor is specified as a composite factor comprising employment level of workers less than 30 (*Y*), and other workers, *i.e.* medium-aged (30-49) or workers older than 49 (*MO*). Labor share is roughly equal to 65 percent to 80-85 percent, following we consider all firms or firms employing at least 20 workers. Table 2 also highlights a substitution elasticity between young workers and others of the order of 0.62; it is smaller considering only firms employing at least 20 workers (0.69 for year-end employment). This shows that the two categories are also imperfect complements. This confirms findings of past studies.

Table 2. Estimated elasticities of substitution between young and medium-aged or old workers through the estimation of a CES production function.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0,7764**	0.6937**	0.6564**	0.3789**
	(0,0623)	(0.2316)	(0.1449)	(0.1746)
	[0,6535; 0,8993]	[0.2370; 1.1504]	[0.3707; 0.9421]	[0.0345; 0.7232]
Labor share α	0,6411**	0.8546**	0,6352**	0.7807**
	(0,0511)	(0.1137)	(0.0576)	[0.0382)
	[0,5402; 0,7420]	[0.6304; 1.0788]	[0.5217; 0.7488]	[0.7053; 0.8560]
Average young to medium-old employment (*Y/MO*)	0,386064421	0,319130961	0,284177661	0,235140229
Ratio of young to medium-aged or old working hours δ	0,731648519	0,727923794	0,993967834	0,987934019

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

In Table 3, we display results when analyzing the degree of substitutability between senior workers and other workers. In this case, labor is specified as a composite factor comprising employment level of workers more than 49 (*O*), and other workers (*YM*), *i.e.* young workers (less than 30) or medium-aged (30-49) workers. In this case, the NLLS routine does not converge considering all firms. Thus, there is a large difference for the labor share: roughly equal to 90 percent, considering firms employing at least 20 workers, but to 48 considering all firms. ES are not significant in this case, but it is difficult to interpret these results because of non-convergence. We therefore only consider findings related to firms employing at least 20 workers. Table 3 highlights a substitution elasticity between old workers and others of the order of 0.87, either considering year-end employment or full-time equivalent employment. This shows that the workers older than 49 and other workers are also imperfect substitutes and thus partial complements in the production.

All these findings confirm results provided by past studies, either considering CES (Grant and Hamermersh, 1981; Hebbing, 1993; Fitzenberger and Kohn, 2006) or translog production functions (Peters, 2015).

Table 3. Estimated elasticities of substitution between old and young or medium-aged workers through the estimation of a CES production function.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	8.581E10	0.8727**	1.423E15	0.8733**
	(1.908E22)	(0.0534)	(5.195E30)	(0.0511)
	[-3.76E22; 3.763E22]	[0.7675; 0.9780]	[-1.02E31; 1.025E31]	[0.7725; 0.9741]
Labor share α	0.4824**	0.8978**	0.5566**	0.9200**
	(0.0332)	(0.1029)	(0.0938)	(0.1044)
	[0.4170; 0.5478]	[0.6948; 1.1008]	[0.3716; 0.7416]	[0.7142; 1.1258]
Average old to young-medium aged employment (*O/YM*)	0,284047782	0,31438339	0,320219843	0,35023629
Ratio of old to young-medium aged working hours δ	1,129394933	1,11641546	1,001818138	1,00213039

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Finally, we deal with interactions between the gender and age criterions, what is, to our knowledge, something new. On the one hand, we consider young female workers. In the estimated production function, employment level of young female (*YF*) and other female workers and all male workers (*MOFM*) are the two parts of the composite labor factor. Table 4 report corresponding estimates. The share of labor in added value is estimated at about 60% (considering all firms or only firms employing at least 20 workers). Besides, considering year-end employment and the sample of firms employing at least 20 workers, young female and other female workers or all male workers are characterized by an ES equal to about 0.73. They are therefore imperfect complements in the production process. It is worth noting that for the same type of job and the same sample, the ES between women and men is 0.80, while that between young people under 30 and others is 0.69. In this case, there is therefore no super additivity linked to the two criteria (for a worker: being a woman, being under 30).

On the other hand, the composite labor factor is composed by both old female workers and all other workers. In this case, the labor share is 0.80. Besides, whatever the sample and the type of employment under consideration, the ES between old female workers and other workers is 0.95. If we consider the sample of companies with 20 or more employees and employment measured in natural persons at the end of the year, the ES between women and men is 0.78, while that between seniors over 49 years old and others is 0.87. There then seems to be a super additivity linked to the two criteria (for a worker: being a woman, being over 49 years old).

Table 4. Estimated elasticities of substitution between young female workers and medium-aged or senior female workers and all male workers through the estimation of a CES production function.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.5844**	0.6804**	0.5622**	0.6236**
	(0.0768)	(0.2087)	(0.0215)	(0.1236)
	[0.4329; 0.7359]	[0.2687; 1.0991]	[0.4409 ; 0.6835]	[0.3798; 0.8674]
Labor share α	0.5325**	0.7350**	0.5527**	0.7583**
	(0.0297)	(0.0332)	(0.0309)	(0.0359)
	[0.4738; 0.5912]	[0.6695; 0.8005]	[0.4917; 0.6137]	[0.6874; 0.8291]
Average young female to other workers employment (YF/*MOF&M*)	0,131202834	0,11846666	0,09241463	0,083159093
Ratio of young female workers to other workers working hours δ	0,69065649	0,68430411	0,98053834	0,97484494

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table 5. Estimated elasticities of substitution between old female workers and young or medium-aged female workers and all male workers through the estimation of a CES production function.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.9696**	0.9582**	0.9692**	0.9585**
	(0.0056)	(0.0174)	(0.0056)	(0.0164)
	[0.9586; 0.9806]	[0.9239; 0.9924]	[0.9581; 0.9803]	[0.9261; 0.9909]
Labor share α	0.6834**	0.8973**	0.7053**	0.9210**
	(0.0512)	(0.1040)	(0.0538)	(0.1053)
	[0.5825; 0.7844]	[0.6922; 1.1023]	[0.5992; 0.8113]	[0.7134; 1.1286]
Average old female to other workers employment (*OF/YMFM*)	0,096305477	0,10520231	0,09999912	0,1087907
Ratio of old female workers to other workers working hours δ	1,019238062	1,00996299	0,98159058	0,9766501

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

To conclude, regardless of the couple of populations of workers under consideration (female / male workers, young workers vs. others, old workers vs. others, or young female / old female workers), there appears to be at least partial complementarity, even if intra-industry heterogeneity (and therefore heterogeneity between firms) is not taken into account.[21]

5.2. Exploring the non-linear impact of diversity on labor productivity

The previous sub-section provide evidence for partial complementarity between female and male workers, as well as between young workers / old workers and other workers. However, to what extent does greater diversity in gender and age (positively) influence the productivity of the company's workforce? Is this effect non-linear? Is it more particularly due to what happens in some industries?

5.2.1. Presentation

We display results provided by rank regressions estimates are displayed. Indeed, as mentioned in Section 3, in this perspective, we consider a two-steps method. First, it consists in neutralizing all the gender or age determinants of technological and organizational choices, job structure by qualification, which could explain the differences between companies (see equation (9)). It is a question of netting out the empirical distributions of the firm workforce by gender or age (young / old workers[22]). Second, for every quartile of the netted-out proportion of female or young / old workers, we regress the rank of labor productivity on the rank of the share of female, young or old workers and covariates as shown by equation (11).

We give estimates for associations through ordinary least squares estimator, and then for causal effect through instrumental variables estimator, using the share of the population under study at the same 5 digits industry level as that of the given firm, but where we exclude the share of the considered firm. We provide results for the overall economy (considering the non-farm and non-financial private business sector) and then explore findings for six main industries: Manufacturing; Construction; Trade and accommodations; Transportation and communication; Real estate, renting and business activities; Education, social and personal services. In all cases, we distinguish the results provided using both balanced (56,269 companies) and unbalanced (111,248) samples.

5.2.2. Associations

Female workers

The distribution of the "association" coefficients of the quartiles shows a strong non-linearity in the relation between gender diversity (within the workforce) and labor productivity, with decreasing productivity gains as we move towards gender diversity (Graph 3a[23]).[24] The associations on the "extremes" are of opposite signs, reflecting a positive association between productivity and diversity: a positive association is obtained on the first quartile and a negative association on the fourth quartile, but almost no significant association is detected near diversity.

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[21] This is likely the reason why our social enterprises are smaller than those based on firm-level data, which is consistent with the literature (Ostry *et al.*, 2018).

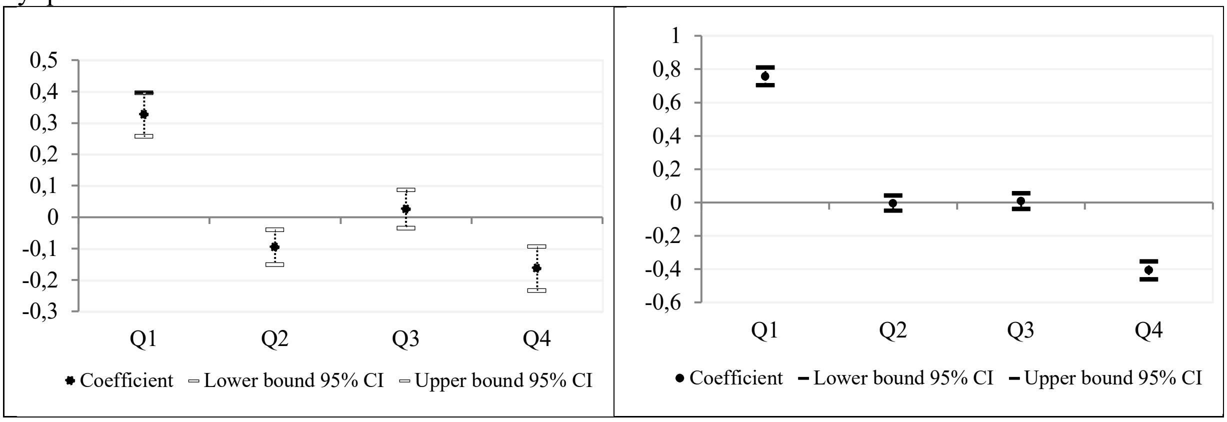
[22] The overall set of estimates is given in Appendix C both all five employed population and both panels.

[23] Full specification of the estimation of equation (11) using OLS are given in Appendix D for the balanced panel when the shares of female or young workers are the variables of interest. Full set of estimates are available on request for old, young and old female worker, as well as for the five populations for estimations considering the unbalanced panel.

[24] As expected, greater precision with estimates provided on the unbalanced panel.

Moreover, we find an asymmetrical relation: a gain of 0.32 (resp. 0.16) position in the rank of productivity is associated to an increase (resp. a decrease) of 1 position in the rank of the share of female workers. The relation seems to be more intensive considering the unbalanced panel. These results are consistent with descriptive statistics provided in Section 4 where labor productivity peaks at Q2-Q3.

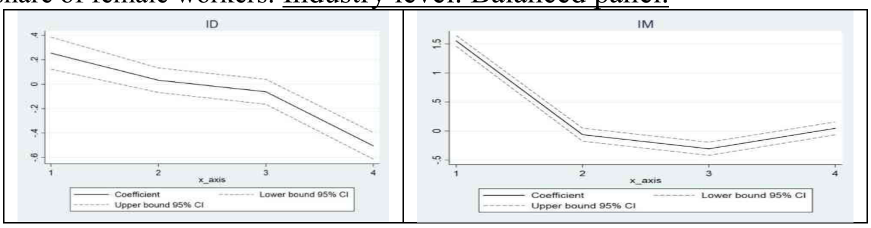
Graph 3a. Associations between the proportion of female workers and labor productivity. Rank-regressions by quartile of the share of female workers.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Focusing on what happens at the industry level, our findings are the following (Graph 3b, for the balanced panel). The same kind of relation between gender diversity and productivity is observed in manufacturing and in real estate/business services, two industries in which the share of female workers is either lower (manufacturing, 29%) or higher (real estate, 48%) than in the economy as a whole (36%). Similar patterns in terms of the relationship between the share of women and productivity are also observed in trade and accommodations, in education/health/social services, and, to a lesser extent, in the transportation and construction industries (Graph 3c). The results are consistent with descriptive statistics, with similar profiles as for statistics, with productivity maxima located in D5 (industry), Q2 (trade and accommodations), and D3–D5 (real estate and business services). Higher labor productivity gains associated from moving towards diversity are therefore concentrated in parts of the distribution of female workers where labor productivity is lower (Q1 and Q4 for commerce; Q1 and Q3 for real estate).

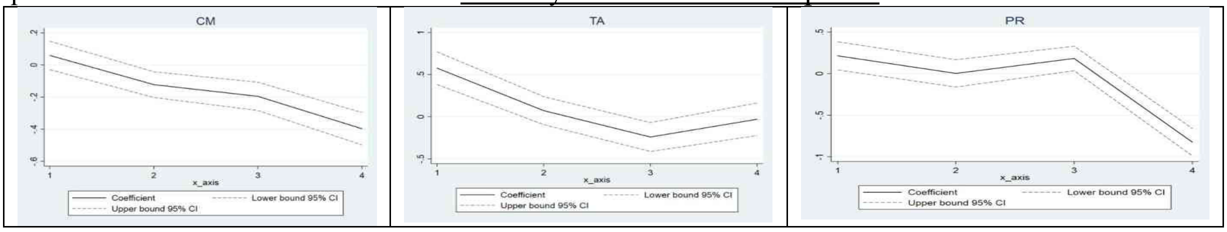
Graph 3b. Associations between the share of female workers and labor productivity. Rank-regressions by quartile of the share of female workers. Industry level. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).

Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. left (resp. right) graph refers to figures for the manufacturing (resp. real estate and business services) sample. CI stands for confidence interval.

Graph 3c. Associations between the share of female workers and labor productivity. Rank-regressions by quartile of the share of female workers. Industry level. Unbalanced panel.

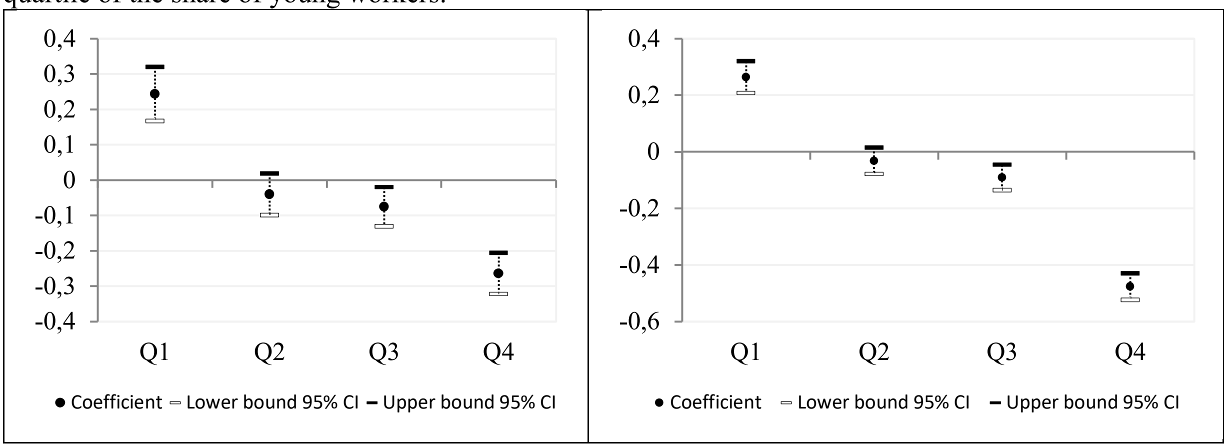


Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. left (resp. center; resp. right) graph refers to figures for the trade and accommodations (resp. transportation and communications; resp. education, health and social services) sample. CI stands for confidence interval.

Young workers

As we focus on young workers, the same kind of result holds in the relation between diversity in terms of young workers and labor productivity (Graph 4a). Decreasing productivity gains are associated to moving to greater diversity in terms of young workers.[25] The associations on the "extremes" are of opposite signs, reflecting still a positive association between productivity and diversity: a positive association is obtained on the first quartile and a negative association on the fourth quartile. Almost no significant association is found near diversity. Contrary to gender diversity, this relation is rather symmetric: a gain of 0.24 (resp. 0.26) position in the rank of productivity is associated to an increase (resp. a decrease) of 1 position in the rank of the share of young workers. Once more, our results seem to be consistent with descriptive statistics.

Graph 4a. Associations between the share of young workers and labor productivity. Rank-regressions by quartile of the share of young workers.



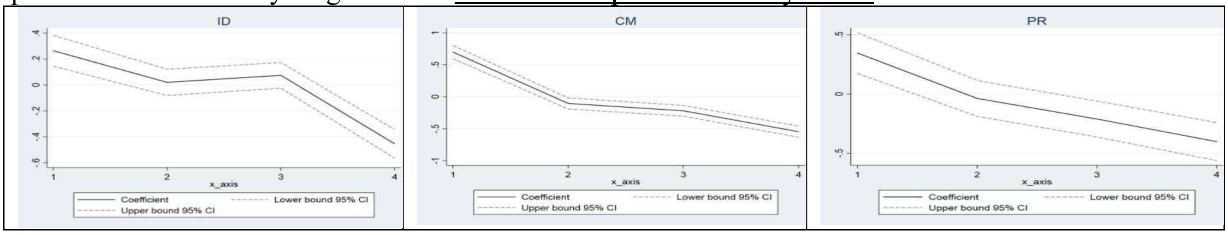
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.

[25] There is still a greater more precision with unbalanced panel characterized by more observations.

Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Similar patterns as for overall economy are observed in manufacturing and construction, in trade and accommodations, and in education/health/social work. However, only in the commerce are the first (positive coefficient) and the last (negative coefficient) statistically significant. Relative to the whole economy (share of young workers: 26%), these results are associated with three industries whose share of young workers is either much higher (commerce/hotels/restaurants: 36%), much lower (manufacturing: 18%), or comparable (education, health, and social work).[26] The results are consistent for both balanced and unbalanced panels, as well as with descriptive statistics displayed in Section 4, with similar profiles as for the overall economy, notably for manufacturing or trade and accommodations.

Graph 4b. Associations between the share of young workers and labor productivity. Rank-regressions by quartile of the share of young workers. Unbalanced panel. Industry level.



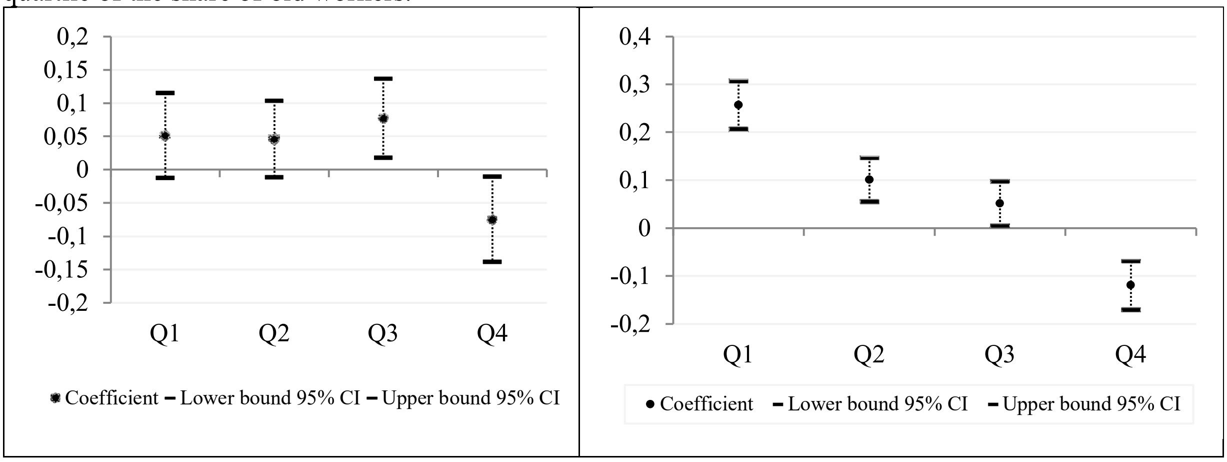
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. center; resp. right) graph refers to figures for the manufacturing (resp. trade and accommodations; resp. education, health and social services) sample. CI stands for confidence interval.

Old workers

Considering workers older than 49, only the unbalanced panel reveals the same kind of relation between diversity (in terms of old workers) and labor productivity: decreasing productivity gains are obtained as we move towards diversity in terms of old workers (Graph 5a). The associations on the "extremes" are of opposite signs, reflecting still a positive association between productivity and diversity: a positive association is obtained on the first quartile and a negative association on the fourth quartile. Positive but smaller association in Q2 and 0 in Q3. This relation is rather an asymmetric one regarding the unbalanced panel: a gain of 0.26 (resp. 0.12) position in the rank of productivity is associated to an increase (resp. a decrease) of 1 position in the rank of the share of old workers in Q1 (resp. Q4).[27]

[26] The same pattern is found in the relation between the share of young workers and productivity for manufacturing, as well as for education, health, and social services, as in the trade and accommodation industries (Q1 > 0; Q4 < 0).
[27] Consistency with descriptive statistics is not clear-cut.

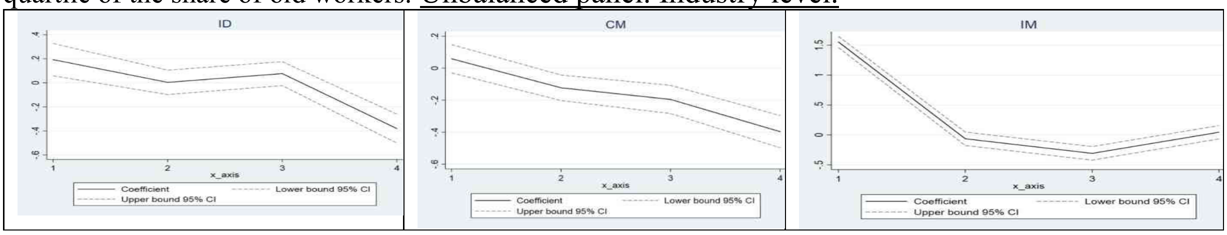
Graph 5a. Associations between the share of old workers and labor productivity. Rank-regressions by quartile of the share of old workers.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Estimates are far less precise for the balanced panel than for the unbalanced panel. Moreover, even if findings are similar for manufacturing and real estate / business services, they are less clear-cut for transportation/ communications or for construction and even different for trades and accommodations; education, health and social services. Therefore, the Graph 5b reports results for the unbalanced panel. The same patterns as for the overall economy in the relation between the proportion of senior workers and productivity is observed in manufacturing, trade and accommodations, real estate/business services, and education/health/social services (Q1 > 0; Q4 < 0). These results appear consistent with productivity profiles across the distribution of senior employment, particularly in manufacturing and even more so in trade and accommodations, where productivity is lowest in Q1.

Graph 5b. Associations between the share of old workers and labor productivity. Rank-regressions by quartile of the share of old workers. Unbalanced panel. Industry level.



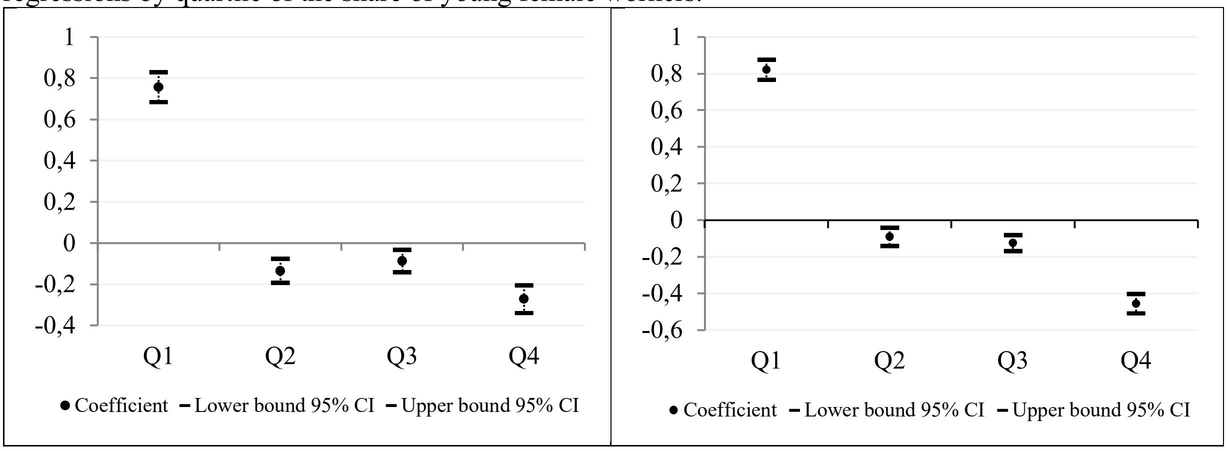
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. center; resp. right) graph refers to figures for the manufacturing (resp. trade and accommodations; resp. real estate and business services) sample. CI stands for confidence interval.

Young and old female workers

As a last analysis, we consider interactions between gender and age criterions.

First, we consider young female workers (*i.e.* female workers aged under 30). Both balanced and unbalanced panels reveal the same kind of strong nonlinear relation between diversity in terms of young female workers and labor productivity: decreasing productivity gains are obtained as we move towards more diversity in terms of young female workers. As previously, associations on the "extremes" are of opposite signs, reflecting still a positive association between productivity and diversity: a positive association is obtained on the first quartile and a negative association on the fourth quartile. Negative and smaller associations are found in Q2 and Q3. Finally, an asymmetric relation is found for both panels. Regarding the balanced panel, a gain of 0.76 (resp. 0.27) position in the rank of productivity is associated to an increase (resp. a decrease) of 1 position in the rank of the share of young female workers. Those findings are rather consistent where a maximum for labor productivity is found in Q3 or D6.

Graph 6a. Associations between the share of young female workers and labor productivity. Rank-regressions by quartile of the share of young female workers.

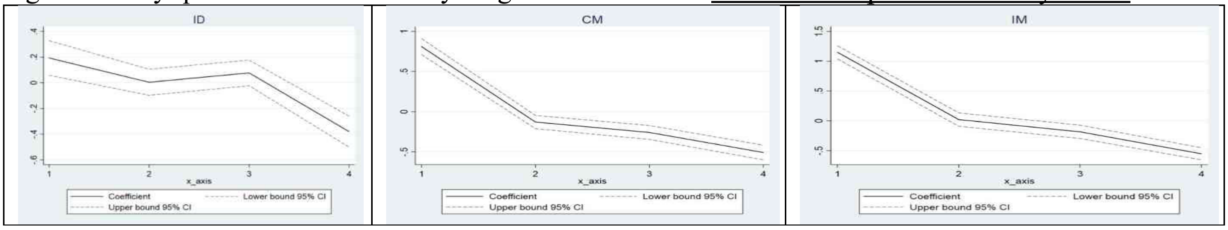


Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Because of greater precision too, we provide results for unbalanced panel (Graph 6b). As for whole economy, a similar pattern is observed (two industries in which the share of young women—17% and 12%, respectively—exceeds the overall economy's average), with gains in rank of productivity in Q1 and Q4 when moving toward greater diversity, either through an increase in the rank of the share of young women (Q1) or through a decrease in that rank (Q4). The same holds in manufacturing. Manufacturing, construction and transportation industries — which employ the fewest young women (5.8%, 2.3% and 4.4%, respectively) relative to the whole economy — also display a similar pattern, but with greater productivity only when moving toward greater diversity for firms in the first quartile.[28]

[28] These results appear consistent with productivity profiles across the distribution of employment of young women.

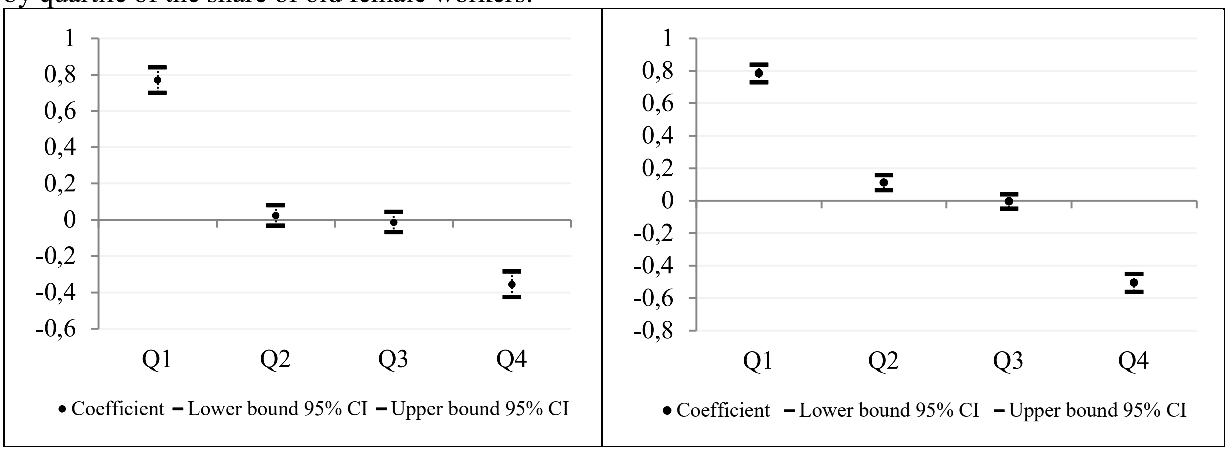
Graph 6b. Associations between the share of young female workers and labor productivity. Rank-regressions by quartile of the share of young female workers. Unbalanced panel. Industry level.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. center; resp. right) graph refers to figures for the manufacturing (resp. trade and accommodations; resp. real estate and business services) sample. CI stands for confidence interval.

Second, we focus on old female workers (*i.e.* female workers aged more than 49). Considering the whole sample, both panels exhibit the same kind of strong non-linear relation between diversity in terms of old female workers and labor productivity: decreasing productivity gains are obtained as we move towards diversity in terms of old female workers (Graph 7a). Associations on the "extremes" are still of opposite signs, reflecting a positive association between productivity and diversity: a positive association is obtained on the first quartile and a negative association on the fourth quartile. Almost 0 associations in Q2 and Q3. The relation between the share of old female workers and labor productivity seems to be a rather asymmetric one for both panels. A gain of 0.8 (resp. about 0.4) position (rank of productivity) is associated to an increase (resp. a decrease) of 1 position (rank of the share of old female workers). These findings are rather consistent with descriptive statistics (productivity is the highest for Q2 / D4).

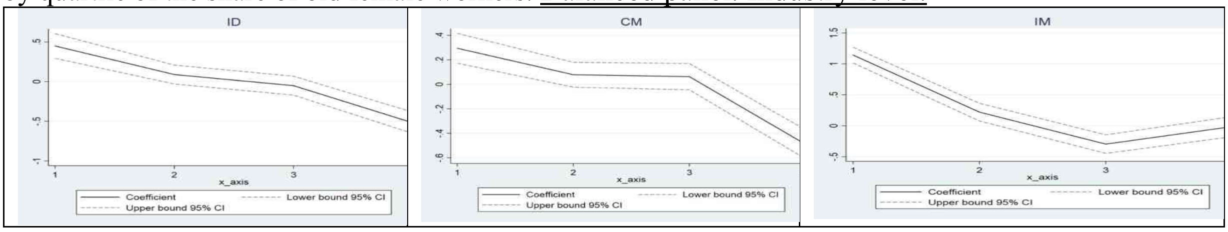
Graph 7a. Associations between the share of old female workers and labor productivity. Rank-regressions by quartile of the share of old female workers.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

In Graph 7b, a similar pattern is observed for the manufacturing, trade and accommodations, and real estate/business services industries (except in Q4 = 0, Q3 < 0). These industries employ either the same share of women as the average in our sample (manufacturing, 8%), a lower share (trad and accommodations, 6.6%), or a higher share (real estate/business services, 9.7%). Considering the unbalanced panel, we also observe the same non-linear pattern for the three other industries: construction, transportation, and education/health/social protection.[29]

Graph 7b. Associations between the share of old female workers and labor productivity. Rank-regressions by quartile of the share of old female workers. Balanced panel. Industry level.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. center; resp. right) graph refers to figures for the manufacturing (resp. trade and accommodations; resp. real estate and business services) sample. CI stands for confidence interval.

5.2.3. Causal effects

Female workers

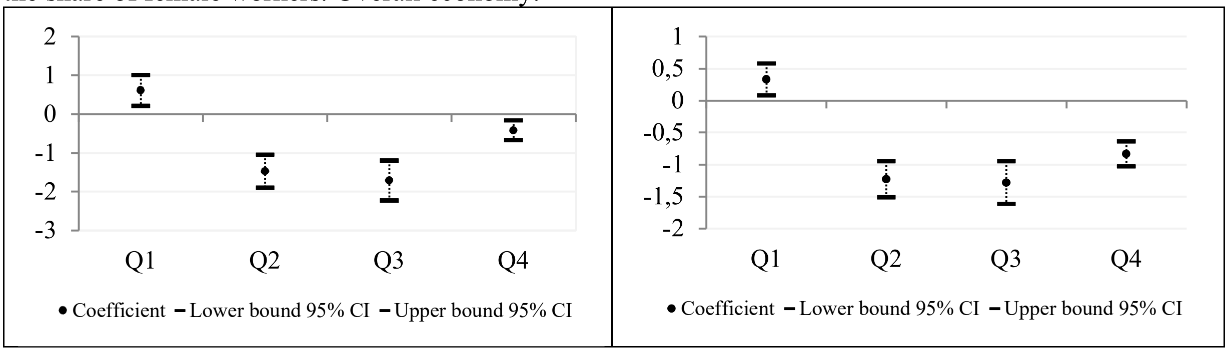
The distribution of the "causal effects" coefficients (*i.e.* IV estimates) associated to quartiles shows a strong non-linear causal effect of gender diversity on labor productivity (Graph 8a). The full set of estimated coefficients for the first and second stage are reported in Tables E and F for both female and young workers.[30] In particular, firms should be encouraged to increase the proportion of female workers when they are in the first quartile, whereas they would instead be inclined to reduce this proportion when it is high. Indeed, if the given firm belongs to the first quartile of share of female workers, a gain of 0.61 position in the rank of productivity is expected from an increase of 1 position of the firm in the rank of share of female workers. The contrary holds notably for the third quartile: +1.5 position for the firm in its rank in terms of productivity) as a consequence of the reduction in the rank of the share of female workers. Considering the unbalanced panel[31], the magnitude of the effects appears on average smaller than for the balanced panel of firms for the largest coefficients in absolute value (Q1 and Q3).

Graph 8b exhibits the same kind of causal relation between gender diversity and productivity is found in the trade and accommodations industries, in the transportation and communication industries and, to a lesser extent, in the education, health and social services industry (only for 4th

[29] These results are consistent with the level of productivity across the distribution of the share of senior women.
[30] The p-value for the Pseudo R2 of excluded instruments is almost equal to zero, confirming the rejection of the null hypothesis of a *ceteris paribus* non-significant link between the endogenous variable and the considered instrument (Table E). As well, Stock and Yogo tests statistics shows that our instrument – the rank in the industry share of female workers – is not weak Table F). When available, the test statistics for the exogeneity test provide evidence for endogeneity of the share of the given employed population, *ie.* female workers in the workforce. Finally, the under-identification test leads to the rejection of the null hypothesis leading us not to reject that are model is just identified.
[31] Corresponding full set of estimates for both the first and the second stages are available on request.

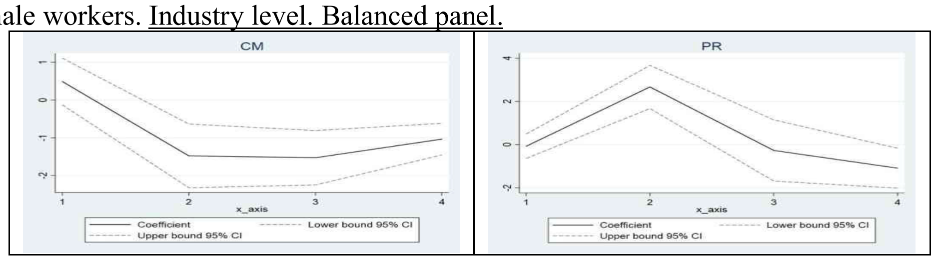
quartile), as for the overall economy. They represent 45% of all non-private and non-financial private sector businesses. Trade and accommodations one the one hand, and education, health and social services industries on the other hand are characterized by a share of female workers (more than 48 and 64 percent respectively) greater than in the overall economy (36 percent). In both industries, it seems thus interesting to reduce the share of female workers for firms in the fourth quartile of the share of female workers: in both cases, this would increase labor productivity. Conversely, in the trade accommodations' industries, even if the coefficient for Q1 is significant at a 5-10 percent level, an increase of one position in the rank of the firm in terms of female workers for those firms that employ initially few female workers (first quartile) induces an increase in labor productivity of 0.5 position. Although this finding holds in the trade and accommodation industries, where the share of female workers (48%) is above that of the overall economy, firms from Q1 are likely to employ a share of female workers smaller than 36 percent. On the other hand, in both retail and food services, as well as in education, health, and social services, a higher proportion of women than in the economy as a whole may be required by the production technology in businesses within these two sectors. Increasing the proportion of women in these two industries beyond the proportion in all businesses with 20 employees (36%) can also be profitable as long as the given share remains below 48% (retail and food services) or 64% (education, health, and social services).

Graph 8a. Effects of the share of female workers on labor productivity. Rank-regressions by quartile of the share of female workers. Overall economy.



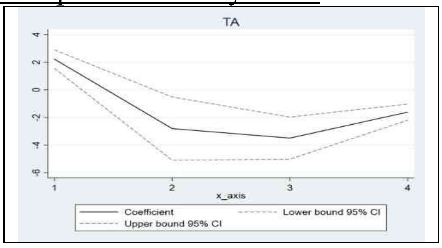
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Graph 8b. Effects of the share of female workers on labor productivity. Rank-regressions by quartile of the share of female workers. Industry level. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the trade and accommodations (resp. education, health and social services) industries. CI stands for confidence interval.

Graph 8c. Effects of the share of female workers on labor productivity. Rank-regressions by quartile of the share of female workers. Unbalanced panel. Industry level.



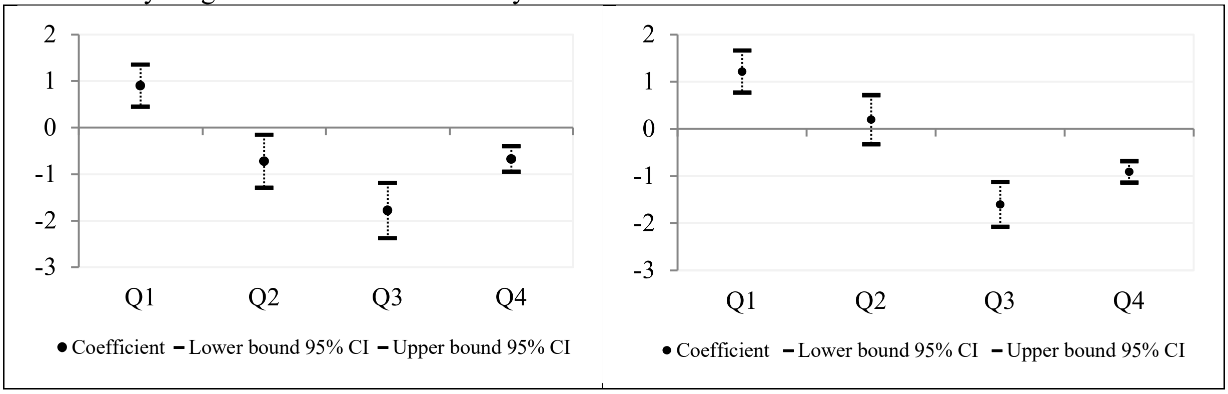
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. The graph refers to figures for the transportation and communications industries. CI stands for confidence interval.

Considering the unbalanced panel, similar patterns in terms of the causal relation between the share of female workers and productivity are also found in the transportation and communications industries, but all along the distribution of female workers (Graph 8c). In this industry characterized by a share of female workers smaller than in the overall economy (about 18 percent against 36 percent), it would in particular profitable for firms to hire more women because it will lead to an increase in the labor productivity. This is notably the case for a firm from the 1st quartile of the share of female workers, where a gain of two positions in the rank of the considered firm in terms of its labor productivity is expected from an increase of 1 position in the rank of the share of female workers.
In conclusion, findings for the overall economy as to the effect of gender diversity on labor productivity are consistent with and may be explained by what we found for a small number of industries.

Young workers
The same kind of relation holds between diversity in terms of workers younger than 30 and labor productivity (Graph 9a). Rather decreasing productivity gains are obtained as we move towards young diversity.[32] The effects on the "extremes" are of opposite signs, reflecting a positive (first quartile) and a negative effect (fourth quartile) of diversity in terms of young workers on labor productivity. Almost no significant effect is found near diversity (Q2). An asymmetric relation is found between share of young workers and labor productivity: for firms of the first (resp. fourth quartile), a gain of 0.9 to 1.2 (resp. 0.7 to 0.9) position in the rank of productivity is expected from an increase (resp. a decrease) of 1 position of the firm rank in terms of the share of young workers, following we consider balanced or unbalanced panels.

[32] The same conclusions can be drawn from Tables E and F in Appendices E and F when testing for the weakness of our instrumental variable, as well as for the exogeneity test and for testing for under-identification. All three tests lead to rejection of the null hypothesis.

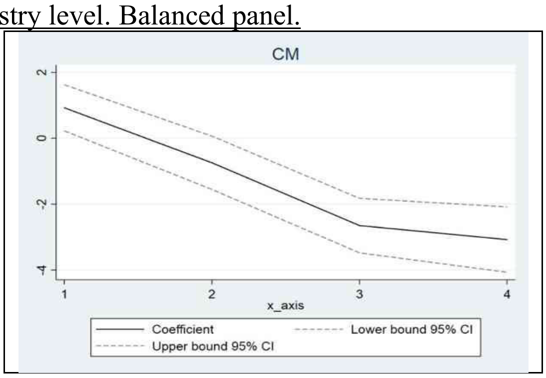
Graph 9a. Effects of the share of young workers on labor productivity. Rank-regressions by quartile of the share of young workers. Overall economy.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Similar patterns as for overall economy in causal effect of diversity in terms of young workers are found in trade and accommodations industries (27% of firms), with a decreasing relation between the share of young workers and labor productivity (Graph 9b). This business sector is characterized by a larger share of young workers than in the overall economy (36 percent VS. 26 percent). Therefore, for a firm in the first quartile, the share of workers younger than 30 is smaller than the industry average and it is profitable for one of the concerned firms to increase the share of the given population of workers: increasing of 1 position the rank of the share of young workers in the trade and accommodation industry lead to an increase of 0.8 position the rank of the considered firm in terms of the share of young workers. The same type of reasoning can be applied as for the gender criterion. This result for Q1 is expected insofar as those firms are characterized by a lower proportion of young people than the average proportion of young people at the level of this industry, or even at the level of the economy as a whole. Conversely, for firms from the fourth quartile, decreasing the rank of the firm in terms of young workers increases labor productivity, a finding that could have been expected given the larger share of young workers than for the overall economy. Thus, the effects of workforce diversity in terms of young workers for the commerce, hotels, and restaurants industry appear to reflect the effects found for overall economy.

Graph 9b. Effects of the share of young workers on labor productivity. Rank-regressions by quartile of the share of young workers. Industry level. Balanced panel.



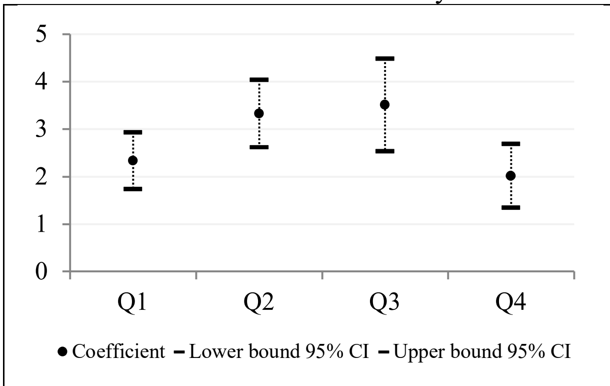
Sources: DADS (Insee) and FARE (Insee).

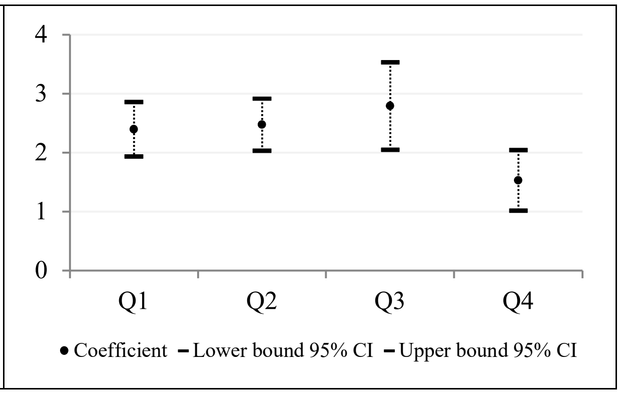
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Graph refers to figures for the trade and accommodations industry. CI stands for confidence interval.

Old workers

In this case, things seem quite different than for female or young workers (Graph 10a). The relation between causal effects by quartiles of diversity in terms of old workers on the labor productivity is rather different than for other female or young workers. (Large) productivity gains appear to be obtained, even if smaller in Q4. The effect of an increase in the rank of the proportion aged 50 and more remains positive, first rising between Q1 and Q3 (an increase of 2.3 to 3.5 positions in firms' productivity rankings), and then declining (to about 2 positions). The same kind of findings hold considering both the balanced and unbalanced panels.

Graph 10a. Effects of the share of old workers on labor productivity. Rank-regressions by quartile of the share of old workers. Overall economy.





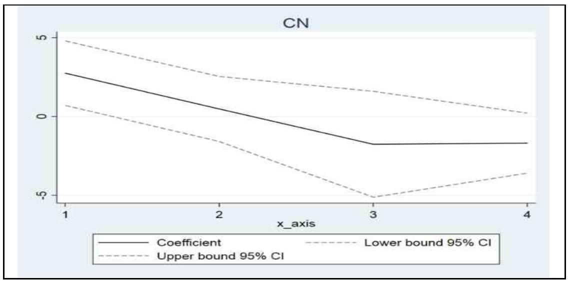
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Looking at what happens at the industry level, a decreasing relation between diversity in terms of old workers and its causal effects on productivity is observed only in the construction industry (which accounts for approximately 9% of businesses) with a positive coefficient in Q1 and a negative one in Q4. This industry is characterized by a share of old workers of the same size as the overall economy (about 22 percent). For both firms from Q1 characterized with low share of old workers, large productivity gains (+2.5 position in the rank of the firm) are expected from increasing the share of workers older than 49. As well, labor productivity gains of the same size are expected from a reduction of 1 position in the rank of the firm in terms of old workers for firms from the fourth quartile.

In the end, in the construction industry, we find systematically productivity gains as we move towards greater diversity in terms of senior workers.[33]

[33] In the case of the unbalanced sample, findings are less clear-cut. The same kind of patterns are found for construction industry, but with greater uncertainty. For both manufacturing and trade/accommodations, productivity gains are obtained whatever the considered quartiles.

Graph 10b. Effects of the share of old workers on labor productivity. Rank-regressions by quartile of the share of old workers. Industry level. Balanced panel.



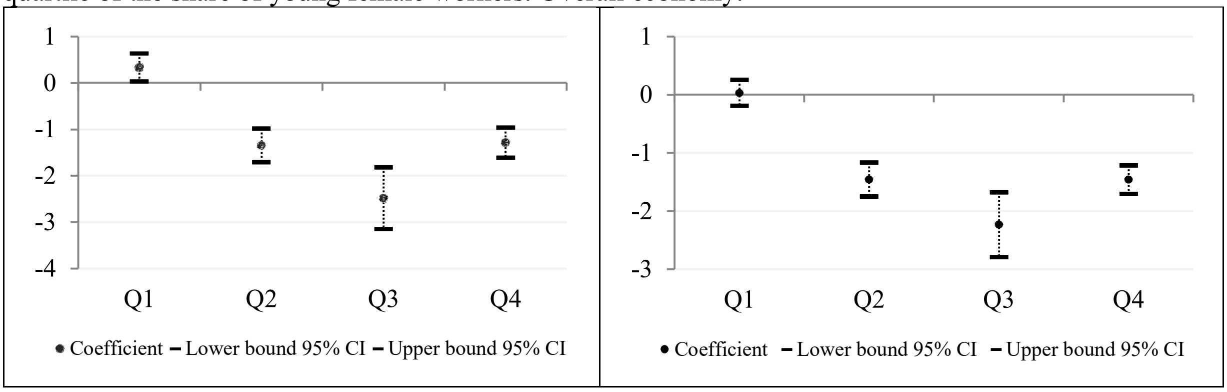
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Graph refers to figures for the construction sample. CI stands for confidence interval.

Young and old female workers

Finally, we focus on interactions between gender and age criterions (Graphs 11a and b, 12a and b). First, we consider young female workers. For the overall economy, the same conclusions hold as for female or young workers (Graph 11a). As for associations, both balanced and unbalanced panels reveal a (rather) nonlinear relation in the productivity gains due to any move to greater diversity in terms of female workers younger than 30. As previously, a positive effect is found in the first quartile, and negative ones in the last three. In particular, the relation is asymmetric for the balanced panel. A gain of 0.34 (resp. 1.28) position (rank of productivity) is obtained through any increase (resp. a decrease) of 1 position (rank of the share of young female workers) for firms from Q1 (resp. Q4). Considering the unbalanced panel, rather consistent findings are, including with descriptive statistics, even if the effect is not significant anymore for Q1. Looking at what happens at the industry level, things are not clear-cut, mainly because of large uncertainty (Graph 11b). A similar pattern as for the overall economy is obtained in real estate, rental and business services (accounting for 16.5% of businesses) or transportation and communication industries (accounting for 7.5% of businesses). In the former, the share of young female workers (about 4 percents) is smaller than in the overall economy (10 percents); in the latter, the contrary holds (12 percents VS. 10 percents). The relation appears to be slightly decreasing only for the transportation and communication industry. A gain in productivity is expected to more diversity for firms from Q1 through an increase in the given share in both industries, whereas only in the transportation and communication industry productivity grains are expected from decreasing the proportion of young female workers for firms in Q4.[34]

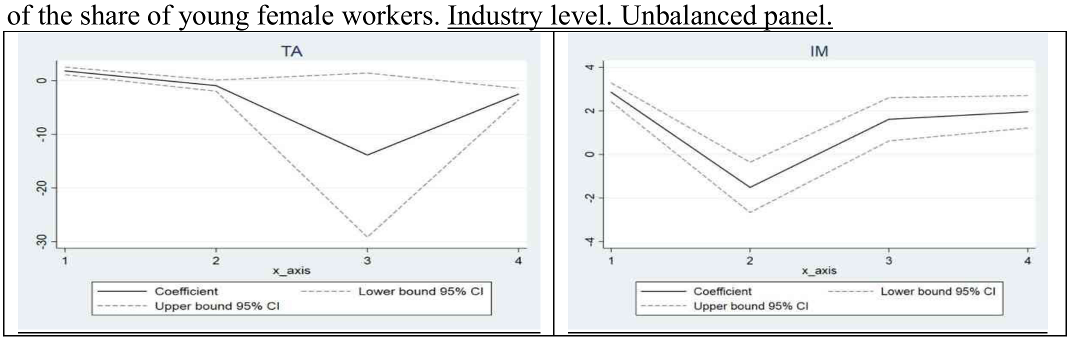
[34] Considering the balanced panel, the impact of greater diversity in terms of young female workers is positive both in Q1 and Q4, as for the overall economy.

Graph 11a. Effects of the share of young female workers on labor productivity. Rank-regressions by quartile of the share of young female workers. Overall economy.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Graph 11b. Effects of the share of young female workers on labor productivity. Rank-regressions by quartile of the share of young female workers. Industry level. Unbalanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the transportation and communication (resp. real estate, rental and business services) industries. CI stands for confidence intervals.

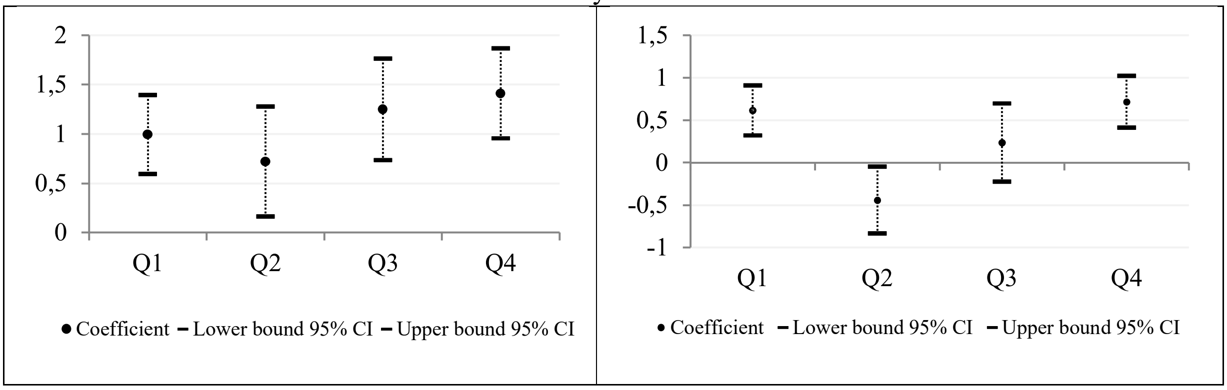
Second, we focus on old female workers. Both panels exhibit the same kind of *U*-shaped relation between diversity in terms of old female workers and labor productivity due to more diversity (Graph 12a). More precision is found through the unbalanced panel. The causal effect of a move towards more diversity in terms of old female workers is obtained for the first quartile, reflecting a positive impact of an increase in diversity on productivity. More ambiguous et almost 0 effects are found in Q2 and Q3. More surprising is the negative impact from increasing the diversity for firms from Q4.[35]

An apparent decreasing relation is found between the causal effect of the diversity in terms of old female workers and its consequence on labor productivity, in the manufacturing (balanced panel; 20% of businesses), and transportation and communication industries (unbalanced panel, 7.5% of businesses). Manufacturing industry is characterized by a share of old female workers identical to

[35] As for associations, the stories are quite different between the two panels. Moreover, both are not always consistent (except for Q1).

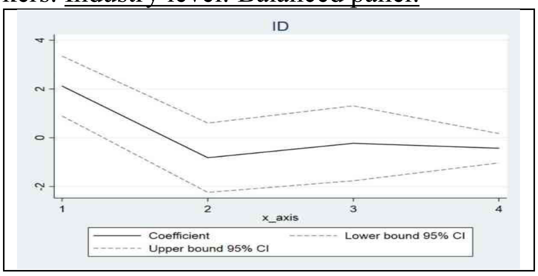
that of overall economy (about 8 percent), whereas transportation and communication industries exhibit a far smaller share of old female workers than the overall economy. Productivity gains are obtained through more diversity for firms from Q1 or Q4 only in the manufacturing (balanced panel) or transportation and communication (unbalanced panel) industries (no impact at all is detected for Q2 or Q3). These sectoral results at appear to be (at least partly) consistent with what is found for the overall economy (except for Q4), in spite of large heterogeneity and uncertainty.[36]

Graph 12a. Effects of the share of old female workers on labor productivity. Rank-regressions by quartile of the share of old female workers. Overall economy.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.

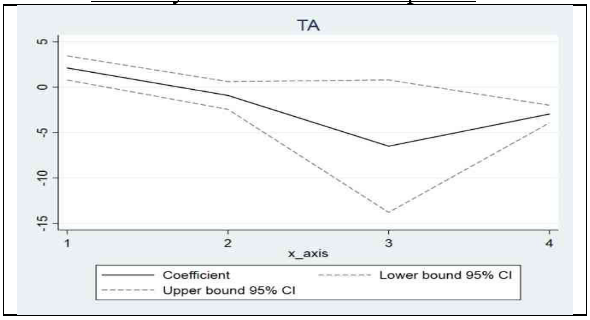
Graph 12b. Effects of the share of old female workers on labor productivity. Rank-regressions by quartile of the share of old female workers. Industry level. Balanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Graph refers to figures for the manufacturing industries. CI stands for confidence interval.

[36] The negative impact for firms from Q4 in the whole economy is due to both real estate, rental and business services, and to education, health and social services. Corresponding graphs are available on request. As well, full sets of estimates for old, young and old female workers for both panels are available on request. The same holds for estimates full specification in the case of the six industries.

Graph 12c. Effects of the share of old female workers on labor productivity. Rank-regressions by quartile of the share of old female workers. Industry level. Unbalanced panel.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Graph refers to figures for the transportation and communication industries. CI stands for confidence interval.

5.3. Discussion

So far, we find three important results for female, young and old workers. First, in the context of the production function, for all three kinds of criterions, we find significant and finite elasticity of substitution. Female and male workers, workers younger than 30 and medium-aged or old workers, as well as workers older than 49 and other workers, are found therefore to be partial substitutes. For all three types of criteria, there appear to be partial complementarities between the pairs of production factors considered. The same kinds of results hold for young or old female workers. This confirms past literature related to this matter. Thus, for instance for female and male workers, in spite of lot of progress to increase the female labor force participation, large gaps remain. Increasing female participation in the labor market should still increase the diversity of production factors and thus increase output more strongly than an equivalent increase in male employment. Such results argue for addressing all discrimination, at least against female, young and old workers. Furthermore, these results argue for distinguishing different categories of workers within the composite labor factor indicator in macroeconomic growth models.

Second, we study the impact of gender and age diversity in the firm workforce, while taking account for potential non-linear relation between diversity and its impact on labor productivity. We highlight several empirical results demonstrating the importance of age and gender diversity for business performance. This applies to the entire economy, excluding the public, agricultural, and financial industries. At least for female workers, young workers or young female workers, there is a decreasing relation between diversity in terms of those populations and the labor productivity of firms. For companies in the lowest quartile of the population studied, increasing the proportion of women, young people, or seniors has a positive impact on labor productivity. Conversely, and similarly, in companies employing the highest proportions of the population studied, a decrease in that proportion increases labor productivity.

Third, these results, which relate to firms employing at least workers from private, non-agricultural and non-financial industries, can be attributed to a limited number of business sectors. Some industries are inherently characterized by a lower proportion of the population employed than the economy as a whole, due to both organizational and technological constraints. Conversely, in other business sectors, the average proportion is higher than the economy average. Nevertheless, increasing the proportion of the population employed is beneficial for companies with the fewest employees in those industries. Similar arguments can be made for companies employing a large proportion of the population (the fourth quartile of the distribution). Considering old workers or old female workers, the non-linear relation between causal does not seem to be of the same form as for female, young or old female workers. However, there are still a small number of industries where increasing the proportion of the population in question in companies with an initially low share (*eg.* first quartile of the distribution), or where decreasing this proportion where it is initially high (*eg.* fourth quartile of the distribution), has the effect of increasing labor productivity in the companies concerned.

Therefore, according to us, this article produces sufficiently robust findings to inspire public policy actions in favor of gender and young workers diversity. It indicates that actions in favor of professional equality and gender or young worker diversity in firms do not only respond to the ethical issues of compliance with the principle of equality.

6. Extensions and robustness

In Section 3, we present the identification methods we intend to use to analyze the relationship between gender diversity in the workforce and firm performance in general. First, we test for potential complementarities between female and male workers, between workers younger than 30 and older workers, and between senior workers (*i.e.* older than 49) and other age groups. Second, we adopt a non-linear method, *à la* Chetty *et al.* (2014), to study the impacts of gender and age diversity on firm labor productivity.
In what follows, as an extension, we provide first some estimations of elasticities of substitution for some industries, where we have a sufficient number of observations, to see to what extent partial complementarity / substitutability between employed population are due to some industries. Then, we provide some alternative estimates for causal effects, considering log-linear regressions by quartile, using equation (8), in spite of some limitations that were mentioned in Section 3.

6.1. Substitutability between job categories depending on the considered industry

In Section 5.1, estimations of ES considering the overall economy considering all private sectors, except the agricultural and financial ones. It shows partial complementarity between any couple of population workers under consideration, and notably between female and male workers, as well as between young workers and medium-aged and workers older than 49.
In this sub-section, given some elements of discussion provided in Section 2, we display for two main industries, namely manufacturing and private services. This allows us to know to what extent our results are potentially more specifically linked to the manufacturing industries or to the private services industries. We focus only the three main comparison groups of workers (female vs. male workers; workers younger than 30 vs older workers; workers older than 49 vs other workers).[37]

[37] Since these refers to two parts of the economy, and given we consider a sectoral pseudo panel of firms at a 2 digits level, thirty industries over the 2009-2015, we already have to face a serious reduction in the number of observations. It is therefore difficult to consider more detailed business sectors of activity, such as those examined in our sectoral analysis of the effects of workforce diversity on labor productivity using the rank-regressions.

Considering female and male workers, except in the case of all firms whatever the size of its workforce and for year-end employment, corresponding ES appears to be smaller for manufacturing industries than for the tertiary business sector (on average 0.46 vs. 0.66 – see Tables G1a and G1b, in Appendix G). Thus, female and male workers seems to be more complementary production factors in the manufacturing industries than the services industries, even if the differences are not necessarily statistically significant from zero, because there is sufficient overlap of corresponding confidence intervals à a 5 percent level.

Looking at both workers younger than 30 and medium aged or senior workers, considering full time equivalent workers and firms employing more than 20 workers, ES is significantly larger for services industries than for manufacturing ones (Tables G2a and b in Appendix G). For other combinations of types of employment variables and firm sample, convergence is not achieved through non-linear least squares. However, allowing to minimize least squares with respect to the delta parameter, seems to lead to greater ES for services industries than for manufacturing industries for the sample containing all firms whatever the size of its workforce: both differences are not statistically different from zero (see corresponding confidence intervals in Tables G2c and d in Appendix G).[38] Therefore, except in one case, the complementary degree between young workers and other workers are not different considering manufacturing and services industries.

Finally, focusing on old workers and medium-aged or young workers, we have to also apply NLLS with respect to the delta parameter, because is never achieved for manufacturing industries as a first approach where delta is considered to be fixed through the information from our data sources. Even if values of ES are also greater in the ser vices industries than in the manufacturing industries, corresponding confidence interval show that those differences are never significant at the 5 percent level (Tables G3a and b in Appendix G).

To conclude, whatever the comparison groups under consideration (female vs. male workers; workers younger than 30 vs. older workers; workers older than 49 vs. younger workers), the degrees of complementarity within the comparison groups seem to be of the same order.

6.3 Robustness to analyzing non-linear effects of diversity through log-linear regressions

In this sub-section, as an alternative to rank-regressions by quartile of the share of the considered category of working population, we consider the aforementioned method, namely log-linear regressions by quartile.
As mentioned in Section 3, the non-linear method à a Chetty *et al.* (2014) can also be applied using equation (10). However, the potential nonlinearity detected during these regressions may be contingent on the chosen specification and therefore on the interpretation of the coefficient (proportion, semi-elasticity, for instance). To reason in terms of semi-elasticity, the outcome variable is considered as a logarithm. However, estimating the relationship between atypism (or diversity) and company performance by taking the logarithm of productivity leads to the exclusion of companies with zero productivity. Nevertheless, in spite of these elements, it can be worth testing the robustness of our results (Section 5.2) to such approach. Corresponding graphs are

[38] Nothing can be said in the case of firms employing more than 20 workers and considering full time employment level because convergence is not achieved.

displayed in Appendix H. For sake of brevity, we focus on the three main categories of workers, on results obtained causal effects of diversity of the workforce on labor productivity for firms employing 20 workers or more included in the overall non-farm and non-financial private business sectors.

Considering the impact of workforce diversity in terms of gender (Graphs H1 in Appendix H), log-linear regressions exhibit similar results as those provided by the rank-regressions, except that they seem to be less precise. Indeed, the relation between diversity in terms of gender and labor productivity is still strongly non-linear. In particular, firms should still be encouraged to increase the proportion of female workers when they are in the first quartile, whereas they would instead be inclined to reduce this proportion when it is high, *ie.* for firms from the third quartile.

Focusing on workforce diversity in terms of workers younger than 30 (Graphs H2 in Appendix H), we get the same kind of results, confirming those provided by rank-regressions in Section 5.2. The relation between the distribution of the share of young workers in the workforce and the logarithm of firm labor productivity is also strongly non-linear and rather asymmetric, with productivity gains from increasing the share of young workers for firms from the first quartile, and from decreasing the corresponding share for firms from the third quartile. For firms of the first (resp. fourth quartile), a gain of 1.39-2.85 (resp. 0.68-0.84) percent in the labor productivity is expected from an increase (resp. a decrease) of 1 pct point the share of young workers in Q1 (resp. Q4).

Finally, things are still less clear-cut for diversity of the workforce in terms of old workers. Indeed, even if the relation between the distribution of the workforce in terms of workers older than 49 and the size of firm labor productivity gains is still non-linear, it is not of the same type as that for female workers or young workers (Graphs H3 in Appendix H). It is also consistent with results from rank-regressions discussed in Section 5.2.[39]

7. Conclusion

This article explores the links between diversity of firm's workforce, in terms of gender or age (considering young and old workers), and firm performance. A wide range of literature already addresses this topic, both theoretically and empirically. However, the issue remains unresolved. The impact of age and gender workforce diversity on firms' growth and labor remains theoretically and empirically inconclusive.

We consider two complementary approaches. The first focuses on the productive complementarities of the populations under study (female and male workers; young and medium-aged or old workers, seniors and other workers). It estimates substitution elasticities in pairs of employed populations within the framework of Cobb Douglas type production functions where the labor factor is a composite aggregate with constant elasticities between the factors of production of the pairs considered. The second analyzes the effects of diversity in terms of women, young people or older workers on labor productivity in companies, allowing these effects to be different depending on the distribution of these criteria in companies and depending on the type of company

[39] In particular, the effect of an increase in the rank of the proportion aged 50 and more remains positive, first rising between Q1 and Q3 (an increase of 2.3 to 3.5 positions in firms' productivity rankings), and then declining (to about 2 positions).

(according to industries). To take account for the potential non-linear effects of gender or age diversity, we consider an approach à la Chetty *et al.* (2014), using an original instrument to cope with reverse causality. For both approaches, we use tax and accounting databases of French firms, with exhaustive coverage over 2009 to 2015 time period.
Several important results can be highlighted. The study carried out on the proportion of female, young or old workers yields a set of converging findings. First, our elasticities of substitution reveal partial complementarities within each pair of production factors considered. In the case of the gender criterion (for example), where the participation of women and men to the labor market is not equal, this implies, in particular, that increasing women's participation has a greater positive impact on firm growth than an equivalent increase in male employment would. Furthermore, from a macroeconomic modeling perspective within endogenous growth models, our results seem to support distinguishing different employment categories within the composite employment indicator, for example, by considering women and men. Second, the results provided by the estimation à la Chetty (Chetty *et al.*, 2014; Dahl and De Leir, 2008) that aims at analyzing the relation between gender and age diversity and labor productivity show strong non linearities. On the one hand a greater diversity (whatever the considered criterion under consideration: female, young, old workers or interactions) is associated with higher labor productivity for the whole economy. On the other hand, by instrumenting the share of the employed population under consideration with the share of the same kind of employment category, but calculated at the same 4 digits level as the company in question (but excluding the latter), we provide evident for a non-linear relation between diversity in terms of female or young workers (as well as for young female workers) and its impact on labor productivity. In particular, for firms belonging to the first quartile of the distribution based on the proportion of the employed population considered (women, young people, or young women), an increase in the proportion of this population leads to an increase in labor productivity. Similarly, a decrease in the proportion of the employed population considered for firms belonging to the fourth quartile of the corresponding distribution leads to the same result. Third, the results obtained across all companies with 20 or more employees in the private, non-agricultural, and non-financial sectors are attributable to firms belonging to some industries. While the associations between diversity in the workforce in terms of female, young or old workers are shared by a large proportion of business industries, the effects on labor productivity obtained through greater diversity in terms of female or young workers reflect what is measured in a small number of activities: namely trade and accommodations, or transportations and communications industries for female workers; trade and accommodations for workers younger than 30. In any case, whether it concerns industries where the proportion of the population concerned (women or young people) is either lower or higher than in all private, non-agricultural and non-financial business sectors, companies in the industry concerned benefit from productivity gains by increasing (respectively decreasing) the share of the population concerned if they are among the companies that initially employ a small share (respectively a large share) of the population concerned. Even in the case of senior workers or old female workers, where the profile of the relation between the diversity considered and its effects on labor productivity is different, a relation of the same type as that observed for female or young workers is detected in two particular business sectors: transportation and communications on the one hand (workers aged 50 and over) and manufacturing (women over 49).

Although we have used two complementary approaches to highlight regularities in the relations between the gender, young and old workers diversity of the workforce and the firm's labor productivity, some limitations of the work carried out are worth noting. We use administrative data

sources that are exhaustive and cover all firms with more than 20 workers in France. Even if the high number of firms allows us to highlight accurate effects, the variables in our databases do not allow us to control for all of the determinants of labor productivity and in particular those related to gender and age diversity in the workforce. In particular, these data do not provide information on the organization of work in a company; they do not provide information about the size and composition by gender and age at the work team level. It is clear that the gender / age distribution of work groups within the company can play a role in the relation between the diversity in terms of female, young or old workers and labor productivity.
More generally, we are not in a position to interpret the individual, organizational or contextual causes of the relation we have been able to identify. Several mechanisms are proposed by the theoretical and applied literature on the links between female, or young / old workers diversity and firm labor productivity, and our data do not enable us to identify the nature of the mechanisms at work. For example, experimental studies indicate that men are more individualistic and value competitive contexts more, which is a potential key to interpreting the links between the proportion of women in teams, their decisions, and their performance (Azmat and Petrongolo, 2014), although this cannot be confirmed here.

Nevertheless, it seems to us that this study produces sufficiently robust findings to inspire public policy actions in favor of (a greater) female, young or old workers diversity. It indicates that actions in favor of professional equality and gender or young worker diversity in firms do not only respond to the ethical issues of compliance with the principle of equality. The performance of some companies can be greatly improved by actions that promote diversity of the workforce in terms of gender or age. Moreover, we show that the most effective action in this area is probably not a general and uniform action for all companies, but an action targeted at a some companies from a small number of industries that can be identified precisely.

References

ACEMOGLU, D., AUTOR., D. H. and LYLE, D. (2004), "Women, War, and Wages: The Effect of Female Labor Supply on the Wage Structure at Midcentury", *Journal of Political Economy*, 112 (3), 497-551.

ADAMS, R. B. and FERREIRA, D. (2009), "Women in the boardroom and their impact on governance and performance", *Journal of Financial Economics*, 94(2), 291–309.

AHERN, K. and DITTMAR, A. (2012), "The changing of the boards: the impact on the firm valuation of mandated female board representation", *Quarterly Journal of Economics*, 127(1), 137-197, Published by: Oxford University Press.

AKERLOF, G. (1976) "The Economics of Caste and of the Rat Race and Other Woeful Tales", The *Quarterly Journal of Economics*, 90(4), 599-617.

AKERLOF, G. A. and KRANTON, R. E (2000), "Economics and Identity", *Quarterly Journal of Economics*, 115(3), 715–753.

ALESINA, A., DEVLEESCHAUWER, A., EASTERLY, W. and KURLAT, S. (2003), "Fractionalization", *Journal of Economic Growth*, 8, 155-194.

ALESINA, A., HARNOSS, J. and RAPOPORT, I. (2016), "Birthplace and Economic Prosperity", *Journal of Economic Growth*, 21(2), 101-138.

ALESINA, A. and LA FERRARA, E. (2005). "Ethnic diversity and economic performance". *Journal of Economic Literature,* 43, 762–800.

ALTONJI, J. G. and BLANK, R. M. (1999), "Race and gender in the labor market", in *Handbook of Labor Economics*, Vol. 3, Ch. 48, 3143-3259.

ANDERSEN, A. K. (2002), “Are Commuting Areas Relevant for the Delimitation of Administrative Regions in Denmark?”, *Regional Studies,* Vol. 36.8, 833–844.
ANGRIST J. D., IMBENS G. W. and RUBIN, D. B., (1996), “Identification of Causal Effects Using Instrumental Variables”, *Journal of the American Statistical Association*, 91(434), 444-555.
APESTEGUIA, J., AZMAT, G. and IRIBERRI, N. (2012), “The impact of gender composition on team performance and decision making: evidence from the field”, *Management Science*, 58(1), Special Issue on Behavioral Economics and Finance (Part 1 of 2), 78-93.
ARNTZ, G. and GREGORY, T. (2014), “What Old Stagers Could Teach Us - Examining Age Complementarities in Regional Innovation Systems”, *Centre for European Economic Research* (ZEW) Manheim, *Discussion paper*, No. 14050.
AZMAT, G. (2014), “Gender diversity in teams. Greater representation of women on decision-making teams may better represent women’s preferences but may not help economic performance”, *IZA World of Labor*, No. 29.
AZMAT, G. and PETRONGOLO B. (2014), “Gender and the labor market: What have we learned from field and lab experiments?”, *Labour Economics,* 30, 32–40.
BARGAIN, O. and LO BUE, M. C. (2025), “The economic gains of closing the employment gender gap: evidence from Morocco”, *Feminist Economics*, forthcoming.
BEAR, S., RAHMAN, N. and POST, C. (2010), “The impact of board diversity and gender composition on corporate social responsibility and firm reputation”*, Journal of Business Ethics,* 97, 207-221.
BEN SLAMA, R., AJINA, A. and LAHKAL, F. (2019), “Board gender diversity and firm financial performance in France: Empirical evidence using quantile difference-in-differences and dose-response models”, *Cogent Economics and Finance*, 7(1), 1-25.
BORGHANS, L., WEEL, B. T. and WEINBERG, B. (2014), “People skills and the labor-market outcomes of underrepresented groups”, *International Labor Relations Review*, 67(2), pp. 287-334
CAMPBELL, K. and MINGUEZ-VERA, A. (2008), “Gender Diversity in the Boardroom and Firm Financial Performance”, *Journal of Business Ethics*, 83, 435–451.
CARD, D. and LEMIEUX, D., (2001), “Can falling supply explain the rising return to college for younger men? A cohort-based analysis”, *Quarterly Journal of Economics*, May, 116(2), 705-746.
CARTER, D., SIMKIN, D. and SIMPSON G. (2003), “Corporate Governance, Board Diversity, and Firm Value”, *Financial Review*, 38, 33-53.
CARTON, A. M. and CUMMINGS, J. N. (2012), “A theory of subgroups in teams”, *Academic Management Review,* 37(3), 441-470.
CAVALCANTI, T. and TAVARES, J. (2016), “The output cost of gender discrimination: a model-based macroeconomics estimate”, *Economic Journal*, 126(590), 109-134.
CHETTY, R., HENDREN N., KLINE P. and SAEZ E. (2014), “Where is the land of opportunity? The geography of intergenerational mobility in the United States”, *Quarterly Journal of Economics*, 129(4), 1553–1623.
DAGSSON, S. and LARSSON, E. (2011), “How age diversity on the Board of Directors affects Firm Performance”, Master’s Thesis in Business Administration, Supervisor: SÄLLBERG, H. .
DAHL, M. W. and DE LEIR, T. (2008), “The association between children's earnings and fathers' lifetime earnings: estimates using administrative data”, *Institute for Research on Poverty*, Discussion Paper, No. 1342-08.
DALE-OLSEN, H., SCHONE, P. and VERNER. M. (2013), “Diversity among Norwegian boards of directors: does a quota for women improve firm performance?”, *Feminist Economics*, 19(4), 110–135.
DARMADI, S. (2011), “Board diversity and firm performance: the Indonesian evidence”, *Corporate Ownership & Control*, Vol. 9, Issue 1, Continued – 5.
DAWSON, J. F. (2012), “Measurement of work group diversity”, Ph. D. thesis, Aston University, Birmingham.
DE MEULENAERE, K., BOONE, C. and BUYL, T. (2016), “Unraveling the impact of workforce age diversity on labor productivity: The moderating role of firm size and job security”, *Journal of Organizational Behavior*, 37, 193–212.

EDO, A. (2020), "The Impact of Immigration on Wage Dynamics: Evidence from the Algerian Independence War", *Journal of the European Economic Association*, Vol. 18, Issue 6, 3210–3260.
ERHARDT, N., WERBEL, J. and SHRADER, D. (2003), "Board of Director Diversity and Firm Financial Performance", *Corporate Governance*, 11(2), 102–111.
FAMA, E. F. (1980), "Agency Problems and the Theory of the Firm", *Journal of Political Economy*, 88 (2), 288-307.
FITZENBERGER, B. and KOHN, K. (2006), "Skill Wage Premia, Employment, and Cohort Effects: Are Workers in Germany All of the Same Type?", *IZA discussion paper*, No. 2185.
GARNERO, A., KAMPELMANN S. and RYCX F. (2014), "The Heterogeneous Effects of Workforce Diversity on Productivity, Wages, and Profits", *Industrial Relations*, 53(3), 430-477.
GARNERO, A., KAMPELMANN, S. and RYCX, F. (2016), "Is Workforce Diversity Always Performance-enhancing? A Literature Review", *Reflets et Perspectives*, LV, 2016/4.
GHOSH, P. K. (2018), "A Study of the Long-run Substitutability Between Men and Women", *IZA Conference.*
GOBEL, C. and ZWICK, T. (2013), "Are personnel measures effective in increasing productivity of old workers?", *Labour Economics*, 22, 80–93.
GOLDIN, C. (1995), "The U-Shaped Female Labor Force Function in Economic Development and Economic Histor". In T.P. Schultz (ed), Investment in Women's Human Capital and Economic Development. Chicago: Chicago University Press. NBER working paper, No. 4707, 1994.
GRANT, G. H. and HAMERMESH, D. S. (1981), "Labor Market Competition among Youths, White Women and Others", *Review of Economics and Statistics*, 63(3), 354-360.
GREEN, C. and HOMROY, S. (2018), "Female directors, board committees and firm performance", *European Economic Review*, 102, 19–38, 2018.
GRUND, C., and WESTERGAARD-NIELSEN, N., (2008), "Age structure of the workforce and firm performance", *International Journal of Manpower*, 29(5), 410-422.
HANLON, M., RAJGOPAL, S. and SHEVLIN, T. (2003), "Are executive stock options associated with future earnings?", *Journal of Accounting and Economics*, 36, 3-43.
HARRISON, D. and KLEIN, C. (2007), "What's the Difference? Diversity Constructs as Separation, Variety, or Disparity in Organizations", *Academy of Management Review*, 32(4), 1199-1228.
HEBBING, G. E. (1993), "Production factor substitution and employment by age group", *Economic Modelling*, 10(3), 217-224.
HOLSTROM, B. (1999), "Managerial Incentive Problems: A Dynamic Perspective", *Review of Economic Studies*, 66(1), Special Issue: Contracts (Jan., 1999), 169-182.
HORWITZ, S. K. and HORWITZ, I. B. (2007), "The Effects of Team Diversity on Team Outcomes: A Meta-Analytic Review of Team Demography", *Journal of Management*, 33(6), 987-1015.
HOYER, W. J. and LINCOURT, A. E. (1998), "Ageing and the Development of Learning", in *Handbook of Implicit Learning*, edited by M. A. Stadler and P. A. Frensch, pp. 445–470. Thousand Oaks, CA: Sage Publications.
HUNT, V., LAYTON, D. and PRINCE, S. (2015), "Why diversity matters", McKinsey & Company.
HUNT, V., PRINCE, S., DIXON-FYLE, S. and YEE, L. (2015), "Delivering through Diversity", McKinsey & Company.
ILMAKUNNAS, P. and ILMAKUNNAS, S. (2011), "Diversity at the Workplace: Whom Does it Benefit?", *De Economist*, 159, 223–255.
JAEGER, D. A., RUIST, J., and STUHLER, J. (2018), "Shift-share instruments and the impact of immigration", *IZA*, discussion paper, No. 11307.
JARRELL, S. B. and STANLEY, T. D. (2004), "Declining Bias and Gender Wage Discrimination? A Meta-Regression Analysis", *Journal of Human Resources*, 39 (3), 828-838.
JOST, L. (2007), "Partitioning Diversity into Independent Alpha and Beta Components", *Ecology*, 88(10), 2427-2439.

KAHANE, L., LONGLEY, N. and SIMMONS, R. (2013), "The effects of coworker heterogeneity on firm-level output: assessing the impacts of cultural and language diversity in the national hockey league", *Review of Economics and Statistics*, 95(1), 302-314.
KAHN, S. and KLASEN, S. (2018), "Macro-economics and gender: recent research on the linkages between economic growth and women's economic empowerment", *World Bank*, International Development Research Centre.
KLASEN, S. (2018), "The Impact of Gender Inequality on Economic Performance in Developing Countries", *Annual Review of Resource Economics*, 10:279–298.
KLASEN, S. and LAMANNA, F. (2009), "The Impact of Gender Inequality in Education and Employment on Economic Growth in Developing Countries: Updates and Extensions", *Feminist Economics*, 15(3), 91–132.
KUNTZ, S., BOEHM, S. A. and BRUCH, H. (2011), "Age diversity, age discrimination climate and performance consequences – a cross organizational study", *Journal of Organizational Behavior*, 32(2) - S. 264-290.
KUNTZ, S., BOEHM, S. A. and BRUCH, H. (2013), "Organizational Performance Consequences of Age Diversity: Inspecting the Role of Diversity-Friendly HR Policies and Top Managers' Negative Age Stereotypes", *Journal of Management Studies*, 50(3), 413-442.
LAZEAR, E. P. (1976), "Age, Experience and Wage Growth", *American Economic Review*, 66(4), 548-558.
LAZEAR, E. P (1998), "Diversity an immigration", *NBER*, working paper, No. 6535.
LAZEAR, E. P. (1999). "Globalization and the Market for Team-Mates", *Economic Journal*, 109(454): C15–40.
LAZEAR, E. P. (1999b). "Culture and language", *Journal of Political Economy,* 107(6), Part. 2.
LAZEAR, E. P. and OYER, P. (2007), "Personnel Economics", NBER, working paper, No. 13480.
LEE, C. L., and FARH, J.-L. (2004), "Joint Effects of Group Efficacy and Gender Diversity on Group Cohesion and Performance", *Applied Psychology*, 53(1), 136–154.
LEONARD, J. and LEVINE, D. (2003), "Diversity, discrimination and performance", *Institute of Industrial Relations*, Working Paper No. iirwps-091-03.
LEV, B. and SOUGIANNIS, T. (1996), "The capitalization, amortization, and value-relevance of R&D", *Journal of Accounting and Economics*, 21, 107-138.
LEWIS, E. and PERI, G. (2015), "Immigration and the Economy of Cities and Regions", in *Handbook of Regional and Urban Economics*, Chap. 10, 5, 625-685.
LIU, Q., WANG, L. F. S. and CHEN, C. L. (2018), "CSR in an oligopoly with foreign competition: Policy and welfare implications", *Economic Modelling*, 72, 1-7.
LONGHI, S. (2013), "Impact of cultural diversity on wages, evidence from panel data", Regional *Science and Urban Economics*, 43, 797–807.
LOVASZ, A. and RIGO, M. (2013), "Vintage effects, aging and productivity", *Labour Economics*, 22, 47–60.
MASSEY, D. S. and DENTON, N. A. (1998), "The Dimensions of Residential Segregation", *Social Forces*, 67(2), 282-314.
MURPHY, K. J. (1999), "Executive compensation", Chap. 38 in *Handbook of Labor Economics*, Vol. 3, Part B, 2485-2563.
NEVO, A. (2000), "Mergers with Differentiated Products: The Case of the Ready-to-Eat Cereal Industry", *RAND Journal of Economics*, 31(3), 395-421.
NON, A. ROHDE, I., de GRIP A. and DOHMEN, T. (2022), "Mission of the company, prosocial attitudes and job preferences: A discrete choice experiment", *Labour Economics*, 74.
OSTERGAARD, C. R., TIMMERMANS, B. and KRISTINSSON, K. (2011), "Does a different view create something new? The effect of employee diversity on innovation", *Research Policy*, 40, 500–509.

OSTRY, J. D., ALVAREZ, J., ESPINOZA, R. and PAPAGEORGIOU, C. (2018), “Economic Gains from Gender Inclusion: New Mechanisms, New Evidence”, *IMF Staff discussion note*, SDN/18/06.
OTTAVIANO, G. I. P. and PERI, G. (2005), “Cities and cultures”, *Journal of Urban Economics*, 58, 304–337.
OZGEN, C. (2021), “The economics of diversity: Innovation, productivity and the labour market”, *Journal of Economic Surveys*, 35(4), 1168-1216.
PARROTTA, P., POZZOLI, D. and PYTLIKOVA, M. (2014a), “Labor diversity and firm productivity”, *European Economic Review*, 66, 144–179.
PARROTTA, P., POZZOLI, D. and PYTLIKOVA, M. (2014a), “The nexus between labor diversity and firm’s innovation”, *Journal of Population Economics*, 27, 303–364.
PELLIZARI, M., PACCAGNELLA, M. and DE GIORGI, G., (2014), “Gender Complementarities in the Labor Market”, *Research in Labor Economics*, 41, 277-298.
PETERS, J. C. (2015), “Do age complementarities affect labour productivity? Evidence from German firm level data”, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2015: Ökonomische Entwicklung - Theorie und Politik - Session: Empirical Labor Economics, No. D07-V3, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft.
PETERSSON, C. and WALLIN, F. (2017), “Three Types of Age Diversity in Boards of Directors and the Relationship to Firm Performance”, Master ’s Thesis, Uppsala University.
SEGUINO, S. (2000), “Gender Inequality and Economic Growth: A Cross-Country Analysis”, *World Development*, 28 (7), 1211-1230.
SHANNON, C. E. (1948), “A Mathematical Theory of Communication”, *The Bell System Technical Journal*, 27, 379–423, 623–656, July, October, 1948.
SHANNON, C. E. and WEAVER, W. (1963), “The mathematical theory of communication”, the University of Illinois Press, Urbana.
SHOCK, N. W. (1962), “The psychology of aging”, *Scientific American*, 206(1), 100-111.
SKIRBEKK, V. (2003), “Age and Individual Productivity: A Literature Survey”, Technical Report No. 2003-028. Rostock: Max Planck Institute for Demographic Research.
SOLAKOGLU, M. N. (2013), “The role of gender diversity on firm performance: a regression quantile approach”, *Applied Economics Letters*, 20(17), 1562–1566.
SOLOW. R. (1956), “A contribution to the theory of economic growth”, *Quarterly Journal of Economics*, 70(1), 65–94.
STOCK, J. and YOGO, M. (2005), “Testing for Weak Instruments in Linear IV Regression”, in: *Andrews DWK Identification and Inference for Econometric Models*, New York: Cambridge University Press, pp. 80-108.
VAN DIJK, H. and VAN ENGEN, M. L. (2013), “A status perspective on the consequences of work group diversity”, *Journal of Occupational and Organizational Psychology*, 86, 223–241.
VANDENBERGHE, V. (2013), “Are firms willing to employ a greying and feminizing workforce?”, *Labour Economics,* 22, 30–46.
WEINBERG, B. A. (2000), “Computer Use and the Demand for Female Workers”, *Industrial Relations Review*, 53(2), 290-308.
WELCH, F. (1979), “Effects of Cohort Size on Earnings: The Baby Boom Babies' Financial Bust”, *Journal of Political Economy*, 87(5), Part 2, S65-S97.
ZELITY, B. (2023), “Age diversity and aggregate productivity”, *Journal of Population Economics*, 36, 1863–1899.

Appendix A. Workforce composition of firms included in samples under study.

Table A1. Descriptive statistics at the company level. Balanced panel.

Variable	**Mean**	**Standard deviation**
Labor productivity (€, thousands):	63,357	458,172
Total business workforce (number of workers):	130.3	1,010.3
Labor force composition (percent of business workforce):		
Proportion of female workers	36.67	26.64
Proportion of workers younger than 30	26.14	16.88
Proportion of female younger than 30	10.48	12.29
Proportion of workers older than 49	22.20	12.42
Proportion of female older than 49	7.58	8.17
Other features of firm workforce (percent of business workforce):		
Proportion of blue-collar workers	39.29	33.25
Proportion of employees	29.02	30.08
Proportion of intermediate workers	16.90	16.24
Proportion of executives	13.77	19.17
Proportion of full-time workers	83.50	19.73
Firm class size (percent of businesses):		
20<=workforce size<50	55.21	49.73
50<=workforce size <100	23.04	42.11
100<=workforce size <250	13.70	34.39
250<=workforce size <500	4.56	20.87
500<=workforce size <1000	2.01	14.04
1000<=workforce size <2000	0.87	9.29
2000<=workforce size <5000	0.43	6.54
Workforce size >=5000	0.17	4.13
Proportion of the business workforce, by region (percent of the company's workforce):		
11-Paris region	21.43	39.04
24-Centre-Val de Loire	3.96	18.45
27-Burgandy	4.49	19.84
28-Normandy	5.21	21.17
32-Hauts-de-France	8.39	26.61
44-Grand Est	8.37	26.72
52-Pays de la Loire	6.71	23.82
53-Brittany	5.02	20.99
75-Nouvelle-Aquitaine	8.54	26.80
76-Occitanie	7.38	24.88
84-Auvergne-Rhône-Alpes	13.60	32.83
93-Provence-Alpes-Côte d'Azur	6.42	23.23
94-Corsica	0.47	6.77

Table A1. Descriptive statistics at the company level. Balanced panel (continued).

Variable	**Mean**	**Standard deviation**
Business' age (years):	26.8	18.95
Other activity indicators of the business:		
Turnover (€, thousands)	35,815	294,125
Value added (€, thousands)	9,560	103,919
Capital intensity ratio (€ per head, thousands)	92,778	560,008
Proportion of wages in value added (percent)	78.664	5.54
Business sectors (percent of firm):		
A-AA-Agriculture, hunting, forestry	-	-
B-BA-Fishing and aquaculture	-	-
C-Extraction industries		
CA-Extraction of energy products	0.01	0.95
CB-Extraction of non-energy products	0.37	6.08
D-Manufacturing industries		
DA-Agriculture and food industries	3.71	18.91
DB- Textile and clothing industries	1.54	12.30
DC-Leather sector and footwear industries	0.26	5.07
DD-Manufacture of wood, and wood products	0.75	8.61
DE-Pulp, paper products; publishing and printing	2.57	15.83
DF-Coking, refined petroleum, and nuclear fuel	0.04	1.93
DG-Chemical and pharmaceutical industries	1.37	11.64
DH-Rubber and plastic industries	1.67	12.83
DI-Manufacturing of other non-metallic mineral products	0.92	9.51
DJ-Metallurgy and manufacture of metal products	4.80	21.37
DK-Manufacturing of machinery and equipment	3.48	18.33
DL-Manufacturing of electrical and electronic goods	1.62	12.64
DM-Transportation equipment manufacturing	1.08	10.36
DN-Other manufacturing industries	0.69	8.28
EA-Electricity, gas, and water supply	0.19	4.34
FA-Construction	11.97	32.47
GA-Wholesale and retail trade, repair of personal and household goods	22.58	41.81
HA-Hotels and restaurants	5.60	22.99
IA-Transportation and communications	8.07	27.23
JA-Financial industries	-	-
KA-Real estate, renting and business activities	17.19	37.73
LA-Public administrations	-	-
MA-Education	0.98	9.87
NA-Health and social work	5.36	22.52
OA-Community, social and personal services	3.17	17.51
PA-Activities of housholds	-	-
QA-Activities of non-governmental organizations	-	-

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: figures correspond to average shares of the overall workforce.

Table A2. Firm workforce composition by industry. Balanced panel.

Workforce population \ Industry (number of workers)	Female workers	Young workers	Old workers	Young female workers	Old female workers
Overall economy (56,269 firms)	36.68	26.14	22.20	10.49	7.58
Manufacturing (13,460 firms)	28.82	18.51	26.93	5.05	8.05
Construction (6,572 firms)	9.54	27.04	22.70	2.06	2.16
Trade, hotels and restaurants (15,285 firms)	43.71	36.10	17.29	17.40	6.65
Transport and telecommunications (4,420 firms)	18.41	16.98	28.38	4.02	4.05
Real estate, rental, and business services (9,272 firms)	48.50	25.01	19.72	12.18	9.71
Education, health, and social assistance (5,250 firms)	64.97	26.06	23.20	17.75	15.11

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: figures correspond to average shares of the overall workforce.

Table A3. Firm workforce composition by industry. Unbalanced panel.

Workforce population \ Industry (number of workers)	Female workers	Young workers	Old workers	Young female workers	Old female workers
Overall economy (124,295 firms)	36.97	28.50	20.66	11.34	7.24
Manufacturing (24,998 firms)	29.00	20.45	26.19	5.78	7.79
Construction (15,516 firms)	9.70	29.64	20.72	2.34	2.07
Trade, hotels and restaurants (33,435 firms)	43.78	37.90	16.21	18.06	6.38
Transport and telecommunications (9,373 firms)	18.49	19.61	26.04	4.46	3.89
Real estate, rental, and business services (24,033 firms)	45.13	27.68	17.78	12.59	8.24
Education, health, and social assistance (13,286 firms)	65.00	27.06	22.83	18.31	14.91

Sources: DADS (Insee) and FARE (Insee).
Scope: 124,295 firms employing 20 workers or more over, perennial or not over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: figures correspond to average shares of the overall workforce.

Appendix B. Average number of workers and corresponding hours of work for the target population over 2009-2015 and for the overall economy.

Table B1. Estimation of the elasticity of substitutions between female and male workers. Descriptive statistics: average number of workers and corresponding hours of work over 2009-2015 for the overall economy.

Statistics / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Number of female workers (1)	7185449,1	4546529,13	4656222,9	3152067,91
Number of male workers (2)	10662034,2	6568631,85	7706917,2	5079379,76
Ratio of (1) to (2): T/N	0,673928536	0,6921577	0,60416153	0,620561576
Monthly hours of work of female workers (3)	102,7137495	108,206804	158,507106	156,0770294
Monthly hours of work of male workers (4)	117,4804799	124,354696	162,52684	160,8149555
Ratio of (3) to (4): δ parameter	0,874304817	0,87014651	0,97526726	0,970538026

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the private non-farm and non-financial industries.

Table B2. Estimation of the elasticity of substitutions between young and medium aged-old workers. Descriptive statistics: average number of workers and corresponding hours of work over 2009-2015 for the overall economy.

Statistics / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Number of young workers (1)	4971109,8	2689037,03	2735858,4	1567064,57
Number of medium-aged workers (2)	12876373,8	8426123,95	9627281,7	6664383,1
Ratio of (1) to (2): T/N	0,386064421	0,31913096	0,28417766	0,23514023
Monthly hours of work of young workers (3)	88,1969265	91,7520355	160,255586	157,443822
Monthly hours of work of medium aged-old workers (4)	120,5454863	126,04621	161,228141	159,366738
Ratio of (3) to (4): δ parameter	0,731648519	0,72792379	0,99396783	0,98793402

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the private non-farm and non-financial industries.

Table B3. Estimation of the elasticity of substitutions between old and young-medium aged workers. Descriptive statistics: average number of workers and corresponding hours of work over 2009-2015 for the overall economy.

Statistics / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Number of old workers (1)	3948090,9	2658601,85	2998684,5	2135146,08
Number of young-medium aged workers (2)	13899390	8456559,44	9364455,6	6096301,59
Ratio of (1) to (2): T/N	0,284047782	0,31438339	0,32021984	0,35023629
Monthly hours of work of old workers (3)	122,4621278	127,896182	161,234563	159,251393
Monthly hours of work of young-medium aged workers (4)	108,431625	114,559665	160,941949	158,912847
Ratio of (3) to (4): δ parameter	1,129394933	1,11641546	1,00181814	1,00213039

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the private non-farm and non-financial industries.

Table B4. Estimation of the elasticity of substitutions between young female workers and other female workers or male workers. Descriptive statistics: average number of workers and corresponding hours of work over 2009-2015 for the overall economy.

Statistics / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Number of young female workers (1)	2070044,7	1177304,67	1045880,4	631966
Number of other female workers or male workers (2)	15777438,9	9937856,62	11317259,7	7599481,67
Ratio of (1) to (2): T/N	0,131202834	0,11846666	0,09241463	0,08315909
Monthly hours of work of young female workers (3)	79,8993451	83,3640644	158,139703	155,300919
Monthly hours of work of other female workers or male workers (4)	115,6860845	121,823124	161,27845	159,308329
Ratio of (3) to (4): δ parameter	0,69065649	0,68430411	0,98053834	0,97484494

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the private non-farm and non-financial industries.

Table B5. Estimation of the elasticity of substitutions between old female workers and other female workers or male workers. Descriptive statistics: average number of workers and corresponding hours of work over 2009-2015 for the overall economy.

Statistics / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Number of old female workers (1)	1567820,7	1058033,1	1123912,8	807641,14
Number of other female workers or male workers (2)	16279662,9	10057127,88	11239227,3	7423806,53
Ratio of (1) to (2): T/N	0,096305477	0,10520231	0,09999912	0,1087907
Monthly hours of work of old female workers (3)	113,4892809	118,81005	158,313717	155,644596
Monthly hours of work of other female workers or male workers (4)	111,347177	117,638023	161,282841	159,365771
Ratio of (3) to (4): δ parameter	1,019238062	1,00996299	0,98159058	0,9766501

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the private non-farm and non-financial industries.

Appendix C. Estimation of the share of the given share of workers: female, young, old or young / old female workers. Full specifications.

Table C1. First step. Estimation of the share of the given share of workers: female, young, old workers and young or old female workers. Sample: balanced panel.

Explanatory variable / Explained variable. Average share of:	Female workers	Young workers	Old workers	Young female workers	Old female workers
Firms characteristics. Activity indicators (average lagged values)					
Business' age (years)	0.001***	-0.001***	0.001***	-0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital intensity	-2.58e-06**	-0.001***	0.001***	-7.29e-06***	6.27e-06***
	(0.031)	(0.000)	(0.000)	(0.000)	(0.000)
Share of wages in value added	-0.001	0.001	-0.001	-0.001	-0.001
	(0.245)	(0.734)	(0.682)	(0.469)	(0.435)
Features of firm workforce (percent of business workforce). Average (lagged) shares of:					
Blue collar workers	-0.405***	-0.217***	0.153***	-0.238***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.403)
Intermediate workers	-0.200***	-0.170***	0.081***	-0.157***	0.006**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.021)
Executives	-0.281***	-0.193***	0.037***	-0.170***	-0.042***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Full-time workers	-0.414***	-0.100***	-0.065***	-0.166***	-0.107***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Workers older than 49	0.030***	-	-	-	-
	(0.000)	-	-	-	-
Female workers	-	-0.029***	0.012***	-	-
	-	(0.000)	(0.000)	-	-
Firm size dummies					
Between 20 and 49 workers	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Between 50 and 99 workers	0.004**	0.008***	-0.008***	0.007***	-0.002***
	(0.014)	(0.000)	(0.000)	(0.000)	(0.001)
Between 100 and 249 workers	0.012***	-0.002	-0.008***	0.006***	-0.001
	(0.000)	(0.127)	(0.000)	(0.000)	(0.871)
Between 250 and 499 workers	0.017***	-0.003	-0.010***	0.010***	-0.001
	(0.000)	(0.147)	(0.000)	(0.000)	(0.286)
Between 500 and 999 workers	0.018***	0.001	-0.015***	0.014***	-0.004**
	(0.000)	(0.917)	(0.000)	(0.000)	(0.037)
Between 1000 and 1999 workers	0.005	-0.001	-0.014***	0.010***	-0.006**
	(0.558)	(0.983)	(0.003)	(0.000)	(0.032)

Between 2000 and 4999 workers	-0.010 (0.300)	-0.004 (0.673)	-0.009 (0.191)	0.006 (0.243)	-0.007** (0.067)
Greater than or equal to 5000 workers	-0.018 (0.216)	-0.016 (0.243)	0.019* (0.084)	-0.013* (0.060)	0.007 (0.246)
Business sector dummies:					
Extraction industries:					
CA-Extraction of energy products	-0.088** (0.041)	0.005 (0.924)	0.177 (0.158)	0.012 (0.658)	-0.020 (0.327)
CB-Extraction of non-energy products	-0.084*** (0.000)	-0.040*** (0.000)	0.049*** (0.000)	0.001 (0.486)	-0.031*** (0.000)
Manufacturing industries:					
DA-Agriculture and food industries	0.151*** (0.000)	0.040*** (0.000)	-0.018*** (0.000)	0.065*** (0.000)	0.023*** (0.000)
DB- Textile and clothing industries	0.226*** (0.000)	-0.062*** (0.000)	0.092*** (0.000)	0.025*** (0.000)	0.113*** (0.000)
DC-Leather sector and footwear industries	0.433*** (0.000)	-0.043*** (0.000)	0.099*** (0.000)	0.074*** (0.000)	0.163*** (0.000)
DD-Manufacture of wood, and wood products	-0.045*** (0.000)	-0.012** (0.033)	0.013** (0.023)	0.003* (0.056)	-0.014*** (0.000)
DE-Pulp, paper products; publishing and printing	0.079*** (0.000)	-0.059*** (0.000)	0.031*** (0.000)	0.003* (0.074)	0.031*** (0.000)
DF-Coking, refined petroleum, and nuclear fuel	-0.042** (0.012)	-0.059*** (0.001)	0.057*** (0.005)	-0.012 (0.248)	-0.004 (0.708)
DG-Chemical and pharmaceutical industries	0.124*** (0.000)	-0.032*** (0.000)	0.012*** (0.004)	0.033*** (0.000)	0.022*** (0.000)
DH-Rubber and plastic industries	0.066*** (0.000)	-0.044*** (0.000)	0.007* (0.052)	0.011*** (0.000)	0.020*** (0.000)
DI-Manufacturing of other non-metallic mineral products	-0.035*** (0.000)	-0.047*** (0.000)	0.030*** (0.000)	0.003 (0.184)	-0.009*** (0.003)
DJ-Metallurgy and manufacture of metal products	-0.054*** (0.000)	-0.033*** (0.000)	0.031*** (0.000)	-0.001 (0.490)	-0.015*** (0.000)
DK-Manufacturing of machinery and equipment	-0.107*** (0.000)	-0.018*** (0.000)	0.037*** (0.000)	-0.016*** (0.000)	-0.023*** (0.000)
DL-Manufacturing of electrical and electronic goods	0.076*** (0.000)	-0.047*** (0.000)	0.049*** (0.000)	-0.006*** (0.001)	0.049*** (0.000)
DM-Transportation equipment manufacturing	-0.015** (0.022)	-0.035*** (0.000)	0.022*** (0.000)	0.001 (0.846)	-0.002 (0.477)
FA-Construction	-0.110*** (0.000)	0.061*** (0.000)	-0.022*** (0.000)	0.001 (0.131)	-0.041*** (0.000)
GA-Wholesale and retail trade, repair of personal and household goods	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***

HA-Hotels and restaurants	-0.134***	-0.214***	-0.085***	0.071***	-0.062***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IA-Transportation and communications	-0.057***	-0.050***	0.030***	0.003**	-0.030***
	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)
KA-Real estate, renting and business activities	0.097***	-0.016***	-0.002	0.008***	0.029***
	(0.000)	(0.000)	(0.162)	(0.000)	(0.000)
MA-Education	0.047***	-0.108***	0.059***	-0.051***	0.039***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
NA-Health and social work	0.238***	-0.090***	0.077***	0.003	0.112***
	(0.000)	(0.000)	(0.000)	(0.210)	(0.000)
OA-Community, social and personal services	0.010**	0.015***	-0.025***	0.020***	-0.001
	(0.041)	(0.000)	(0.000)	(0.000)	(0.843)
Region (percent of employed workforce):					
11-Paris region	0.004	-0.006	-0.008	0.002	0.002
	(0.694)	(0.470)	(0.170)	(0.730)	(0.614)
24-Centre-Val de Loire	0.024**	-0.002	-0.006	0.004	0.009**
	(0.022)	(0.776)	(0.323)	(0.345)	(0.019)
27-Burgandy	0.025**	0.002	-0.009	0.004	0.009**
	(0.017)	(0.834)	(0.163)	(0.365)	(0.015)
28-Normandy	0.016	0.003	-0.015**	0.006	0.001
	(0.138)	(0.685)	(0.018)	(0.178)	(0.717)
32-Hauts-de-France	-0.017	0.009	-0.031***	0.004	-0.013***
	(0.104)	(0.227)	(0.000)	(0.447)	(0.000)
44-Grand Est	0.011	0.002	-0.012**	0.002	0.002
	(0.288)	(0.814)	(0.041)	(0.607)	(0.560)
52-Pays de la Loire	0.004	0.017**	-0.038***	0.007	-0.008**
	(0.680)	(0.031)	(0.000)	(0.148)	(0.023)
53-Brittany	0.003	0.001	-0.028***	0.001	-0.004
	(0.769)	(0.919)	(0.000)	(0.805)	(0.307)
75-Nouvelle-Aquitaine	0.010	-0.008	-0.013**	-0.001	0.001
	(0.325)	(0.304)	(0.035)	(0.774)	(0.674)
76-Occitanie	-0.014	-0.003	-0.022***	-0.005	-0.008**
	(0.180)	(0.706)	(0.000)	(0.322)	(0.027)
84-Auvergne-Rhône-Alpes	0.007	0.009	-0.023***	0.003	-0.002
	(0.471)	(0.236)	(0.000)	(0.455)	(0.665)
93-Provence-Alpes-Côte d'Azur	-0.001	-0.009	-0.006	-0.004	0.003
	(0.970)	(0.267)	(0.335)	(0.382)	(0.464)
94-Corsica	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***

Intercept	0.903	0.526	0.169	0.384	0.149
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R2	0.619	0.439	0.279	0.608	0.365
Number of observations	56,256	56,256	56.256	56,256	56,256

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: figures correspond estimated coefficients through OLS applied to equation (9) using time averages of considered variables over 2009-2015 for the balanced panel. Robust standard errors within parentheses.

Table C2. First step. Estimation of the share of the given share of workers: female, young, old workers and young or old female workers. Sample: unbalanced panel.

Explanatory variable / Explained variable. Average share of:	Female workers	Young workers	Old workers	Young female workers	Old female workers
Firm characteristics. Activity indicators (average lagged values):					
Business' age (years)	0.001***	-0.001***	0.001***	-0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Capital intensity	-1.40e-08	-8.56e-07	1.39e-06*	-3.30e-07	4.90e-07
	(0.803)	(0.291)	(0.077)	(0.336)	(0.111)
Share of wages in value added	0.001	-0.001	7.74e-06	-5.03e-06	6.76e-06
	(0.350)	(0.135)	(0.205)	(0.412)	(0.192)
Features of firm workforce (percent of business workforce). Average (lagged) shares of:					
Blue collar workers	-0.372***	-0.195***	0.142***	-0.221***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.490)
Intermediate workers	-0.182***	-0.157***	0.076***	-0.148***	0.007***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)
Executives	-0.243***	-0.176***	0.035***	-0.159***	-0.034***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Full-time workers	-0.378***	-0.067***	-0.073***	-0.140***	-0.108***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Workers older than 49	0.045***	-	-	-	-
	(0.000)	-	-	-	-
Female workers	-	-0.016***	0.013***	-	-
	-	(0.000)	(0.000)	-	-
Firm size dummies:					
Between 20 and 49 workers	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Between 50 and 99 workers	0.008***	-0.001	-0.001	0.006***	0.001
	(0.014)	(0.692)	(0.398)	(0.000)	(0.873)
Between 100 and 249 workers	0.013***	-0.015***	0.001	0.003***	0.003***
	(0.000)	(0.000)	(0.514)	(0.002)	(0.000)
Between 250 and 499 workers	0.019***	-0.016***	-0.001	0.008***	0.001
	(0.000)	(0.000)	(0.771)	(0.000)	(0.359)
Between 500 and 999 workers	0.018***	-0.010***	-0.007***	0.013***	-0.001
	(0.000)	(0.004)	(0.009)	(0.000)	(0.453)
Between 1000 and 1999 workers	0.008	-0.007	-0.006	0.010***	-0.003
	(0.248)	(0.168)	(0.172)	(0.007)	(0.237)
Business sector dummies:					
Extraction industries:					

CA-Extraction of energy products	-0.099** (0.013)	-0.054 (0.149)	0.208** (0.038)	-0.022 (0.195)	-0.001 (0.936)
CB-Extraction of non-energy products	-0.117*** (0.000)	-0.065*** (0.000)	0.067*** (0.000)	-0.018*** (0.000)	-0.030*** (0.000)
Manufacturing industries:					
DA-Agriculture and food industries	0.121*** (0.000)	0.043*** (0.000)	-0.015*** (0.000)	0.057*** (0.000)	0.020*** (0.000)
DB- Textile and clothing industries	0.193*** (0.000)	-0.084*** (0.000)	0.104*** (0.000)	0.009*** (0.000)	0.112*** (0.000)
DC-Leather sector and footwear industries	0.407*** (0.000)	-0.061*** (0.000)	0.110*** (0.000)	0.065*** (0.000)	0.164*** (0.000)
DD-Manufacture of wood, and wood products	-0.049** (0.019)	-0.015*** (0.002)	0.019*** (0.000)	-0.014*** (0.000)	-0.017*** (0.000)
DE-Pulp, paper products; publishing and printing	0.096*** (0.000)	-0.068*** (0.000)	0.031*** (0.000)	-0.008*** (0.000)	0.027*** (0.000)
DF-Coking, refined petroleum, and nuclear fuel	-0.042** (0.012)	-0.082*** (0.000)	0.070*** (0.000)	-0.027*** (0.002)	-0.002 (0.815)
DG-Chemical and pharmaceutical industries	0.124*** (0.000)	-0.044*** (0.000)	0.019*** (0.000)	0.021*** (0.000)	0.019*** (0.000)
DH-Rubber and plastic industries	0.036*** (0.000)	-0.059*** (0.000)	0.013*** (0.000)	-0.006*** (0.000)	0.018*** (0.000)
DI-Manufacturing of other non-metallic mineral products	-0.061*** (0.000)	-0.063*** (0.000)	0.039*** (0.000)	-0.014*** (0.000)	-0.009*** (0.001)
DJ-Metallurgy and manufacture of metal products	-0.090*** (0.000)	-0.045*** (0.000)	0.039*** (0.000)	-0.019*** (0.000)	-0.017*** (0.000)
DK-Manufacturing of machinery and equipment	-0.138*** (0.000)	-0.028*** (0.000)	0.041*** (0.000)	-0.032*** (0.000)	-0.027*** (0.000)
DL-Manufacturing of electrical and electronic goods	0.046*** (0.000)	-0.061*** (0.000)	0.057*** (0.000)	-0.020*** (0.000)	0.047*** (0.000)
DM-Transportation equipment manufacturing	-0.052*** (0.000)	-0.046*** (0.000)	0.027*** (0.000)	-0.017*** (0.000)	-0.007*** (0.003)
DN-Other manufacturing industries	0.165*** (0.000)	-0.039*** (0.000)	0.029*** (0.000)	0.023*** (0.000)	0.055*** (0.000)
EA-Electricity, gas, and water supply	-0.101*** (0.000)	-0.038*** (0.000)	0.039*** (0.002)	-0.028*** (0.000)	-0.017*** (0.000)
FA-Construction	-0.142*** (0.000)	0.051*** (0.000)	-0.018*** (0.000)	-0.019*** (0.000)	-0.041*** (0.000)
GA-Wholesale and retail trade, repair of personal and household goods	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
HA-Hotels and restaurants	-0.101***	-0.207***	-0.083***	0.069***	-0.052***

	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IA-Transportation and communications	-0.084***	-0.057***	0.031***	-0.014**	-0.028***
	(0.000)	(0.000)	(0.000)	(0.019)	(0.000)
KA-Real estate, renting and business activities	0.068***	-0.019***	-0.004***	-0.001	0.022***
	(0.000)	(0.000)	(0.002)	(0.761)	(0.000)
MA-Education	0.074***	-0.104***	0.052***	-0.040***	0.041***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
NA-Health and social work	0.243***	-0.088***	0.073***	0.007***	0.113***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
OA-Community, social and personal services	0.026***	0.006***	-0.016***	0.019***	0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.758)
<u>Region (percent of employed workforce):</u>					
11-Paris region	-0.001	-0.003	-0.012**	0.001	-0.004
	(0.198)	(0.647)	(0.016)	(0.758)	(0.350)
24-Centre-Val de Loire	0.019**	-0.001	-0.007	0.004	0.006**
	(0.022)	(0.921)	(0.160)	(0.350)	(0.038)
27-Burgandy	0.021***	-0.002	-0.005	0.002	0.009***
	(0.010)	(0.777)	(0.361)	(0.586)	(0.002)
28-Normandy	0.012	0.004	-0.014***	0.005	0.001
	(0.149)	(0.535)	(0.010)	(0.208)	(0.725)
32-Hauts-de-France	-0.022***	0.008	-0.028***	0.001	-0.012***
	(0.005)	(0.176)	(0.000)	(0.748)	(0.000)
44-Grand Est	0.004	0.002	-0.011**	0.001	0.002
	(0.574)	(0.710)	(0.036)	(0.873)	(0.506)
52-Pays de la Loire	0.005	0.018***	-0.037***	0.007*	-0.008***
	(0.516)	(0.005)	(0.000)	(0.068)	(0.006)
53-Brittany	-0.001	-0.002	-0.024***	-0.001	-0.003
	(0.946)	(0.694)	(0.000)	(0.700)	(0.280)
75-Nouvelle-Aquitaine	0.005	-0.009	-0.010**	-0.002	0.001
	(0.514)	(0.133)	(0.044)	(0.587)	(0.848)
76-Occitanie	-0.012	-0.004	-0.019***	-0.005	-0.007**
	(0.142)	(0.497)	(0.000)	(0.186)	(0.016)
84-Auvergne-Rhône-Alpes	0.003	0.011*	-0.023***	0.003	-0.003
	(0.692)	(0.083)	(0.000)	(0.342)	(0.345)
93-Provence-Alpes-Côte d'Azur	-0.006	-0.008	-0.006	-0.005	0.001
	(0.183)	(0.193)	(0.235)	(0.226)	(0.628)

94-Corsica	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Intercept	0.863 (0.000)	0.498 (0.000)	0.170 (0.000)	0.364 (0.000)	0.147 (0.000)
R2	0.576	0.381	0.264	0.520	0.348
Number of observations	89,329	89,329	89,329	86,329	56,256

Sources: DADS (Insee) and FARE (Insee).
Scope: 124,295 firms employing 20 workers or more over, perennial or not over 2009-2016 and coming from the non-farm and non-financial industries.
Notes: figures correspond estimated coefficients through OLS applied to equation (9) using time averages of considered variables over 2009-2015 for the balanced panel. Robust standard errors within parentheses.

Appendix D1. Association between the proportion of given population of workers and labor productivity: OLS rank-regression by quartile of female and young female workers.

Table D. Association between the proportion of given population of workers and labor productivity. OLS rank-regression by quartile of female or young workers.

	Average share of female workers				Average share of young workers			
	First quartile	Second quartile	Third quartile	Fourth quartile	First quartile	Second quartile	Third quartile	Fourth quartile
Rank quartile of the share of the given employed population (female or young workers)	0.327*** (0.000)	-0.096*** (0.001)	0.025 (0.405)	-0.163*** (0.000)	0.244*** (0.000)	-0.039 (0.189)	-0.075*** (0.000)	-0.264*** (0.000)
Firm characteristics. Activity indicators (average lagged values):								
Business' age (years)	93.8*** (0.000)	65.8*** (0.000)	96.5*** (0.000)	140.1*** (0.000)	142.3*** (0.000)	101.7*** (0.000)	82.6*** (0.000)	97.9*** (0.000)
Firm size dummies								
Between 20 and 49 workers	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Between 50 and 99 workers	-1,307.0*** (0.000)	-131.1 (0.625)	-305.5 (0.312)	-2,520.6*** (0.000)	-538.4 (0.113)	-1280.8*** (0.000)	-909.7*** (0.002)	-826.4*** (0.003)
Between 100 and 249 workers	387.3 (0.320)	1,430.5*** (0.000)	2,580.7*** (0.000)	-1,813.2*** (0.004)	528.2 (0.269)	987.5*** (0.008)	1,043.9*** (0.002)	398.0 (0.297)

Between 250 and 499 workers	1,715.2***	2,680.8***	3,719.9***	-351.9	121.9	2,985.5***	3,944.3***	240.7
	(0.006)	(0.000)	(0.000)	(0.590)	(0.888)	(0.000)	(0.000)	(0.708)
Between 500 and 999 workers	2,493.2***	5,668.9***	4,276.9***	-1,068.7	3,024.7***	4,365.6***	4,668.6***	-979.4
	(0.002)	(0.000)	(0.000)	(0.268)	(0.008)	(0.000)	(0.000)	(0.305)
Between 1000 and 1999 workers	3,845.1***	4,037.9***	5,347.8***	-4,352.7***	-2,276.7	4,502.9***	3,693.3***	49.6
	(0.001)	(0.002)	(0.000)	(0.008)	(0.249)	(0.000)	(0.006)	(0.977)
Between 2000 and 4999 workers	883.5	8,627.5***	3,957.6**	4,302.7*	189.3	7,417.6***	6,017.2***	2,432.9
	(0.604)	(0.000)	(0.039)	(0.057)	(0.948)	(0.002)	(0.000)	(0.301)
Greater than or equal to 5000 workers	-617.9 (0.872)	9,050.8*** (0.000)	9,556.9*** (0.000)	-8,360.1*** (0.009)	-6,658.1 (0.202)	2,561.0 (0.524)	8,304.9*** (0.000)	3,035.2 (0.157)
Business sector dummies								
Extraction industries:								
CA-Extraction of energy products	24,346.1*** (0.000)	17,886.5*** (0.000)	30,582.8*** (0.000)	31,361.1*** (0.000)	23,126.9*** (0.000)	- -	24,899.06*** (0.000)	31,646.6*** (0.000)
CB-Extraction of non-energy products	5,809.3 (0.283)	16,486.3*** (0.000)	20,975.7*** (0.000)	14,577.1*** (0.000)	7,733.6** (0.028)	16,797.5*** (0.000)	20,473.6*** (0.000)	17,260.6*** (0.000)
Manufacturing industries:								
DA-Agriculture and food industries	5,257.8*** (0.000)	1,571.9* (0.084)	1,300.3* (0.099)	-1,292.3** (0.043)	-323.8 (0.650)	3,872.9*** (0.000)	3,299.5*** (0.000)	-4,036.6*** (0.000)
DB- Textile and clothing industries	-772.3 (0.299)	-4,122.7** (0.012)	3,173.4** (0.038)	-7,073.9*** (0.000)	-10,864.7*** (0.000)	-6,001.5*** (0.000)	-1,129.9 (0.288)	4,015.4*** (0.000)
DC-Leather sector and footwear industries	1,348.5 (0.489)	-7,427.9* (0.064)	-5,877.9 (0.121)	-9,937.8*** (0.000)	-13,480.4*** (0.000)	-9,173.6*** (0.000)	-5,097.2** (0.015)	-1,583.2 (0.515)
DD-Manufacture of wood, and wood products	-1,112.3 (0.476)	-1,198.6 (0.218)	3,169.0** (0.044)	-5,871.6*** (0.000)	-6,858.8*** (0.000)	-3,136.0** (0.012)	2,340.3* (0.087)	2,803.6** (0.037)
DE-Pulp, paper products; publishing and printing	9,685.6*** (0.000)	4,894.4*** (0.000)	5,349.3*** (0.000)	158.8 (0.834)	6.5 (0.994)	2,908.0*** (0.000)	6,602.3*** (0.000)	10,891.9*** (0.000)

DF-Coking, refined petroleum, and nuclear fuel	20,842.8*** (0.000)	20,335.8*** (0.000)	20,159.9*** (0.000)	17,097.0*** (0.009)	13,180.0*** (0.000)	19,706.4*** (0.000)	18,008.0*** (0.000)	28,205.3*** (0.000)
DG-Chemical and pharmaceutical industries	15,380.2*** (0.000)	15,587.2*** (0.000)	15,801.0*** (0.000)	9,400.3*** (0.000)	10,742.5*** (0.000)	12,302.8*** (0.000)	14,901.9*** (0.000)	14,362.7*** (0.000)
DH-Rubber and plastic industries	4,694.7*** (0.000)	4,718.2*** (0.000)	5,974.5*** (0.000)	1,743.5** (0.046)	-1,785.8* (0.099)	2,443.6*** (0.001)	6,855.3*** (0.000)	6,819.1*** (0.000)
DI-Manufacturing of other non-metallic mineral products	3,046.2*** (0.008)	4,967.8*** (0.000)	6,135.7*** (0.001)	-1,547.3 (0.276)	-3,341.3* (0.064)	3,517.7*** (0.000)	5,548.9*** (0.000)	6,954.3*** (0.000)
DJ-Metallurgy and manufacture of metal products	1,186.6* (0.056)	2,701.0*** (0.000)	6,416.6*** (0.000)	2,185.0*** (0.001)	-1,655.8** (0.012)	2,780.9*** (0.000)	4,959.8*** (0.000)	5,521.6*** (0.000)
DK-Manufacturing of machinery and equipment	4,568.6*** (0.000)	5,400.8*** (0.000)	9,977.9*** (0.000)	8,198.0*** (0.000)	3,668.8*** (0.000)	5,690.4*** (0.000)	8,475.6*** (0.000)	7,926.1*** (0.000)
DL-Manufacturing of electrical and electronic goods	7,950.6*** (0.000)	8,261.7*** (0.000)	9,355.3*** (0.000)	1,205.8 (0.183)	-595.4 (0.637)	5,843.6*** (0.000)	7,525.9*** (0.000)	8,075.7*** (0.000)
DM-Transportation equipment manufacturing	-2,876.6*** (0.006)	2,872.8*** (0.002)	5,805.6*** (0.000)	2,816.8* (0.065)	-380.1 (0.804)	-81.0 (0.940)	5,7700.0*** (0.000)	1,824.4 (0.126)
DN-Other manufacturing industries	4,429.9*** (0.000)	5,922.5*** (0.003)	6.9773.4*** (0.000)	1,632.0 (0.225)	-1,474.9 (0.414)	4,228.2*** (0.003)	4.652.6*** (0.000)	5,956.9*** (0.000)
EA-Electricity, gas, and water supply	14,418.8*** (0.000)	12,173.0*** (0.000)	14,655.9*** (0.000)	18,110.8*** (0.000)	11,898.3*** (0.000)	14,489.8*** (0.000)	12,800.6*** (0.000)	15,481.7*** (0.000)
FA-Construction	80.0 (0.938)	607.9* (0.081)	3,878.8*** (0.000)	4,178.4*** (0.000)	-151.2 (0.715)	1,474.5*** (0.000)	2,235.9*** (0.000)	76.1 (0.829)
GA-Wholesale and retail trade, repair of personal and household goods	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***

HA-Hotels and restaurants	-18,718.9*** (0.000)	-16,805.6*** (0.000)	-9,082.1*** (0.000)	-9,045.8*** (0.000)	-11,151.9*** (0.000)	-11,663.7*** (0.000)	-11,098.5*** (0.000)	-15,350.2*** (0.000)
IA-Transportation and communications	-12,009.8*** (0.000)	-7,226.3*** (0.000)	-2,955.1*** (0.000)	-1,576.0** (0.016)	-13,134.1*** (0.000)	-6,125.3*** (0.000)	-3,726.7*** (0.000)	-2,695.5*** (0.000)
KA-Real estate, renting and business activities	2,793.8*** (0.000)	4,625.0*** (0.000)	6,616.4*** (0.000)	-1,067.9** (0.011)	-3,882.9*** (0.000)	25.5 (0.959)	5,012.6*** (0.000)	6,613.1*** (0.000)
MA-Education	-6,935.3*** (0.000)	-12,664.1*** (0.000)	-10,921.4*** (0.000)	-9,992.5*** (0.000)	-17,792.6*** (0.000)	-12,160.3*** (0.000)	-8,962.0*** (0.000)	-693.2 (0.708)
NA-Health and social work	-17,858.8*** (0.000)	-12,399.3*** (0.000)	-8,0231.5*** (0.000)	-2,027.2*** (0.001)	-17,669.0*** (0.000)	-9,479.7*** (0.000)	-7,521.9*** (0.000)	-3,097.2*** (0.000)
OA-Community, social and personal services	4,066.5*** (0.000)	2,945.7*** (0.001)	-290.3 (0.799)	-11,421.6*** (0.000)	-5,784.6*** (0.000)	-927.5 (0.351)	-162.4 (0.853)	2,339.7** (0.012)
11-Paris region	3,433.4 (0.145)	7,804.8*** (0.000)	10,542.6*** (0.000)	14,145.1*** (0.000)	7,986.6*** (0.000)	9,394.8*** (0.000)	11,982.8*** (0.000)	7,264.8*** (0.001)
24-Centre-Val de Loire	-2,539.6 (0.292)	-459.4 (0.796)	762.0 (0.630)	-697.6 (0.776)	720.6 (0.525)	-394.3 (0.841)	1,168.5 (0.525)	-3,529.9 (0.107)
27-Burgandy	-1,925.5 (0.421)	-711.7 (0.687)	-353.5 (0.630)	-2,145.1 (0.380)	-1,185.5 (0.596)	-1,521.0 (0.436)	1,493.9 (0.410)	-2,400.8 (0.272)
28-Normandy	-1,631.2 (0.496)	-8.2 (0.996)	-881.5 (0.569)	-281.8 (0.908)	1,204.6 (0.588)	-1,041.04 (0.595)	1,823.2 (0.314)	-3,033.3 (0.169)
32-Hauts-de-France	-2,668.7 (0.261)	-239.7 (0.894)	-78.9 (0.958)	-372.9 (0.877)	-507.2 (0.816)	-602.1 (0.755)	2,024.9 (0.259)	-2,928.6 (0.175)
44-Grand Est	-621.7 (0.793)	921.5 (0.597)	806.2 (0.599)	-258.8 (0.914)	731.5 (0.738)	-513.4 (0.790)	4,031.9** (0.025)	-1,994.3 (0.355)
52-Pays de la Loire	-2,774.4 (0.244)	-82.5 (0.963)	-567.4 (0.711)	-2,427.4 (0.316)	703.7 (0.749)	-1,405.5 (0.469)	1,227.1 (0.497)	-4,260.0** (0.049)
53-Brittany	-3,326.9 (0.165)	209.6 (0.906)	829.4 (0.591)	179.7 (0.941)	232.3 (0.917)	-759.4 (0.697)	1,776.5 (0.329)	-2,221.9 (0.308)
75-Nouvelle-Aquitaine	-2,794.8 (0.238)	191.6 (0.909)	110.4 (0.942)	69.6 (0.977)	682.6 (0.754)	-779.4 (0.685)	1,525.3 (0.394)	-2,448.8 (0.256)
76-Occitanie	-3,759.8 (0.115)	199.1 (0.910)	847.9 (0.576)	363.8 (0.880)	258.0 (0.906)	-172.2 (0.929)	1,777.2 (0.322)	-2,165.8 (0.316)
84-Auvergne-Rhône-Alpes	-493.7 (0.834)	2,394.9 (0.167)	2,554.1* (0.090)	2,676.1 (0.264)	3,435.9 (0.112)	1,568.3 (0.412)	4,216.6** (0.018)	-341.1 (0.873)
	-485.5	3,391.6*	3,260.8**	2,587.5	4,355.2**	1,515.4	4,227.8**	315.3

93-Provence-Alpes-Côte d'Azur	(0.839)	(0.055)	(0.034)	(0.288)	(0.048)	(0.408)	(0.020)	(0.884)
94-Corsica	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Intercept	25,823.1*** (0.000)	26,986.7*** (0.000)	18,769.3*** (0.000)	29,422.2*** (0.000)	24,607.9*** (0.000)	25,986.7*** (0.000)	22,626.8*** (0.000)	35,320.7*** (0.000)
R2	0.283	0.224	0.213	0.191	0.160	0.179	0.210	0.287
Number of observations	14,066	14,065	14,066	14,065	14,066	14,065	14,066	14,065

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
*Notes: figures correspond estimated coefficients through OLS applied to equation (11) using time averages of considered variables over 2009-2015 for the balanced panel; robust standard errors within parentheses; * (resp. **; resp. ***) stands for significance level at a 10 (resp. 5; resp. 1) percent level.*
Reading note: for any firm from the first quartile in terms of the share of female workers, an increase of 0.327 position in the rank of a firm in labor productivity is associated to an increase of 1 position in the rank of the considered firm. Corresponding coefficient is significant at a 1 percent level.

Appendix E. Effect of proportion of the given population of workers on labor productivity. IV Rank-regressions by quartile of proportion of female or young workers. IV first stage regression estimates.

Table E. Effect of proportion of the given population of workers on labor productivity. IV Rank-regressions by quartile of proportion of female (respectively young, respectively old) workers. First stage estimates. Sample: balanced panel.

Explanatory variable / Explained variable. Average share of:	Female workers				Young workers			
	First quartile	Second quartile	Third quartile	Fourth quartile	First quartile	Second quartile	Third quartile	Fourth quartile
Rank quartile of the instrument for the share of the given employed population (female or young workers) in the same industry as the considered firms	0.051*** (0.000)	0.050*** (0.000)	0.045*** (0.000)	0.085*** (0.000)	0.043*** (0.000)	0.033*** (0.000)	0.034*** (0.000)	0.064*** (0.000)
Firm characteristics. Activity indicators (average lagged values):								
Business' age (years)	1.8 (0.259)	-11.6*** (0.000)	-0.59*** (0.758)	140.1*** (0.000)	25.5*** (0.000)	7.6*** (0.000)	1.5 (0.380)	-18.5*** (0.000)
Firm size dummies:								
Between 20 and 49 workers	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*	*Ref.*
Between 50 and 99 workers	323.0*** (0.000)	-7.6 (0.924)	-0.4 (0.996)	-404.1*** (0.000)	544.7*** (0.000)	2.5 (0.977)	-193.1** (0.024)	-397.8*** (0.000)
Between 100 and 249 workers	359.6*** (0.000)	-182.4* (0.063)	3.7 (0.972)	-774.9*** (0.000)	1,197.1*** (0.000)	122.6 (0.229)	-236.2** (0.019)	-652.9*** (0.000)
Between 250 and 499 workers	349.1*** (0.018)	-26.7 (0.879)	-153.8 (0.378)	-734.2*** (0.000)	1,317.1*** (0.000)	5.6 (0.971)	-336.8** (0.039)	-676.4*** (0.000)
Between 500 and 999 workers	713.5*** (0.001)	409.5* (0.085)	138.4 (0.577)	-1,247.0*** (0.000)	1,918.5*** (0.000)	-207.3 (0.355)	-467.4** (0.042)	-381.7 (0.167)
Between 1000 and 1999 workers	990.0*** (0.002)	680.5* (0.054)	-718.4* (0.066)	-864.9*** (0.009)	1,837.5*** (0.000)	-0.6 (0.998)	-844.4** (0.021)	454.8 (0.276)
Between 2000 and 4999 workers	1,467.4*** (0.000)	915.7** (0.083)	525.7 (0.273)	-1,362.1*** (0.002)	1,389.9*** (0.005)	-106.3 (0.800)	214.6 (0.694)	1,248.4** (0.048)

Greater than or equal to 5000 workers	1,645.4*** (0.006)	331.2 (0.658)	1,613.9** (0.024)	-1,1175.9* (0.063)	-1,180.9 (0.178)	926.8 (0.215)	-513.9 (0.374)	620.9 (0.443)
Business sector dummies								
Extraction industries:								
CA-Extraction of energy products	-68.5 (0.776)	-519.1*** (0.000)	4,857.3*** (0.000)	-2,519.6*** (0.000)	-5,561.6*** (0.000)	- -	2,240.3 (0.551)	1,607.8*** (0.000)
CB-Extraction of non-energy products	2,148.9*** (0.000)	3,193.2*** (0.000)	-701.8* (0.059)	-2,963.1*** (0.007)	2,701.8*** (0.000)	394.2 (0.403)	47.4 (0.923)	-964.8 (0.157)
Manufacturing industries:								
DA-Agriculture and food industries	-2,242.6*** (0.000)	-43.4 (0.846)	469.2** (0.018)	85,5 (0.607)	787.7*** (0.000)	-255.4 (0.194)	3.3 (0.987)	1,112.1*** (0.000)
DB- Textile and clothing industries	-4,318.2*** (0.000)	672.4 (0.110)	453.3 (0.300)	1,769.3*** (0.000)	2,765.6*** (0.000)	-259.8 (0.312)	-443.1 (0.130)	400.3 (0.178)
DC-Leather sector and footwear industries	-4,462.5*** (0.000)	-1,621.5 (0.132)	1,608.9* (0.091)	1,172.7*** (0.003)	2,302.7*** (0.000)	648.8 (0.297)	-689.8 (0.235)	-73.7 (0.904)
DD-Manufacture of wood, and wood products	2,000.3*** (0.000)	-534.8* (0.066)	-624.1* (0.103)	1,036.2** (0.017)	1,474.6*** (0.000)	30.7 (0.932)	-435.1 (0.289)	474.4 (0.254)
DE-Pulp, paper products; publishing and printing	-1,256.4*** (0.000)	34.5 (0.892)	274.1 (0.255)	-63.9 (0.763)	2,685.2*** (0.000)	44.1 (0.830)	-735.1*** (0.000)	280.8 (0.276)
DF-Coking, refined petroleum, and nuclear fuel	3,159.1*** (0.006)	1,822.6 (0.268)	-1,308.3 (0.429)	-1,826.7 (0.114)	2,453.7*** (0.000)	-4,122.8*** (0.000)	-91.5 (0.954)	1,461.4 (0.649)

DG-Chemical and pharmaceutical industries	-2,033.1*** (0.000)	871.7* (0.054)	1,120.3*** (0.003)	348.3 (0.157)	1,832.1*** (0.000)	220.9 (0.389)	-387.3 (0.157)	-44.2*** (0.881)
DH-Rubber and plastic industries	-1,082.4*** (0.000)	-572.0** (0.045)	-216.5 (0.497)	599.7** (0.012)	2,648.1*** (0.000)	-97.2 (0.677)	-294.1 (0.209)	-200.3 (0.260)
DI-Manufacturing of other non-metallic mineral products	1,752.0*** (0.000)	-632.4** (0.017)	-2,300.1*** (0.000)	2,083.2*** (0.000)	2,998.6*** (0.064)	129.1 (0.676)	-884.7*** (0.003)	-325.5 (0.453)
DJ-Metallurgy and manufacture of metal products	2,558.6*** (0.000)	-188.4 (0.171)	-504.3*** (0.007)	154.3 (0.430)	2,432.2*** (0.000)	-334.6** (0.043)	-569.1*** (0.000)	-644.6*** (0.000)
DK-Manufacturing of machinery and equipment	2,425.2*** (0.000)	1,543.2*** (0.000)	-1,605.7*** (0.000)	-107.9 (0.719)	2,010.0*** (0.000)	-179.8 (0.323)	-405.8** (0.028)	-40.7 (0.838)
DL-Manufacturing of electrical and electronic goods	-1,767.8*** (0.000)	537.9 (0.132)	354.2 (0.331)	1,879.7*** (0.000)	2,170.8*** (0.000)	-272.2 (0.246)	-168.8 (0.515)	426.1 (0.164)
DM-Transportation equipment manufacturing	2,040.8*** (0.000)	-239.9 (0.425)	-720.7* (0.101)	1,266.8*** (0.003)	1,815.7*** (0.000)	-695.6** (0.034)	-580.9** (0.049)	-17.4 (0.964)
DN-Other manufacturing industries	-2,713.3*** (0.000)	227.8 (0.684)	941.2** (0.038)	320.3 (0.387)	1,817.6*** (0.414)	-396.2*** (0.330)	-78.6 (0.647)	-874.9** (0.026)
EA-Electricity, gas, and water supply	1,956.1** (0.013)	399.0 (0.588)	-422.7 (0.437)	-1,994.8*** (0.007)	953.0 (0.261)	510.7 (0.507)	-629.8 (0.351)	-496.9 (0.563)
FA-Construction	2,582.2*** (0.000)	3,125.0*** (0.000)	-2,173.4*** (0.000)	-691.2*** (0.002)	727.5*** (0.000)	-140.4 (0.260)	-146.5*** (0.230)	201.3* (0.085)
GA-Wholesale and retail trade, repair of personal and household goods	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
HA-Hotels and restaurants	-1,054.5*** (0.000)	208.4 (0.266)	364.5** (0.036)	-746.2*** (0.000)	-2,679.3*** (0.000)	21.68 (0.928)	985.5*** (0.000)	-1,579.9*** (0.000)

IA-Transportation and communications	396.5*** (0.029)	1,292.8*** (0.000)	-1,394.3*** (0.000)	268.0 (0.120)	1,763.1*** (0.000)	-188.1 (0.154)	-530.4*** (0.000)	143.6 (0.339)
KA-Real estate, renting and business activities	-3,226.6*** (0.000)	306.5** (0.042)	474.9*** (0.000)	538.9*** (0.000)	-111.9 (0.256)	-317.8*** (0.007)	-380.1*** (0.001)	1,030.6*** (0.000)
MA-Education	-3,238.9*** (0.000)	368.8 (0.439)	954.4** (0.021)	27.1 (0.909)	1,479.6*** (0.000)	-527.9 (0.123)	-1,014.1*** (0.007)	1,587.4*** (0.000)
NA-Health and social work	-3,531.2*** (0.000)	837.8*** (0.004)	1,319.2*** (0.000)	-3,265.0*** (0.000)	1,235.8*** (0.000)	-258.1 (0.106)	-188.3 (0.202)	-948.9*** (0.000)
OA-Community, social and personal services	-1,142.6*** (0.000)	385.4* (0.103)	281.1 (0.265)	599,7*** (0.002)	-113.6 (0.536)	-185.1 (0.414)	-62.8 (0.771)	1,662.1*** (0.000)
Region (percent of employed workforce):								
11-Paris region	475.9 (0.310)	281.9 (0.547)	540.8 (0.184)	-453.8 (0.299)	-314.7 (0.484)	-529.4 (0.353)	84.7 (0.875)	987.4* (0.086)
24-Centre-Val de Loire	416.2 (0.392)	-470.5 (0.336)	288.1 (0.511)	-605.9 (0.193)	224.6 (0.636)	-480.3 (0.415)	61.9 (0.912)	326.9 (0.581)
27-Burgandy	430.4 (0.374)	-600.7 (0.212)	288.8 (0.504)	-929.1** (0.043)	35.4 (0.940)	-402.1 (0.495)	-532.6 (0.337)	214.2 (0.717)
28-Normandy	572.1 (0.237)	-305.9 (0.523)	508.3 (0.230)	-544.7 (0.231)	124.1 (0.792)	-464.9 (0.426)	94.4 (0.865)	148.6 (0.800)
32-Hauts-de-France	752.5 (0.114)	336.7 (0.478)	282.5 (0.493)	-605.9 (0.193)	-60.9 (0.894)	-155.8 (0.787	-207.4 (0.704)	393.8 (0.498)
44-Grand Est	807.0* (0.089)	-376.4 (0.435)	119.5 (0.774)	-571.2 (0.200)	-195.9 (0.669)	-353.7 (0.540)	-294.3 (0.590)	501.3 (0.388)
52-Pays de la Loire	619.3 (0.196)	198.4 (0.676)	288.1 (0.492)	-383.3 (0.396)	-507.2 (0.272)	-565.5 (0.331)	-155.3 (0.778)	314.7 (0.589)
53-Brittany	634.4 (0.189)	82.1 (0.864)	94.9 (0.823)	-511.9 (0.262)	-327.4 (0.487)	-431.1 (0.460)	-54.9 (0.921)	62.6 (0.915)
75-Nouvelle-Aquitaine	778.6* (0.102)	-35.6 (0.940)	206.7 (0.617)	-880.2** (0.048)	197.3 (0.668)	-398.9 (0.489)	-229.3 (0.674)	83.3 (0.886)
76-Occitanie	982.7** (0.040)	150.9 (0.752)	478.1 (0.250)	-823.4* (0.065)	114.0 (0.804)	-521.1 (0.368)	84.3 (0.878)	546.4 (0.348)
84-Auvergne-Rhône-Alpes	752.9 (0.110)	-135.9 (0.771)	75.6 (0.854)	-917.7** (0.037)	-97.1 (0.830)	-99.2 (0.962)	-103.4 (0.849)	572.4 (0.321)

93-Provence-Alpes-Côte d'Azur	653.0 (0.976)	-113.0 (0.814)	450.6 (0.282)	-495.8 (0.268)	287.5 (0.536)	-172.3 (0.767)	-143.4 (0.794)	314.3 (0.591)
94-Corsica	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Intercept	6,744.7*** (0.000)	19,386.8*** (0.000)	34,022.0*** (0.000)	46,637.3*** (0.000)	4,957.5*** (0.000)	20,257.9*** (0.000)	34,538.7*** (0.000)	46,523.5*** (0.000)
Number of observations	14,066	14,065	14,066	14,065	14,066	14,065	14,066	14,065
R2	0.241	0.125	0.123	0.154	0.173	0.019	0.020	0.129
Partial R-squared of excluded instruments (p-value)	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial industries.
*Notes: figures correspond estimated coefficients through OLS applied to the regression of the share of the considered population on the corresponding instrument (share of the given population computed on the same industry as the considered firm), and the control variables of the second stage as a first stage of IV, using time averages of considered variables over 2009-2015 for the balanced panel; robust standard errors within parentheses; * (resp. **; resp. ***) stands for significance level at a 10 (resp. 5; resp. 1) percent level.*
Reading note: for any firm from the first quartile in terms of the share of female workers, the rank of the firm in the distribution of the overall economy (all industries, with the exception of the non-farm, non-financial and public business sectors) is ceteris paribus positively correlated with the position in the rank of a firm in labor productivity is associated to an increase of 1 position in the rank of the considered firm. Corresponding coefficient is significant at a 1 percent level.

Appendix F. Effect of proportion of the given population of workers on labor productivity. IV Rank-regressions by quartile of proportion of female or young workers. Estimates of the IV second step: estimated coefficients from the structural equation.

Table F. Effect of proportion of the given population of workers on labor productivity. IV Rank-regressions by quartile of proportion of female (respectively young, respectively old) workers. Second stage estimates. Sample: balanced panel.

Explanatory variable. Average share in:	Female workers				Young workers			
	First quartile	Second quartile	Third quartile	Fourth quartile	First quartile	Second quartile	Third quartile	Fourth quartile
Rank quartile of the share of the given employed population (female or young workers)	0.617*** (0.002)	-1.468*** (0.000)	-1.710*** (0.000)	-0.414*** (0.001)	0.903*** (0.000)	-0.722** (0.013)	-1.780*** (0.000)	-0.673*** (0.000)
Firm characteristics. Activity indicators (average lagged values):								
Business' age (years)	93.4***	47.7***	93.2***	150.3***	125.3***	101.7***	86.4***	91.0***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Firm size dummies: Between 20 and 49 workers	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Between 50 and 99 workers	-1,383.5***	-160.2	-255.9	-2,617.6***	-851.0**	-1280.8***	-1,207.7***	-970.7***
	(0.000)	(0.580)	(0.442)	(0.000)	(0.019)	(0.000)	(0.000)	(0.001)
Between 100 and 249 workers	299.1	1,144.5***	2,695.9***	-2,007.2***	-220.9	987.5***	748.8*	187.6
	(0.446)	(0.001)	(0.000)	(0.004)	(0.688)	(0.008)	(0.051)	(0.630)
Between 250 and 499 workers	1,662.0***	2,696.0***	3,618.3***	-538.4	-697.6	2,985.5***	3,499.0***	27.3
	(0.007)	(0.000)	(0.000)	(0.412)	(0.447)	(0.000)	(0.000)	(0.966)
Between 500 and 999 workers	2,338.2***	6,125.2***	4,674.3***	-1,359.8	1,847.0	4,365.6***	3,945.1***	-1,027.2
	(0.004)	(0.000)	(0.000)	(0.163)	(0.133)	(0.000)	(0.000)	(0.281)
Between 1000 and 1999 workers	3,645.2***	4,946.8***	4,376.2***	-4,502.3***	-3,429.4*	4,502.9***	2,340.1	358.6
	(0.002)	(0.001)	(0.004)	(0.006)	(0.092)	(0.000)	(0.126)	(0.834)
Between 2000 and 4999 workers	554.9 (0.744)	9,699.8*** (0.000)	5,172.2*** (0.010)	4,039.7* (0.074)	-662.7 (0.820)	7,417.6*** (0.002)	6,350.0*** (0.000)	3,137.8 (0.183)
Greater than or equal to 5000 workers	-993.7 (0.796)	9,408.3*** (0.000)	12,742.1*** (0.000)	-8,544.7*** (0.008)	-5,703.7 (0.297)	2,561.0 (0.524)	7,788.1*** (0.000)	3,512.7 (0.132)
Business sector dummies								

Extraction industries:								
CA-Extraction of energy products	24,404.8*** (0.000)	18,770.9*** (0.000)	39,735.7*** (0.000)	30,428.5*** (0.000)	27,177.8*** (0.000)	- -	21,772.4*** (0.000)	32,553.4*** (0.000)
CB-Extraction of non-energy products	5,027.7 (0.350)	21,527.3*** (0.000)	19,428.7*** (0.000)	13,484.7*** (0.000)	5,7033.7 (0.297)	16,797.5*** (0.000)	20,367.9*** (0.000)	16,613.5*** (0.000)
Manufacturing industries:								
DA-Agriculture and food industries	5,846.2*** (0.000)	1,946.8** (0.036)	2,030.9** (0.016)	-1,348.6** (0.035)	-198.6 (0.650)	3,872.9*** (0.000)	2,710.1*** (0.001)	-3,632.2*** (0.000)
DB- Textile and clothing industries	539.1 (0.646)	-2,904.9* (0.086)	3,882.3** (0.020)	-6,632.9*** (0.000)	-12,832.8*** (0.000)	-6,001.5*** (0.000)	-2,211.3* (0.072)	3,917.5*** (0.000)
DC-Leather sector and footwear industries	-55.0 (0.980)	-5,070.1 (0.224)	-3,432.2 (0.425)	-9,564.4*** (0.000)	-15,009.9*** (0.000)	-9,173.6*** (0.000)	-6,188.9** (0.021)	-1,738.9 (0.482)
DD-Manufacture of wood, and wood products	-2,075.7 (0.217)	-1,628.2 (0.128)	1,712.4 (0.316)	-5,743.3*** (0.000)	-8,030.6*** (0.000)	-3,136.0** (0.012)	1,430.4 (0.355)	2,866.3** (0.030)
DE-Pulp, paper products; publishing and printing	9,991.0*** (0.000)	5,228.3*** (0.000)	5,613.3*** (0.000)	50.1 (0.947)	-1,978.8* (0.089)	2,908.0*** (0.000)	5,247.7*** (0.000)	10,593.6*** (0.000)
DF-Coking, refined petroleum, and nuclear fuel	19,687.6*** (0.000)	23,599.5*** (0.000)	17,556.1*** (0.000)	16,212.3*** (0.013)	11,415.8*** (0.004)	19,706.4*** (0.000)	17,749.2*** (0.000)	28,457.1*** (0.000)
DG-Chemical and pharmaceutical industries	16,024.6*** (0.000)	16,882.9*** (0.000)	17,689.4*** (0.000)	9,548.8*** (0.000)	9,322.3*** (0.000)	12,302.8*** (0.000)	14,039.4*** (0.000)	14,149.8*** (0.000)
DH-Rubber and plastic industries	4,890.5*** (0.000)	4,418.1*** (0.000)	5,517.4*** (0.000)	1,751.3** (0.044)	-3,833.6*** (0.004)	2,443.6*** (0.001)	6,156.4*** (0.000)	6,482.7*** (0.000)
DI-Manufacturing of other non-metallic mineral products	2,490.2** (0.039)	4,315.9*** (0.000)	1,972.7 (0.332)	-1,033.4 (0.456)	-5,573.7*** (0.005)	3,517.7*** (0.000)	3,881.9*** (0.000)	6,639.9*** (0.000)

DJ-Metallurgy and manufacture of metal products	-166.8	2,812.5***	5,293.9***	2,079.4***	-3,500.8***	2,780.9***	3,829.6***	5,097.5***
	(0.843)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.000)
DK-Manufacturing of machinery and equipment	3,761.5***	7,953.9***	6,928.0***	8,000.2***	2,137.7**	5,690.4***	7,642.2***	7,762.5***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.015)	(0.000)	(0.000)	(0.000)
DL-Manufacturing of electrical and electronic goods	8,338.4***	9,413.4***	9,653.1***	1,548.2*	-2,311.4*	5,843.6***	6,997.5***	7,997.5***
	(0.000)	(0.000)	(0.000)	(0.088)	(0.101)	(0.000)	(0.000)	(0.000)
DM-Transportation equipment manufacturing	-3,566.7***	2,380.2***	4,312.3***	3,089.7**	-1,704.5	-81.0	4,634.6***	1,655.4
	(0.002)	(0.005)	(0.006)	(0.041)	(0.305)	(0.940)	(0.000)	(0.170)
DN-Other manufacturing industries	5,057.6***	6,847.4***	8,030.4***	1,507.7	-2,853.9	4,228.2***	4.381.1***	5,387.9***
	(0.000)	(0.001)	(0.000)	(0.259)	(0.128)	(0.003)	(0.002)	(0.000)
EA-Electricity, gas, and water supply	13,727.4***	13,131.9***	13,709.1***	17,496.2***	11,098.9***	14,489.8***	11,536.1***	15,081.6***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
FA-Construction	-710.5	5,330.9***	-162.3	3,846.5***	-472.7	1,474.5***	1,794.4***	33.0
	(0.583)	(0.000)	(0.824)	(0.000)	(0.338)	(0.000)	(0.000)	(0.926)
GA-Wholesale and retail trade, repair of personal and household goods	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
HA-Hotels and restaurants	-18,443.7***	-16,485.1***	-8,517.6***	-9,286.9***	-9,126.8***	-11,663.7***	-10,399.6***	-14,504.7***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
IA-Transportation and communications	-12,179.4***	-5,330.0***	-5,735.2***	-1,543.9**	-14,367.8***	-6,125.3***	-4,721.1***	-2,724.4***
	(0.000)	(0.000)	(0.000)	(0.018)	(0.000)	(0.000)	(0.000)	(0.000)
KA-Real estate, renting and business activities	3,276.5***	5,585.3***	7,612.4***	-933.8**	-3,932.2***	25.5	4,322.6***	7,008.8***
	(0.000)	(0.000)	(0.000)	(0.028)	(0.000)	(0.959)	(0.000)	(0.000)
MA-Education	-6,109.2***	-11,602.7***	-9,541.4***	-10,134.8***	-18,782.1***	-12,160.3***	-11,012.9***	-208.8
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.914)
NA-Health and social work	-16,815.6***	-10,462.5***	-5,349.9***	-2,804.1***	-18,524.6***	-9,479.7***	-7,885.2***	-3,587.7***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	4,412.3***	3,310.4***	-290.3	-11,221.3***	-5,692.2***	-927.5	-596.3	3,015.1***

OA-Community, social and personal services	(0.000)	(0.000)	(0.799)	(0.000)	(0.000)	(0.351)	(0.515)	(0.002)
<u>Region (percent of employed workforce):</u>								
11-Paris region	3,239.2 (0.174)	7,474.6*** (0.000)	11,265.1*** (0.000)	13,933.9*** (0.000)	8,251.6*** (0.000)	9,394.8*** (0.000)	12,136.9*** (0.000)	7,724.6*** (0.000)
24-Centre-Val de Loire	-2,688.5 (0.270)	-950.9 (0.599)	1,331.7 (0.454)	-897.9 (0.714)	688.1 (0.770)	-394.3 (0.841)	1,284.4 (0.549)	-3,301.3 (0.140)
27-Burgandy	-2,082.9 (0.389)	-1,351.7 (0.452)	125.9 (0.943)	-2,819.9 (0.321)	-1,122.3 (0.632)	-1,521.0 (0.436)	600.7 (0.778)	-2,263.7 (0.311)
28-Normandy	-1,843.6 (0.447)	-287.9 (0.872)	10.8 (0.995)	-481.1 (0.844)	1,189.9 (0.609)	-1,041.04 (0.595)	1,982.4 (0.349)	-2,863.6 (0.199)
32-Hauts-de-France	-2,943.7 (0.221)	424.1 (0.812)	393.3 (0.817)	-589.3 (0.804)	-422.9 (0.853)	-602.1 (0.755)	1,653.7 (0.431)	-2,737.9 (0.215)
44-Grand Est	-904.4 (0.707)	612.8 (0.729)	982.6 (0.566)	-461.2 (0.848)	930.3 (0.685)	-513.4 (0.790)	3,525.6* (0.093)	-1,720.6 (0.435)
52-Pays de la Loire	-2,999.2 (0.213)	349.9 (0.845)	-38.6 (0.982)	-2,584.4 (0.284)	1,122.3 (0.627)	-1,405.5 (0.469)	1,004.8 (0.634)	-4,094.1* (0.049)
53-Brittany	-3,545.9 (0.144)	457.6 (0.799)	1,019.7 (0.555)	7.95 (0.997)	507.2 (0.827)	-759.4 (0.697)	1,708.7 (0.421)	-2,179.9 (0.328)
75-Nouvelle-Aquitaine	-3,051.5 (0.204)	297.0 (0.867)	431.1 (0.799)	-221.3 (0.927)	621.8 (0.786)	-779.4 (0.685)	1,152.4 (0.582)	-2,361.2 (0.284)
76-Occitanie	-4,083.6* (0.091)	558.8 (0.754)	1,655.3 (0.330)	90.4 (0.970)	267.9 (0.907)	-172.2 (0.929)	1,976.2 (0.346)	-1,895.4 (0.392)
84-Auvergne-Rhône-Alpes	-757.4 (0.751)	2,322.3 (0.185)	2,649.9 (0.116)	2,376.9 (0.321)	3,576.9 (0.115)	1,568.3 (0.412)	4,057.4** (0.051)	-53.1 (0.981)
93-Provence-Alpes-Côte d'Azur	730.7 (0.763)	3,263.2 (0.170)	3,921.8** (0.023)	2,389.9 (0.325)	4,218.6* (0.068)	1,515.4 (0.408)	3,936.3* (0.063)	497.2 (0.823)
94-Corsica	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***	***Ref.***
Intercept	23,690.7*** (0.000)	54,956.9*** (0.000)	80,466.7*** (0.000)	42,100.3*** (0.000)	20,785*** (0.000)	25,986.7*** (0.000)	83,325.7*** (0.000)	55,325.8*** (0.000)
Number of observations	14,066	14,065	14,066	14,065	14,066	14,065	14,066	14,065
R2	0.279	0.224	0.031	0.188	0.140	0.149	0.007	0.293
Underidentification test	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Weak identification test (Kleibergen-Paap rk Wald statistic)	463.3(r)	321.7(r)	259.6(r)	1114.6(r)	375.6(r)	183.2(r)	188.9(r)	753.9(r)
10% Critical value for Cragg-Donald statistic and i.i.d errors	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
Endogeneity test	-	-	-	-	-	0.017	0.000	

Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 firms employing 20 workers or more over, perennial over 2009-2016 and coming from the non-farm and non-financial private industries.
*Notes: figures correspond to estimated coefficients through IV estimation applied to equation (11) using time averages of considered variables over 2009-2015 for the balanced panel; robust standard errors within parentheses; * (resp. **; resp. ***) stands for significance level at a 10 (resp. 5; resp. 1) percent level.*
Reading note: for any firm from the first quartile in terms of the share of female workers, an increase of 1 position in the rank of the considered firm in terms of female workers implies an increase of 0.617 position in the rank of a firm in labor productivity. Corresponding coefficient is significant at a 1 percent level.

Appendix G. Estimation of the elasticity of substitutions considering the three main comparison groups. Results distinguishing manufacturing and services industries.

Table G1a. Estimated elasticities of substitution between female and male workers through the estimation of a CES production function. **Industry: Manufacturing.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.4714 (0.2506) [-0.0259; 0.9686]	0.8743** (0.0481) [0.7789; 0.9697]	0.4714** (0.2348) [0.0133; 0.9448]	0.4617 ** (0.2348) [0.0707; 0.8526]
Labor share α	0.5151** (0.0450) [0.4258; 0.6045]	0.9117** (0.1084) [0.6967; 1.1268]	0.5276** (0.0462) [0.4360; 0.6192]	0.7694** (0.0397) [0.6907; 0.8481]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G1b. Estimated elasticities of substitution between female and male workers through the estimation of a CES production function. **Industry: Services.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	-0.3651	0.8919**	0.8857**	0.8795**
	(1.2767)	(0.0353)	(0.0064)	(0.0401)
	[-2.9089; 2.1787]	[0.8216; 0.9620]	[0.8730; 0.8985]	[0.7997; 0.9594)
Labor share α	0.5433**	0.8209**	0.9980**	0.8356**
	(0.0358)	(0.2416)	(0.0542)	(0.2435)
	[0.4718; 0.6147]	[0.3403; 1.3016]	[0.9079; 1.0881]	[0.3510; 1.3201]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G2a. Estimated elasticities of substitution between young and medium-aged or old workers through the estimation of a CES production function. **Industries: Manufacturing.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.3903**	0.2669	0.3627**	0.0153
	(0.1720)	(0.3573)	(0.1622)	(164.1)
	[0.0490; 0.7316]	[-0.4423; 0.9757]	[0.0490;0.6844]	[-325.6; 325.6]
Labor share α	0.5128**	0.8092**	0.5337**	0.8458**
	(0.0447)	(0.1026)	(0.0472)	(0.1035)
	[0.4242; 0.6014]	[0.6054; 1.0126]	[0.4400;0.6273]	[0.6404; 1.0513]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G2b. Estimated elasticities of substitution between young and medium-aged or old workers through the estimation of a CES production function. **Industries: Services.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.0195	0.9583**	0.8738**	0,9550**
	(1.3735)	(0.0152)	(0.0087)	(0,1585)
	[-2.7173; 2.7563]	[0.9281;0.9885]	[0.8565; 0.8911]	[0,6394; 1,2705]
Labor share α	0.6392**	0.8012**	0.8664**	0,8121**
	(0.1742)	(0.2407)	(0.0387)	(0,2864)
	[0.2921; 0.9863]	[0.3222;1.2801]	[0.7894; 0.9435]	[0,2422; 1,3819]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G3c. Estimated elasticities of substitution between young and medium-aged or old workers through the estimation of a CES production function. *Estimating also the young workers CES coefficient* (δ). **Industry: manufacturing**.

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.7456** (0.4141) [-0.0760;1.5672]	0.4104 (0.8987) [-1.3729;2.1938]	0.5880 (0.5042) [-0.4124;1.5884]	0.0153 (0.7370) [-1.4472;1.4777]
Young workers CES weight coefficient δ	0.4335** (0.4165) [0.3929;1.2599]	2.8083 -9.2486 [-15.5453;21.1618]	0.5343 (0.4811) [-0.4202;1.4889]	0.16 (.) [..;...]
Labor share α	0.5559** (0.0883) [0.3807;0.7312]	0.8889** (0.1116) [0.6674;1.1104]	0.5622** '(0.0868) [0.3900;0.7345]	0.9288** (0.1550) [0.6212;1.2364]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G3d. Estimated elasticities of substitution between young and medium-aged or old workers through the estimation of a CES production function. *Estimating also the young workers CES coefficient* (δ). **Industries: services.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.8618** (0.0845) [0.6934; 1.0302]	0.9770** (0.1505) [0.6775; 1.2765]	0.5690 (1.0322) [-1.4882; 2.6261]	0,9550** '(0.1585) [0,6394; 1,2705]
Young workers CES weight coefficient δ	1.3875 (1.3029) [-1.2091; 3.9842]	0.6369** -0.3158 [0.0102; 1.2636]	17.8160 (219.8) [-420.3; 456.0]	0,2602 (0,9260) [-1,5825; 2,1030]
Labor share α	0.8598** (0.0662) [0.7278;0.9918]	0.8194** (0.2913) [0.2398;1.3990]	0.7595** (0.0759) [0.6082;0.9108]	0,8121** (0,2864) [0,2422; 1,3819]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

Table G3a. Estimated elasticities of substitution between old and young or medium-aged workers through the estimation of a CES production function. Estimating also the old workers CES coefficient (δ). **Industry: manufacturing.**

Structural estimates / Kind of employment and sample	(1) Year-end workforce. All firms	(2) Year-end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	1.6196	1.1186**	1.4123**	1.0427**
	(1.4474)	(0.2283)	(0.7073)	(0.2193)
	[-1.2523; 4.4914]	[0.6656; 1.5717]	[0.0084; 2.8157]	[0.6074; 1.4780]
Old workers CES weight coefficient δ	-0.5842	-0.2628	-0.5107	-0.1051
	(0.6368)	(0.4109)	-0,4818	(0.5043)
	[-1.8497; 0.6813]	[-1.0782; 0.5526]	[-1.4667; 0.4453]	[-1.1058; 0.0,8957]
Labor share α	0.5425**	0.9255**	0.5741**	0.9496**
	(0.0793)	(0.1118)	(0.0816)	(0.1128)
	[0.3852;0.6998]	[0.7036;1.1474]	[0.4121;0.7360]	[0.7036;1.1474]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

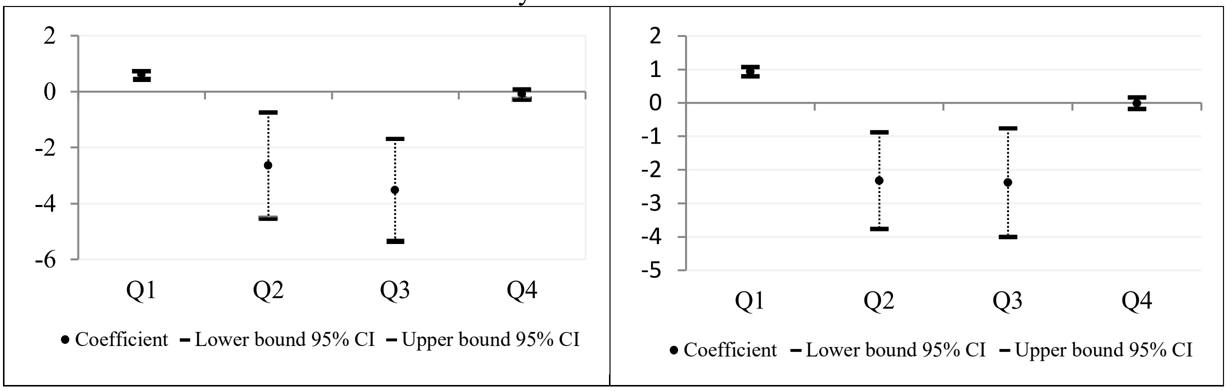
Table G3b. Estimated elasticities of substitution between old and young or medium-aged workers through the estimation of a CES production function. Estimating also the old workers CES coefficient (δ). **Industries: Services.**

Structural estimates / Kind of employment and sample	(1) Year end workforce. All firms	(2) Year end workforce. Firms employing 20 workers or more	(3) Full time equivalent workforce. All firms	(4) Full time equivalent workforce. Firms employing 20 workers or more
Constant elasticity of substitution σ	0.8866**	0.8907**	1,0330**	0,9037**
	(0.0445)	(0.1056)	(0,0737)	(0,1043)
	[0.7979;0.9754]	[0.6804;1.1009]	[0,8861;1,1799]	[0,6960;1,1113]
Old workers CES weight coefficient δ	1.0873	1.0216	-0,1715	0,7501
	(0.6273)	(1.5969)	(0,3506)	(1,2256)
	[-0.1630;2.3376]	[-2.1564;4.1996]	[-0,8703;0,5272]	[-1,6889;3,1892]
Labor share α	1.1163**	0.9121**	0,7878**	0,8904**
	(0.1026)	(0.3018)	(0,1604)	(0,2959)
	[0.9118;1.3209]	[0.3114;1.5127]	[0,4681;1,1075]	[0,3014;1,4793]

Sources: DADS (Insee, file 1/12th) and Alisse (FARE, Insee).
Scope: sectoral balanced panel of 38 industries over the 2009-2015 time period, using firms coming from the non-farm and non-financial industries.
Notes: standard error within parentheses; 95% percent confidence interval in brackets. (1) Year-end workforce in all firms. (2) Year-end workforce in firms employing 20 workers or more. (3) Full-time equivalent workforce in all firms. (4) Full-time equivalent workforce in firms employing 20 workers of more.

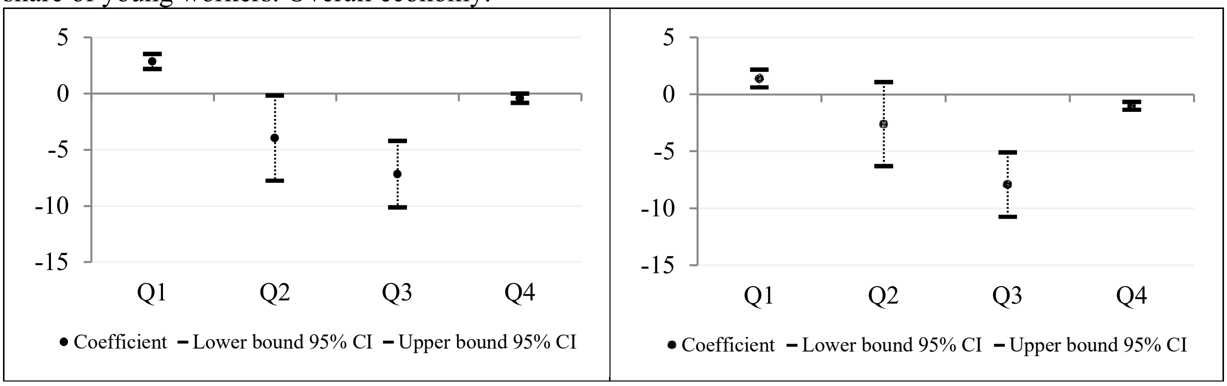
Appendix H. Effect of proportion of the given population of workers on labor productivity. IV Log-linear regressions by quartile of proportion of the considered group of workers. Results for the overall economy (non-farm and non-financial private sectors).

Graph H1. Effects of the share of female workers on labor productivity. Log-regressions by quartile of the share of female workers. Overall economy.



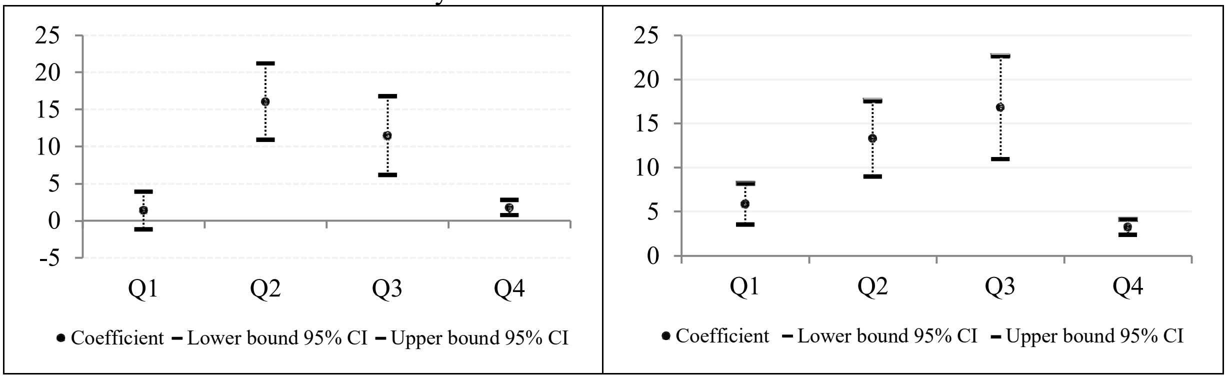
Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Graph H2. Effects of the share of young workers on labor productivity. Log-regressions by quartile of the share of young workers. Overall economy.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.

Graph H3. Effects of the share of old workers on labor productivity. Log-regressions by quartile of the share of old workers. Overall economy.



Sources: DADS (Insee) and FARE (Insee).
Scope: 56,262 (resp. 112, 948) firms employing 20 workers or more over, perennial (resp. perennial or not) over 2009-2016 and coming from the private non-farm and non-financial industries.
Notes: point estimates by quartile. Left (resp. right) graph refers to figures for the balanced (resp. unbalanced) sample. CI stands for confidence interval.