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Job polarization in aging economies ☆

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HIGHLIGHTS

- Goods and services are complementary for seniors and substitute for young people.
- New technologies replace labor input in routine tasks.
- Labor input reallocates towards the service sector in aging societies.

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ABSTRACT

The progressive diffusion of ICT explains the raise in the number of highly paid jobs but has difficulties in justifying that of low-paid jobs. Classifying occupations according to their median wage in 1993, we analyze their employment growth until 2010, which is highest both in the top and in the bottom of the distribution, and lowest in the middle. Low-paid personnel services arise as the main factor responsible for the increase in the proportion of employment at the bottom of the wage distribution. We argue that population aging can explain the increased demand for personal services and thus the rise of employment in low-paid positions. Our argument goes as follows: goods and personal services are complementary for seniors. The decrease in the relative price of goods, induced by the progressive replacement of labor input in routine tasks by machines, is then associated with an increased demand for personal services if the proportion of seniors is increasing. We thus complement the existing literature on employment polarization by showing that demographic trends also play first order role.

1. Introduction

This paper investigates the impact of aging on recent labor market dynamics. Autor and Dorn (2013) show that employment changes in the US since the mid-1990s are U-shaped, with relative employment decreases in the middle of the wage distribution and relative gains at the tails. At the bottom of the distribution, they find that employment gains are accounted for by growth in low-skilled service occupations; these jobs often involve assisting or caring for others (e.g. food service, security guards, janitors, child care workers, hairdressers). Autor and Dorn (2013) relate this job polarization to the combination of non-neutral technological progress and consumer preferences that favor variety over specialization. Non-neutral technological progress reduces the cost of routine tasks since labor input is replaced by cheaper machines, but it has only a minor impact on the cost of work associated with service occupations. This results in a decrease in the relative price of goods with respect to services. If goods and services are complements the demand for service occupation outputs will increase, resulting in an increase in both employment and wages in service occupations. Autor and Dorn (2013) are silent about the potential reasons behind this complementarity in consumers' preferences. They also fail to explain the absence of labor market polarization before the mid-1990s even though American technological diffusion started in the 1980s. We believe that population aging explains both of these

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phenomena. Because goods and personal services are complements for seniors, population aging—in conjunction with technological progress—increases demand for these services. Further, labor market polarization appeared when population aging started to become an issue for most western economies.

We propose a simple theoretical framework following Baumol (1967) to test our hypothesis. Our model provides an equation to estimate the elasticity of substitution between goods and personal services by age group. It further allows us to analyze the combined impact of population aging and technological progress on demand for labor input in the personal service sector.

Our contribution is twofold. First, we estimate age-specific elasticities of substitution between goods and personal services. If the elasticity of substitution is constant, then aging is sufficient to produce job polarization at the bottom of the wage distribution and allows for increased complementarity (with an upper bound). These elasticities suggest that goods and personal services are indeed complements for older households while being substitutes for young ones.

Second, in the context of technological change between 1993 and 2010, we estimate the contribution of population aging to the increased concentration of jobs at the bottom of the wage distribution. We provide evidence of the gradual polarization[1] of the labor market and find that demand for service occupation outputs drives employment growth at the lower tail of the distribution while driving up wages for this type of job.

To our knowledge, this is the first paper that presents evidence of job polarization in French data with a stress on employment growth in the service occupation sector. Dealing with the relationship between polarization and the wage distribution is left for future research. Our objective here is to analyze the combined contribution of aging and technological change to the job polarization process, in terms of employment changes.

The paper is organized as follows. Section 2 is a literature review. Section 3 sketches the theoretical framework. Section 4 empirically validates our assumption concerning the divergent elasticity of substitution between goods and personal services for seniors and young workers. Section 5 provides evidence of job polarization in the French labor market. It shows that employment demand for service occupations has increased due to the combined effect of technological change and aging. Section 6 concludes.

2. Literature review

The literature is far from unanimous concerning the reasons behind the increased demand for labor input in non-routine manual jobs. Initially, most of the literature simply focused on the progression of wage inequalities. Using US data, Lemieux (2006) and Autor et al. (2008) found that wage inequalities between the ninth and the fifth decile had increased more than wage inequalities between the ninth and the first decile, suggesting a rising demand for jobs at the two extremes of the distribution or, at least, a decreasing demand for jobs in the middle of the distribution.

Autor et al. (2006) for the US, Spitz-Oener (2006) for Germany, Maurin and Thesmar (2004) for France, and Goos and Manning (2007) for the UK find that labor input in routine positions (those in the middle of the wage distribution) has been gradually replaced by cheaper and more productive machines. This automation improved the productivity of labor input in abstract tasks (those at the top of the wage distribution) by facilitating access to information. On the other hand, this new technology created a mass of jobless medium-skilled workers. Part of this mass may remain unemployed,[2] whereas another part may be reallocated towards more labor-demanding sectors. Obviously, in spite of the increased demand for qualified labor in abstract positions, there is a skill mismatch since medium-skilled workers do not have the required qualifications to apply for these types of non-routine jobs. They will thus have to switch to manual, non-routine positions (see Goos and Manning (2007)). The productivity for these positions has remained unaffected. These types of position are difficult to automate or outsource since they require interpersonal and environmental adaptability as well as direct physical proximity. But why should the demand for these jobs rise in such a way as to absorb part of the workers that have been replaced by machines? Our paper points to population aging as an answer to this question.

Using British data, Manning (2004) has already observed that the employment of low-skilled workers is increasingly dependent on their physical proximity to high-skilled workers, as low-skilled work is increasingly concentrated in the non-traded sector. According to him, if there are relatively more skilled workers in a city, we could expect the demand for unskilled labor in the non-traded sector to rise. This would lead to fewer unskilled workers in the traded sector and an overall increase in demand for—and wages of—the unskilled. Within a delimited geographical space, a kind of complementarity between unskilled and skilled workers seems to arise. The biased nature of technological progress must have directly promoted skilled labor and indirectly (via the complementary relationship) unskilled labor.

Based on US data, Mazzolari and Ragusa (2013) provide an explanation similar to Manning (2004)'s of the increasing demand for low-paid services. Their idea is that low-skilled workers are employed in non-tradeable, time-intensive services that are substitutes for home production activities. Over the past decades, wage gains at the top of the wage distribution have increased the opportunity cost for high-skilled workers in spending time on domestic activities. Rather than implementing this domestic production themselves, high-skilled workers now prefer to buy these home services. So the increase in demand for low-paid services at the bottom of the wage distribution results from the combination of a substitution effect (the opportunity cost of one hour of home production is now higher for high-skilled workers) and an income effect (because high-skilled workers are wealthier, they can buy more services). In sum, Mazzolari and Ragusa (2013) and Manning (2004) conclude that rising wage inequality between highly paid skilled workers and unskilled workers will induce the formers to demand more low-skilled services so as to free up more of their time for market work.

Based on 16 European countries, Goos et al. (2009) also analyze the importance of income inequality effects. They conclude that the relative growth in low-paid service occupations cannot be explained by the increase in real income and non-homothetic preferences. The higher income elasticities they estimate are actually associated with the top of the wage distribution (more precisely, with the three high-paid industries: (*i*) financial intermediation, (*ii*) real estate, renting and business activity, and (*iii*) transport, storage and communication). Goos et al. (2009) find that the automation hypothesis remains the most important factor behind the observed shift in the employment structure. Little support is found for the hypothesis that changes in product demand are driven by income inequality effects.[3] Further they find a relatively small,

[1] By definition, a polarization process implies an increasing concentration in both extremes of a given distribution. In this paper, we will often refer to polarization at the bottom of the distribution or polarization at the top of the distribution, meaning that the focus of the analysis is on the bottom or the top tail of the wage distribution, even if we are aware that polarization must concern both extremes of the distribution.

[2] Cheron et al. (2011) show that the diffusion of new technologies has fostered a gradual increase in the relative unemployment rate of medium-skilled workers.

[3] Rather than focusing on income inequality effects, Clark (1957) considers a uniform income effect. He argues that the income elasticity of the demand for personal services is greater than one, in which case, a general rise in income will tend to shift employment towards service-intensive occupations. This pure income effect is not considered by more recent papers, which focus rather on the impact that the recent increase in income inequality has had on job polarization.

negative effect of globalization on demand for offshorable jobs; the real driving force of this decreased demand is technological change.

Autor and Dorn (2013) confirm these findings for US data. More precisely they consider three potential explanations for the rise in service occupation employment: 1) offshoring, which displaces low-skilled workers into non-offshorable service occupations; 2) rising income at the top of the wage distribution, which stimulates demand for personal services by wealthy households; and 3) rising returns to education, leading college-educated workers to increase the labor supply and substitute market for home-based production of household services. They find that these mechanisms are not empirically important drivers of polarization. They further stress that increased automation fosters a reduction in the price of goods relative to the price of personal services. This leads to an increase in demand for personal services only if goods and personal services are complements. Biased technological progress is necessary, but not sufficient, to explain job polarization; on its own, it can only justify polarization at the *top* of the distribution as it increases the productivity of abstract tasks. To explain polarization at the *bottom* of the distribution, where the productivity of labor remains unaffected by ICT diffusion, we also require goods and personal services to be, at least, weakly complementary. In this way, biased technological progress fosters a reduction in the relative price of goods.

To summarize, in order to understand the concentration of jobs at both extremes of the wage distribution, we need to combine biased technological change with a complementary relationship between goods and personal services, as in Autor and Dorn (2013). Our originality lies in our stress on aging, which allows us to understand the time lag between technological diffusion and polarization. Because the diffusion of skill-biased technologies started in the 1980s, whereas the polarization process is a more recent phenomenon (beginning in the second half of the 1990s), we argue that the aggregate elasticity of substitution between goods and personal services has decreased with respect to past decades, when we observed biased technological change but no polarization. Our paper therefore adopts a novel perspective by pointing to the combined effects of population aging and technological progress as the main drivers of the increase in demand for personal services, controlling for the potential effect produced by the increase in income inequality.

3. A simple theoretical model

Suppose an economy can be broadly divided into two sectors: the routine goods sector, employing labor and capital to produce goods, and the low-skilled, personal service sector, employing labor to produce value. Because routine tasks in the goods sector are easily automated, they can be implemented by capital or labor. Both factors are assumed to be perfectly substitutable in the production process of routine goods. Moreover, technological progress positively affects the relative productivity of capital. Finally, note that technological progress does not affect the marginal productivity of labor in the personal service sector. It will, however, decrease the relative productivity of labor with respect to capital in the goods sector.

3.1. The household decision

3.1.1. Consumption decision

For simplicity, we assume a large representative household composed of individuals who might be retired, unemployed, or employed in either the goods or personal services sector. Each individual has a different elasticity of substitution between goods and personal services. However, the aggregation of all individual preferences[4] yields a single utility function that the representative household maximizes subject to the aggregate budget constraint. More precisely,

$$\max_{q_{gt},q_{st}} U\left(q_{gt},q_{st}\right)=\left[(1-a_s)q_{gt}^{\theta}+a_s q_{st}^{\theta}\right]^{1/\theta} \qquad \theta<1 \tag{1}$$

subject to

$$p_{gt}q_{gt}+p_{st}q_{st}=y_t, \tag{2}$$

where q_{gt} denotes the quantity of goods, q_{st} the quantity of personal services, and p_{gt} and p_{st}, their prices. $a_s>0$ is the weight of personal services in the consumption basket. The household's income is y_t and comes from wages earned by employed individuals and the retirement pensions of seniors. The household's aggregate elasticity of substitution between goods and personal services is given by $\epsilon=\frac{1}{1-\theta}$. Replacing the first order conditions in the budget constraint yields the following demand for personal services:

$$q_{st}=a_s^{\frac{1}{1-\theta}}\frac{p_{st}^{\frac{1}{\theta-1}}}{P_t^{\theta}}y_t, \tag{3}$$

with the price index denoted $P_t=\left[(1-a_s)^{\frac{1}{1-\theta}}p_{gt}^{\frac{\theta}{\theta-1}}+a_s^{\frac{1}{1-\theta}}p_{st}^{\frac{\theta}{\theta-1}}\right]^{\frac{\theta-1}{\theta}}$. Taking logarithms on both sides of Eq. (3) gives the following log-linear demand for services:

$$\log q_{st}=\log y_t-\epsilon\log p_{st}+(\epsilon-1)\log P_t+\epsilon\log a_s. \tag{4}$$

A log-linear approximation of the aggregate price index is:

$$\log P_t=\alpha\log p_{gt}+(1-\alpha)\log p_{st}, \tag{5}$$

where α is the share of income spent on the routine good sector. In other words, α approximates the size of the goods sector. Substituting Eq. (5) in Eq. (4) yields:

$$\log q_{st}=\log y_t-\epsilon\log p_{st}+(\epsilon-1)\alpha\log p_{gt}+(\epsilon-1)(1-\alpha)\log p_{st}+\epsilon\log a_s. \tag{6}$$

3.1.2. Labor supply decision

Young members of the household inelastically supply one unit of labor, though they may be employed or unemployed. Participation issues are not considered, so we assume that all young individuals participate in the labor market.[5] Moreover, due to perfect labor mobility between sectors, wages in the two sectors are equal. Individuals are therefore indifferent between working in one sector or the other.

3.2. Production decisions

We also suppose a perfectly competitive environment for the goods and services markets but an imperfect competitive environment for the labor market. Firms set prices for goods and services equal to their respective marginal costs. These marginal costs are closely linked to wages paid by the firm. Wages are assumed to be the result of a bargaining process. In the routine goods sector, wages equal the marginal productivity of labor. In the low-qualified personal services sector,

[4] It is beyond the scope of this paper to deal with aggregation issues since the unique goal of the theoretical model is to provide a framework giving a rationale to the results obtained in the following sections.

[5] Being unemployed or not participating in the labor market is equivalent in this context. This is because there are no unemployment benefits. Unemployed people simply generate domestic production. One might object that the participation margin has been shown to play a role in accounting for cyclical unemployment. However, in this paper, we focus on long run labor market adjustments. In France, during the period considered in our econometric exercise, the participation rate of young workers has remained fairly constant at 41.2% with a standard deviation of only 1.2 points (Source: INSEE).

we assume that the firm pays the worker a wage set to his outside opportunity of employment.[6]

In the routine goods sector, technological progress increases the relative productivity of capital, which boosts aggregate production. As capital and labor are substitutable in the goods sector, the increasing relative productivity of capital encourages firms to increase their demand for capital with respect to labor. The subsequent increases in production are due to this increased use of capital. The production function in the routine good sector is:

$$q_{gt} = \left(a_{Kt}K_t^{\rho} + a_{Lt}L_{gt}^{\rho}\right)^{1/\rho} \text{ with } a_{Kt} = \phi_K e^{gt} \text{ and } a_{Lt} + a_{Kt} = 1 \tag{7}$$

where K_t and L_{gt} are capital and labor, while the growth rate of technological progress is given by g. An increase in g improves the relative productivity of capital, which should lead to a rise in the demand for this production factor. As in Autor and Dorn (2013), we normalize the good price to one: $p_{gt} = 1$.[7]

While technological progress raises productivity in the goods sector, productivity in the low-skilled services sector, which employs only labor, remains unaffected. This is consistent with the view that personal services require interpersonal and environmental adaptability as well as direct physical proximity. The productivity of labor in this sector does not depend on capital intensity. We normalize this productivity to unity as in Autor and Dorn (2013). The production function then takes on a very simple form:

$$q_{st} = L_{st}. \tag{8}$$

Because wages in the services sector equal the value of the outside opportunity of employment, the marginal cost in the services sector equals: $b \cdot e^{gt}$, where b can be interpreted as the value of leisure or home production. The value of the outside opportunity of employment increases at the same pace as the aggregate productivity of the economy. The price set by this sector is then given by $p_{st} = b \cdot e^{gt}$. Replacing $p_{gt} = 1$ and $p_{st} = b \cdot e^{gt}$ in Eq. (6), and applying Eq. (8), yields:

$$\log\ L_{st} = C + \log\ y_t - (\alpha(\epsilon - 1))gt - gt, \tag{9}$$

where C is a constant. Since the total labor supply is normalized to 1 (i.e. $L_{st} + L_{gt} = 1$), L_{st} is the labor share in the service occupation sector. In Eq. (9), income positively influences the employment share in personal services. The impact of technological progress depends on the degree of substitutability between goods and personal services. On the one hand, there is a direct negative impact equal to $-gt$ of growth on employment in personal services. It results from the increase in personal service wages associated with the rise in g. On the other hand, the impact of $-(\alpha(\epsilon - 1))gt$ depends on the value of ϵ. If goods and personal services are complements ($0 < \epsilon < 1$), the term $-(\alpha(\epsilon - 1))gt$ becomes positive, meaning that technological progress increases the demand for personal services and, hence, employment in this sector. The importance of this effect is scaled by α; the larger the α, the more significant the effect. If goods and personal services are substitutes then $\epsilon > 1$; then the term $-(\alpha(\epsilon - 1))gt$ is negative. This implies that technological progress reduces employment in personal services. This reduction is amplified as α increases.

Autor and Dorn (2013)'s "routinization" hypothesis, according to which the larger the share of routine jobs the more marked the job polarization process, contributes to job polarization at the bottom of the job quality distribution when goods and personal services are complements. The question that arises then is: when are goods and personal services complements rather than substitutes? The age composition of the population determines the aggregate elasticity of substitution between goods and personal services (see Appendix A). Combining population aging with the progressive replacement of labor input in routine tasks by relatively more productive machines explains the increase in the proportion of employment at the bottom of the wage distribution.

Our model has a number of testable implications. First, a reduced form of Eq. (4) is estimated so as to compare the value of the elasticity of substitution between goods and personal services for households belonging to different age groups. This is done in Section 4. Second, a reduced form of Eq. (9) will allow us to estimate the combined impact of aging and automation on the demand for low-skilled personal services (Section 5). While the share of seniors does not explicitly appear in Eq. (9), we can consider this share as a proxy of the degree of complementarity or substitutability between goods and personal services (see Appendix A).

4. Estimating the elasticity of substitution between goods and personal services

Our main claim is that, combined with technological progress, population aging induces an increase in demand in the low-skilled personal service sector (i.e. job polarization at the bottom of the wage distribution) due to the complementary relationship between goods and personal services. More precisely, we argue that for seniors good and services are more complementary than for young workers. Since recent technological changes have reduced the price of goods, demand for personal services will tend to increase if goods and personal services are complementary. Conversely, we expect a reduction in the demand for services if they are substitutes with respect to goods.

4.1. The 2006 Household Budget Survey

The aim of the Household Budget Survey (HBS) is to compile data on the expenditure and resources of French households. The study of expenditure is the central purpose of the survey. All household expenditure is recorded. The nature of these expenses is broken down into a classification of about 900 budgetary items compatible with the classification used in the national accounts. All expenses are covered, including those not associated with the consumption of goods and personal services.[8] In addition to expenses, the survey collects information about non-monetary consumption (e.g. food produced for own consumption and imputed rentals). Essentially, the family household budget survey collects monetary data, leaving the more specialized surveys on each item of consumption (e.g. transportation, housing, leisure, or holidays) to use a more qualitative approach to household behavior. Nevertheless, in order to illustrate these monetary data, some complementary questions are asked about the financial situation as perceived by the household.

The statistical unit is the household and all ordinary French households are covered.[9] The survey began in 1979 and takes place approximately every 5 years. Since 2001, expenditure has been classified according to the European classification, which differs considerably

[6] With Nash bargaining on wages, our model is equivalent to a setting in which workers have different bargaining powers across sectors. In the routine goods sector, workers are assumed to have much more bargaining power than in the personal services sector. This is because wages equal the marginal productivity of labor in the goods sector while, in the personal services sector, firms pay a wage equal to the workers' outside opportunity of employment. This is consistent with the empirical evidence. Hirsch and Berger (1984) find evidence of larger union density in more capital-intensive firms. Further, using the 2013 release of the Data Base on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts (ICTWSS), we find that the average union density is 40% in manufacturing industries versus 1% in hotels and 4% in household services. This average was calculated using the latest observations for Australia, Austria, Belgium, France, Germany, Spain, Ireland, Italy, Switzerland, and the US. This suggests that workers in the goods-producing sector have much more bargaining power than their counterparts in the personal services sector.

[7] Since we have a real model, only relative prices matter.

[8] The precise expenses are: taxes and contributions, insurance premiums, major home renovation expenditure, inter-household transfers, purchase of second-hand goods and loan repayments.

[9] This includes the overseas departments.

from the French classification, which was used until 1995. For this reason, the results of the 2001 and 2006 editions of the survey cannot yet be compared directly with those from previous years. Due to the absence of a panel and since expenditures on personal services are only detailed in the 2006 survey, we employ it in our study. The 2006 (random, self-weighted) sample consists of about 20,000 dwellings in mainland France and 5000 in the overseas departments. The number of households surveyed is about 10,240 for mainland France and 3134 for the overseas departments.

4.2. Computing the price and expenditures for personal services in the survey

We consider senior households to be those composed of one or two people older than 60. We eliminate all senior households where a younger individual resides. This is because the presence of the younger individual may skew the older household's demand as he could help out with services that might otherwise be purchased. We have more than 2540 senior households. We define a young household as one composed of one or two 30–45 years old who do not have children. We have more than 1800 young households.

The survey provides information on the annual expenditures of hiring someone for personal services.[10] Most households, particularly young ones, declare zero expenditure on the majority of these services. House cleaning is the expenditure for which the number of households declaring a strictly positive quantity is the highest; 472 senior households and 120 young households declare strictly positive house cleaning expenditure.[11] Thus, we will focus on this type of personal service. Additional robustness tests where we consider all expenditures on personal services are presented in Appendix B.1 and confirm the results presented in this section.

The first problem we must deal with is the lack of information concerning the number of hours worked by the personal service employee. There is only one variable in which households declare the number of hours hired over the previous two months. However, there are a great number of missing observations in this variable. We solve both problems sequentially. First, since we deal with yearly expenditures, in order to compute the hourly cost we assume that the number of annual hours worked by a personal service employee is six times the number of hours worked over the two month period. Next, to deal with the problem of missing data, we compute the average number of hours hired, grouping households with comparable yearly expenditures together. These averages are then imputed to those households with missing data that have similar personal expenditure levels. Clearly, this process assumes that households with comparable house cleaning expenditures hire a similar number of hours.

Finally, to compute the hourly price paid by households for personal services, we divide yearly expenditure by yearly hours (declared or imputed). Obviously, since yearly hours are computed by extrapolating the number of hours declared for the two months preceding the survey to the whole year, the hourly price is, in many cases, unreasonable. We drop these unreasonable observations.[12] The final sample of households declaring a strictly positive house cleaning expenditure (and thus paying a strictly positive hourly price) is reduced to 425 senior households and 114 young households. For households (young and old) whose cleaning expenditure equals zero we set the hourly price equal to the 2006 minimum wage of €6.9285. This value seems quite reasonable given that the median of the sample equals €6.11 and the mean €9.46.

4.3. Estimates of the elasticity of substitution

We now have all the required information to estimate the reduced form of:

$$\log q_{st} = \log y_t - \epsilon \log p_{st} + (\epsilon - 1) \log P_t + \epsilon \log a_s.$$

Due to data availability problems, we assume that the general consumption price index $P_t = \left[(1-a_s)^{\frac{1}{1-\theta}} p_{gt}^{\frac{\theta}{\theta-1}} + a_s^{\frac{1}{1-\theta}} p_{st}^{\frac{\theta}{\theta-1}} \right]^{\frac{\theta-1}{\theta}}$ is constant across individuals.[13] This term together with the weight a_s is then included in the constant. Our estimation reduces to:

$$\log q_{si} = C + \log y_i - \epsilon \log p_{si} + \mu, \tag{10}$$

where i represents the individual household, ϵ stands for the elasticity of substitution, C for the constant, y for income, p_s for the hourly price of house cleaning services and μ for the error term. Income[14] is computed from the database and varies across households. The hourly price of personal services also varies among households and results from the computations explained above. For each type of household, we implement weighted OLS estimation with and without geographical dummies so as to test the robustness of the results. The coefficients are stable, which makes us quite confident about our results. Moreover, by implementing weighted regressions, we eliminate the potential problem associated with an over-representation of certain types of households. The data do not allow us to determine the precise location of the household. They do however provide the geographical area of the household's main residence (Mediterranean zone, Center-east, Southwest, West, East, North, Paris metropolitan region) and the type of city of residence (rural area, city of less than 20,000 inhabitants, city having between 20,000 and 100,000 inhabitants, city of more than 100,000 inhabitants, city of Paris). We interact both variables so as to obtain more precise geographical dummies (40 dummies).

Table 1 summarizes our results. Columns 1 and 2 provide the estimation of the elasticity of substitution (coefficient on p_s) for senior households when we only consider those households declaring positive house cleaning expenditures. The corresponding elasticity for young households is in columns 5 and 6. The size of the sample is quite small, particularly for young households where there are only 113 observations. This makes us very cautious when interpreting the coefficients.[15]

Columns 3 and 4 include results for all senior households. The corresponding results for young households are contained in columns 7 and 8. Here, the size of the sample increases to 2362 observations for seniors and 1802 observations for young workers. However, it must be noted that only 17% of the observations for seniors and 6% of the observations for young households are strictly positive. Our sample is thus left-censored.[16] The estimated elasticity is significant and below unity for

[10] Personal services considered in the survey are house cleaning, child care, shopping, domestic health care, and garden care.

[11] For child care there are no senior households declaring a strictly positive expenditure and there are 32 young households declaring strictly positive expenditures. For shopping there are 24 senior households and zero young households. For domestic health care 8 senior households and 1 young household declare a strictly positive expenditure. For gardening there are 71 senior households and 7 young households. For other services there are 24 senior households and 1 young household.

[12] We believe that an hourly price above €150 is too high to be realistic and an hourly price below €1 is far too low, even for households for which the cost of these personal services may be subsidized. There is always a marginal cost borne by the household. This happens with most medicines, which are greatly, but not fully, subsidized.

[13] Due to the great amount of missing information on the large number of expenditures made by the household, trying to estimate the particular price index per household would introduce a major source of measurement error in our model.

[14] Income refers to permanent income and results from the sum of the retirement pension (if any), salary or income from self-employment.

[15] Estimated elasticities are below one. However, these elasticities remain above the elasticities estimated for senior households over the reduced sample (columns 1–2). This suggests that goods and personal services are more complementary for senior households than for young households.

[16] In order to deal with left-censored observations, we have also implemented a Tobit estimation which is available from the authors' web appendix (http://thepthida.sopraseuth.free.fr, https://sites.google.com/site/morenogalbiseva). Estimated coefficients correspond to the average marginal effects (they can no longer be interpreted as elasticities) and they appear to be lower for seniors than for young households.

Table 1
Elasticity of substitution between goods and personal services (house cleaning). Budget Household Survey 2006.

	Dependent variable: demand for house cleaning services							
	Senior households with positive expenditure		All senior households		Young households with positive expenditure		All young households	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log *y*	0.0266***	0.0345***	0.135***	0.146***	0.212***	0.177***	0.326***	0.322***
	(0.000562)	(0.000566)	(0.000870)	(0.000867)	(0.00163)	(0.00152)	(0.000821)	(0.000806)
Log *ps*	−0.103***	−0.0900***	**−0.904*****	**−0.900*****	−0.267***	−0.214***	**−1.232*****	**−1.243*****
	(0.000475)	(0.000469)	(0.00163)	(0.00162)	(0.00115)	(0.00117)	(0.00236)	(0.00237)
Geograph. dummies	Yes	No	Yes	No	Yes	No	Yes	No
Observations	400	400	2362	2362	113	113	1802	1802
R-squared	0.105	0.031	0.063	0.045	0.325	0.19	0.120	0.104
VIF	12.04	1.07	16.93	1.01	7.43	1.00	13.77	1.000

Standard errors in parentheses: ***$p < 0.01$.

seniors while it is significant and above unity for young households. That is, goods and personal services are complements for seniors and substitutes for young households.

What is remarkable in Table 1 is the stability of the coefficients independent of the introduction of geographical dummies. The inclusion of geographical dummies induces a multicollinearity problem (the variance inflation factor, VIF,[17] is above 5) that disappears when we eliminate geographical dummies in columns 2, 4, 6, and 8. However, the value of the coefficients associated with log *ps* and log *y* in columns 1 and 2, 3 and 4, 5 and 6, and 7 and 8, remains quite close and the degree of significance unchanged. The multicollinearity concern induced by geographical dummies does not then seem like a major problem in the estimation of the elasticity of substitution. Appendix B.2 proposes a similar exercise on a pooled sample of young and senior households. Results remain robust. Goods and personal services are complements for seniors.

5. Job polarization and aging in French microdata

The polarization of the labor market has been largely documented for some OECD countries.[18] In this section we show that this polarization process also applies to the French case. Next, we try to gain insights into the type of jobs concentrated at the bottom of the wage distribution. Personal services arise as the main determinant of employment growth at the lower tail of the distribution. Finally, after investigating a possible gender composition effect behind job polarization at the bottom of the distribution, we perform an econometric analysis of the role of population aging, in the context of technological change, on this job polarization process. A reduced form of Eq. (9) is then estimated.

5.1. The French Labor Force Survey

The French Labor Force Survey (LFS) was launched in 1950 and established as an annual survey in 1982. Redesigned in 2003, it is now a continuous survey providing quarterly data. Participation is compulsory and it covers private households in mainland France. All individuals in the household older than 15 are surveyed.

The quarterly sample is divided into 13 weeks. From a theoretical point of view, the sampling method consists of a stratification of mainland France into 189 strata (21 French regions × 9 types of urban unit) and a first stage sampling of areas in each stratum (with different probabilities, average sampling rate = 1/600). Areas contain about 20 dwellings and among them only primary residences are surveyed. Each area is surveyed over 6 consecutive quarters. Every quarter, the sample contains 6 sub-samples: 1/6 of the sample is surveyed for the first time, 1/6 is surveyed for the second time, and 1/6 is surveyed for the 6th (and last) time. When it was run as an annual survey, every year a third of the sample was renewed meaning that each individual was interviewed only 3 times. The collection method has always been a face-to-face interview.[19]

Topics covered by the LFS concern employment, unemployment, underemployment, hours of work, wages, duration of employment and unemployment (length of service), discouraged workers, industry, occupation, status in employment, education/qualification, and other jobs. The French LFS provides the occupation for each employed individual among a list of 350 possible occupations such as “gardener”, “messenger”, “clerks in banking activities” and “financial managers”.[20] Some occupations are characterized by a very general definition and a large number of employed individuals. In this case, we disaggregate these jobs by industry.[21] For instance, secretaries are divided into secretaries in the food industry, in the car industry, etc. This leaves us with 452 occupations each year.

5.2. Evidence of job polarization in France

The French LFS allows us to have a look at trends in the quality of jobs (i.e. employment structure). As in Goos and Manning (2007), quality is proxied by the median hourly wage for each job at the beginning of the period.

We first relate the job quality in 1993 to the average subsequent change in log employment from 1993 through 2010.[22] Fig. 1 presents the average change in log employment in the 1993–2010 period (Y-axis) for each job quality, proxied by its median wage (X-axis).[23] Circle sizes denote the employment level in 1993. We also present a quadratic fit of average employment growth by job quality. Panel (*i*) of

[17] The VIF quantifies the severity of multicollinearity in an OLS regression analysis. It provides an index that measures how much the variance of an estimated regression coefficient is increased because of collinearity. A VIF below 5 implies no multicollinearity problem.

[18] See Goos and Manning (2007) for the UK, Autor et al. (2006) for the US, Spitz-Oener (2006) for Germany or Goos et al. (2009) for 16 European countries.

[19] Since 2003, a telephone interview has been employed for intermediate surveys (2nd to 5th).

[20] With this range of possible jobs, the wage distribution captures both low and high paid jobs. However, the number of observations in top jobs is particularly low in all surveys. The sample does not capture the increase in wage inequality due to the top 1% of the wage distribution (Landais, 2008).

[21] Appendix C provides a description of the occupations.

[22] Unfortunately, we could not use the LFS prior to 1993 because of a drastic change in industry classification. Thus it was not possible to obtain consistent industry codes over time.

[23] For the sake of clarity, all graphs in this section have been rescaled by removing outliers from the chart. The outliers are not excluded in computing the quadratic regression curves. The web appendix (http://thepthida.sopraseuth.free.fr, https://sites.google.com/site/morenogalbiseva) presents graphs including outliers.

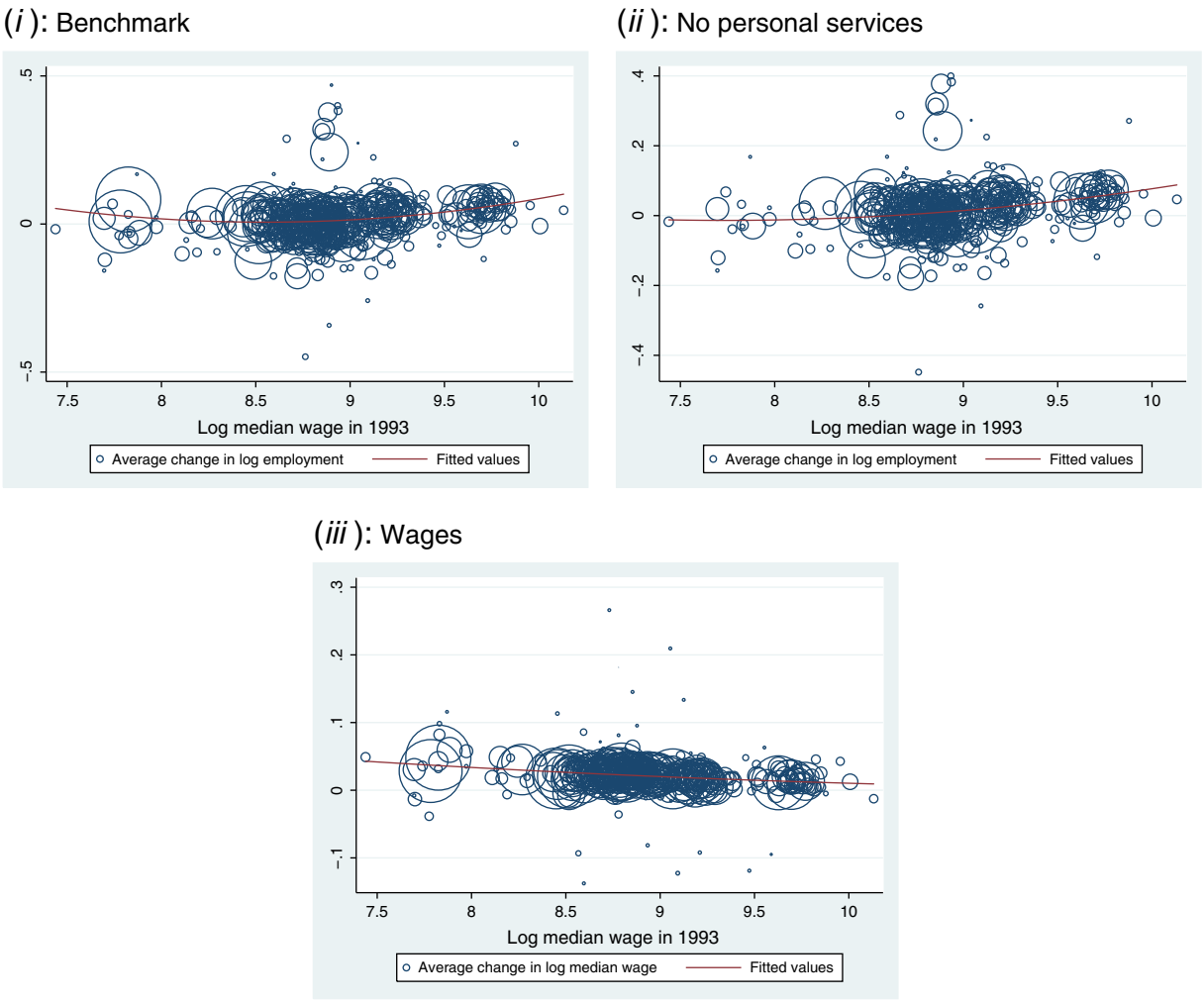

Fig. 1. Average employment and wage growth by job median wage (1993–2007). X-axis: Log-median wage in 1993. The size of the circles corresponds to the employment level in 1993. Y-axis: Average growth rate of employment between 1993 and 2010.

Fig. 1 suggests a U-shaped relationship between employment growth and job quality.[24] The quadratic fit can be represented as follows:

$$d(\text{logemployment}) = \alpha \log w_{1993} + \beta\ (\log w_{1993})^2 + C$$
$$d(\text{logemployment}) = \underset{(0.0009208^{***})}{-0.6384738}\log w_{1993} + \underset{(0.0000521^{***})}{0.0373618}\ (\log w_{1993})^2 + \underset{(0.0040663^{***})}{2.734133} \quad (11)$$

where standard errors are presented in parentheses.[25] While the coefficient of the linear term, $\log w_{1993}$, is negative and significant, the coefficient associated with the quadratic term, $(\log w_{1993})^2$, is positive and significant, confirming a U-shaped employment structure prevailed between 1993 and 2010. Over the past decades, jobs in the middle of the wage distribution have been characterized by low employment growth while the rise in employment has been greater for jobs at the top and bottom of the wage distribution.

At the lower end of the job quality distribution, two jobs are characterized by a high employment level in 1993 and strong subsequent employment growth. These large circles correspond to occupations related to child care and house cleaning or, more generally, personal service occupations. This is clearly observed in Panel (*ii*) of Fig. 1 which reveals that, if personal service occupations are excluded from the analysis, the U-shape curve disappears.[26]

Panel (*iii*) shows that the increased demand for jobs at the bottom of the wage distribution, has caused wages there to increase more than for other jobs.[27] The three figures together send a clear message: between 1993 and 2010, positions at the bottom and at the top of the wage distribution have benefited from larger increases in employment than positions in the middle. This is particularly true for personal services, which have experienced the biggest increases in both employment and wages.

Finally, various factors could potentially cause this concentration of jobs at the bottom of the wage distribution. While our paper focuses on the combined effect of technological progress and aging, feminization of the labor force could also be a source of this job polarization, with women accounting for the growth in relatively low-paid occupations. But, as Fig. 2 shows, one observes similar patterns for male and female employment considered separately in the 1993–2010 period. The

[24] We choose to consider the change in log employment over the 1993–2010 period, as in Goos and Manning (2007). Autor and Dorn (2013) examine the change in employment share. We observe that the relationship between job quality and change in employment share is still U-shaped, thereby suggesting job polarization.

[25] $(***)$: significant at 1%. $(**)$: significant at 5%. $(*)$: significant at 10%.

[26] Actually, the quadratic fit of the bottom part of the job distribution now equals:

$$d(\log \text{employment}) = \underset{(0.0047966^{***})}{0.2334882}\log w_{1993} \underset{(0.0002856^{***})}{-0.0135525}\ (\log w_{1993})^2 \underset{(0.0201244^{***})}{-1.005486}$$

suggesting an inverted U-shape progression in this part of the distribution.

[27] The quadratic fit of the wage distribution equals:

$$d(\log \text{wage}) = \underset{(0.0001888^{***})}{-0.0450597}\log w_{1993} + \underset{(0.0000107^{***})}{0.0018549}\ (\log w_{1993})^2 + \underset{(0.0008338^{***})}{0.2754366}.$$

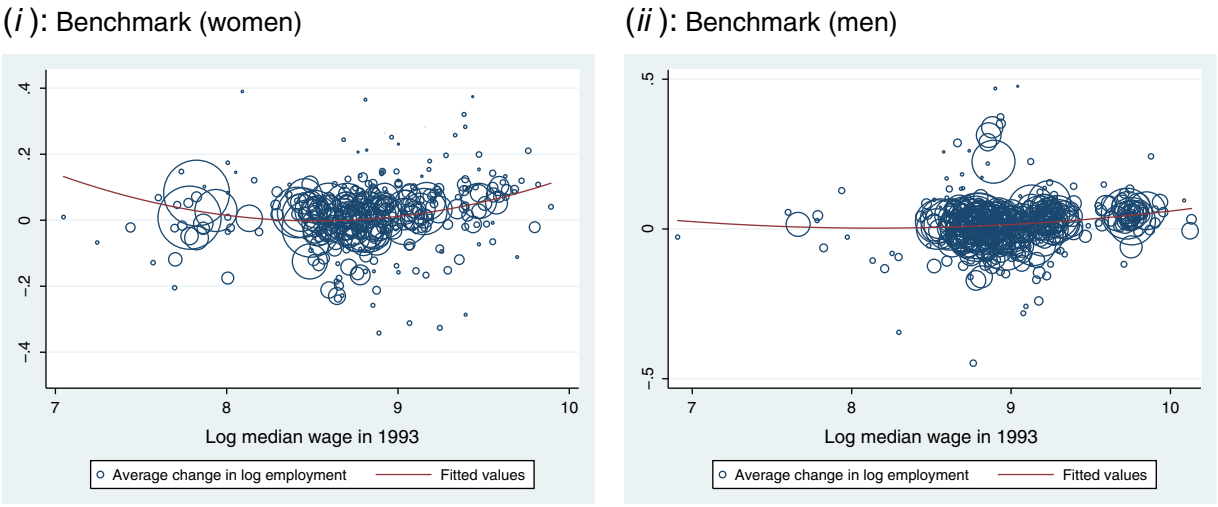

Fig. 2. Average employment growth for men and women by job median wage (1993–2007). X-axis: Log-median wage in 1993. The size of the circles corresponds to the employment level in 1993. Y-axis: Average growth rate of employment between 1993 and 2010.

results do not change with respect to the pooled sample. The quadratic fit confirms this result for both men and women:

$$d(\log \text{female employment}) = \underset{(0.0017161^{***})}{-1.048863 \log w_{1993}} + \underset{(0.0001^{***})}{0.0614585 (\log w_{1993})^2} + \underset{(0.0073536^{***})}{4.472667}$$

$$d(\log \text{male employment}) = \underset{(0.0020772^{***})}{-0.2995561 \log w_{1993}} + \underset{(0.0001138^{***})}{0.0181389 (\log w_{1993})^2} + \underset{(0.0094687^{***})}{1.241833}.$$

In sum, three conclusions can be drawn from Figs. 1 and 2 that are consistent with the literature presented in Section 2. First, over the past decades the French labor market has become more polarized. Second, as shown in Panel (*ii*) of Fig. 1, the main driver of job polarization at the bottom of the wage distribution is personal services.[28] Finally, one of the main explanations for the increase in the share of personal services is the feminization of the labor force. However, empirical evidence contradicts this hypothesis since, regardless of whether we consider the male or female labor force, the polarization process arises. Apart from the integration of women into the labor market, one of the major demographic changes that are likely to have influenced the labor market structure over the past years is population aging. We would thus like to evaluate the role of population aging over the past 18 years on job polarization at the bottom of the wage distribution.

5.3. Change in service employment share and aging

Our estimation is based on the time-derivative of Eq. (9), that is:

$$\dot{L}_{st} = \dot{y}_t - (\alpha(\epsilon - 1))g - g. \tag{12}$$

We will proxy the aggregate elasticity of substitution between goods and personal services in a particular geographical unit by the share of seniors (see Appendix A). As in Autor and Dorn (2013), we proxy technological change by the share of routine employment in the geographical unit.[29] We identify routine occupations in the list of our 452 jobs. Unlike other papers on the subject, we do not have a Dictionary of Occupational Titles allowing us to determine the task composition of each occupation. We are thus obliged to classify jobs as either routine or non routine (see Appendix E for details). For our benchmark regression, we adopt a tight definition of routine (so as to be sure that all jobs considered mainly include routine tasks). Control variables will not be introduced in variation so as to avoid causality problems. The value of these variables will be fixed at their initial level.

Our empirical investigation relies on a panel of small geographical units: the French departments. We consider 96 departments included in 21 regions. Our sample spans 1993–2010, which yields panel data of more than 1700 observations. Looking at the department level rather than the regional level allows us to consider a larger sample. A further benefit is that the empirical exercise will measure whether the relationship is pervasive over smaller geographical units. Moreover, this approach is consistent with the commuting zone approach of Autor and Dorn (2013).

In each department, for each year, we compute the share of service employment in total employment. We then compute the yearly change in this share. Finally, we employ these values to compute the change in the share of services employment in total employment for the periods 1993–2001 and 2002–2010. Since we have data on 18 years, we consider intervals of 9 years because we believe this period is long enough to allow for an adjustment of the employment structure following a modification in the demand due to a demographic change. For each department, each of the two intervals constitutes our dependent variable. With 96 departments and two changes in the service employment share (1993–2001 and 2002–2010) this yields panel data of 192 observations.

Our empirical exercise is close to that of Autor and Dorn (2013) and extends their analysis to French data. We would like to draw attention to the demand shift associated with the combined effect of aging and technological change as the main determinant of job polarization at the bottom of the distribution. The estimated equation is:

$$d\left(\frac{N_{i,t}^{service}}{N_{i,t}}\right) = \alpha + \beta\ old_{i,t-1} \cdot routine_{i,t-1} + \gamma X_{i,t-1} + e_{i,t}, \tag{13}$$

where $d\left(\frac{N_{i,t}^{service}}{N_{i,t}}\right)$ denotes the change in service employment share $\left(\frac{N_{i,t}^{service}}{N_{i,t}} - \frac{N_{i,t-1}^{service}}{N_{i,t-1}}\right)$ in department i and period $t-(t-1)$. Appendix E provides the list of service occupations. We adjust standard errors for clustering of observations at the department level.

Our paper explores the view that population aging may lead to a rise in the share of service employment in a context of technological

[28] These results are confirmed by Table 5 in Appendix D.

[29] Autor and Dorn (2013) find that the share of routine employment in a commuting zone at the beginning of the decade is highly predictive of computer adoption during that decade.

Table 2
Change in service employment share: benchmark estimation. Department level (1993–2010).

	Dependent variable: change in service employment share					
	(1)	(2)	(3)	(4)	(5)	(6)
Old_{t-1}	0.0765					
	(0.0634)					
$Routine_{t-1}$		0.0278*				
		(0.0157)				
$Old_{t-1} \cdot Routine_{t-1}$			**0.126***	**0.128***	**0.151****	**0.149****
			(0.0681)	(0.0683)	(0.0644)	(0.0651)
$Unemployment_{t-1}$					0.00353	0.00315
					(0.0519)	(0.0517)
$Female_{t-1}$						−0.00514
						(0.0105)
$Manufacture_{t-1}$					0.0278***	0.0282***
					(0.00909)	(0.00920)
$Managers_{t-1}$				0.00817	0.0141	0.0142
				(0.0114)	(0.0119)	(0.0122)
Fixed effects:						
Year	Yes	Yes	Yes	Yes	Yes	Yes
Department	Yes	Yes	Yes	Yes	Yes	Yes
Prop. min. wage	−0.0314**	−0.0333**	−0.0326**	−0.0319**	−0.0253**	−0.0246**
	(0.0129)	(0.0127)	(0.0126)	(0.0126)	(0.0119)	(0.0121)
Observations	192	192	192	192	192	192
R-squared	0.544	0.555	0.556	0.558	0.581	0.582
VIF	5.16	2.34	2.38	2.70	4.12	4.38

Standard errors in parentheses: $***p < 0.01$, $**p < 0.05$, and $*p < 0.1$.

change.[30] This effect is measured by the interaction between the share of individuals aged 60 and older over the total population in department i at the start of the period $[t-1, t]$ and the share of individuals employed in routine positions in department i at the start of the period $[t-1, t]$. The value of both shares is taken at the start of the period to capture the exogenous effect of aging on the growth of the personal service employment share in the presence of technological change. If our hypothesis is confirmed by the data, we expect the coefficient of the interacted variable to be positive.

Our benchmark equation stacks the two time periods discussed earlier, and includes a full set of time effects, department effects and a proxy of their interacted effect. Department dummies allow us to capture time-invariant determinants of the share of service employment across departments, such as geographical characteristics (e.g. weather, sea, proportion of urban and rural areas). Time dummies allow us to capture time-varying determinants of the share of service employment common to all departments (this mainly concerns institutional reforms).

Because our regressions exploit heterogeneity across French departments, the impact of national institutional reforms should be captured by time dummies. However, we could argue that a given institutional change may have heterogeneous effects across departments. Ideally, we would introduce time and department interacted fixed effects to control for this time-varying spatial heterogeneity. However, this would raise the number of control variables above the number of observations. We thus proxy these interacted fixed effects by the proportion of individuals earning the minimum wage (between 1 and 1.1 times the minimum wage) in each department. This variable changes from one year to the next and from one department to another. Therefore, it allows us to control for the time-varying heterogeneous effect of national reforms across departments. Furthermore, individuals earning the minimum wage are likely to have been affected by major institutional reforms in France during the period considered. One such reform was the minimum wage itself, which evolved significantly around 2000. Another reform was the introduction of the RSA[31] in 2007–2008. The beginning-of-period values of four additional explanatory variables[32] (denoted by $X_{i,t-1}$) are also included in our specification:

1. The share of managers[33] in department i. This variable seeks to capture the income effect, invoked by Mazzolari and Ragusa (2013) and Manning (2004), responsible for the increase in demand for low-skilled personal services. This variable also controls for another effect highlighted in Manning (2004), according to whom the employment of low-skilled workers is increasingly dependent on physical proximity to high-skilled workers.
2. The unemployment rate measures local labor market conditions. The expected sign of this coefficient is unknown a priori as a high unemployment rate can have divergent effects. On the one hand, when the unemployment rate is high the average level of income that can be spent on service activities is low, thereby decreasing demand for personal services (such as gardeners, house cleaners, child care). On the other hand, a high unemployment rate may promote a more intensive labor switch towards the service sector. Depending on which effect dominates, the coefficient will be positive or negative.
3. The share of manufacturing jobs is another indicator of local labor market conditions. To avoid collinearity problems, from the set of manufacturing jobs we discard those that are already included as routine in the regression. So, in the share of manufacturing jobs, we actually find only the share of non-routine jobs in the manufacturing sector. The expected sign of this variable is ambiguous. On the one hand, it controls for a composition effect. The service sector is likely to expand more slowly if there is a large share of non-routine

[30] In Autor and Dorn (2013), the authors introduce the share of seniors in a commuting zone as a control variable of a regression trying to estimate the impact of the routine employment share in the growth of service employment. They recognize that they are unable to provide an explanation for the negative and significant coefficient associated with the share of seniors, since they expected this coefficient to be positive.

[31] *Revenu de Solidarité Active*. Minimum income guaranteed to all French individuals fulfilling a given number of characteristics.

[32] By taking the value at the beginning of the 9-year period, we essentially avoid endogeneity issues. Table 6 in the web Appendix displays the estimation results obtained when the explanatory variables are defined in variation and shows the problems linked to this approach.

[33] The INSEE (National Statistical Institute) classification includes the following list of managers: engineers, managers from the public and private sector, professors, scientific occupations, administrative managers, marketing managers, journalists, and jobs in the arts and life performance.

manufacturing employment. On the other hand, it may also capture an income effect since people employed in non-routine manufacturing positions may ask for personal services.

4. The share of the active female labor force[34] constitutes another potential demand shifter. Many services, such as restaurant meals or housekeeping, serve as substitutes for household production. Hence, higher female labor force participation might be expected to raise demand for these services (see Manning (2004) or Mazzolari and Ragusa (2013)). On the other hand, many personal service jobs are implemented by women so lower female labor force participation may prevent them from providing some personal services.

All variables are computed using the French LFS except the share of old workers and the unemployment rate, which are taken from the French Institute of Statistics database (INSEE).[35]

Controlling for fixed effects (i.e. department, year and a proxy of the interacted fixed effect), columns 1 and 2 of Table 2 report the estimates on the individual impact of the proportion of seniors and the share of routine jobs on the demand for services. While the share of seniors on its own displays a non-significant positive effect, the coefficient associated with the routine variable is positive and significant. Population aging alone does not seem to have a significant effect on the demand for personal services, while, consistent with the literature, the "routinization" hypothesis displays a small but positive and significant coefficient.

Column 3 interacts both population aging and the "routinization" hypothesis. The new variable better matches Eq. (9) which accounts for the divergent effect of technological progress resulting from relationship between goods and personal services (i.e. whether they are compliments or substitutes). The estimated coefficient on this variable is positive, significant and displays a larger value than the coefficient associated with the individual variables old_{t-1} and $routine_{t-1}$.

In column 4, we add to the benchmark regression an alternative demand shifter: the share of managers in the department. By controlling for managers, we aim to capture the income inequality effect outlined in Mazzolari and Ragusa (2013) and Manning (2004). The coefficient on the main explanatory variable remains essentially unaffected by the introduction of the share of managers. The estimated coefficient associated with this variable is positive but not significant. The increase in employment share in the personal service sector does not seem to respond to the income inequality effect resulting from the increased presence of highly-paid managers in the department (this is consistent with Autor and Dorn (2013) and Goos et al. (2009)). Rather, it responds to the demand shift explained by the combined effect of technological change and aging.

Column 5 introduces two additional variables to control for local labor market conditions: the unemployment rate and the share of non-routine manufacturing employment in the department. Whereas the former is not significant, the proportion of non-routine manufacturing employment displays a positive and significant effect, which could be interpreted as an income effect.

Finally, column 6 controls for female labor force participation. This variable does not display a significant role and its inclusion does not modify the size or significance of the rest of the coefficients.

Additional robustness tests are included in a web Appendix (see http://thepthida.sopraseuth.free.fr, https://sites.google.com/site/morenogalbiseva). We report estimates for alternative regression specifications or definitions of routine occupations. We also control for the potential effect associated with the approval in July 2005 of the "Law for the development of Personal Services". Estimations from Table 2, as well as the robustness tests provided in the web Appendix, confirm that, in a context of technological progress, population aging has promoted employment growth in the personal service sector. This effect remains significant after controlling for the potential impact of other demand shifters such as the share of highly paid managers, the share of workers in non-routine manufacture tasks, and institutional changes.

6. Conclusion

Over the past years, the economic literature has faced difficulties in explaining the reasons behind the observed polarization of the labor market between "lovely and lousy" jobs. While a general consensus exists around the idea that biased technological progress is the main cause behind the progressive concentration of jobs at the top of the wage distribution, the concentration of jobs at the *bottom* of the wage distribution is more difficult to explain. Contrary to jobs at the top of the distribution, productivity of positions at the bottom of the distribution has not been improved by technological progress, so the rise in demand for this type of job is more difficult to understand. A recent explanation proposed by Autor and Dorn (2013) states that if goods and personal services are complements, the diffusion of new technologies yields a rise in demand for personal services since the relative price of goods falls.

Autor and Dorn (2013) do not to provide an explanation as to why we do not observe any polarization of the labor market before the mid-1990s, even though American technological diffusion started in the 1980s. Our paper points to population aging as the main reason behind the increased complementary relationship between goods and personal services. Using the French Household Budget Survey, we estimate the elasticity of substitution between goods and personal services for young and old households. Our estimations reveal that goods and personal services tend to be complementary for seniors and substitutable for young households. Then, if the elasticity of substitution is constant, population aging is enough to explain the reduction in the elasticity of substitution at the aggregate level.

This increased complementary relation between goods and services since the mid-1990s was associated with a reduction in the relative price of goods resulting from the automation of routine jobs. This caused an increase in demand for personal services. Using the share of seniors as a proxy for the aggregate complementary–substitutability relationship between goods and personal services, we estimated the combined impact of population aging and technological progress on the demand for personal service employment. The estimations confirm our initial guess: the combined effect of population aging and technological diffusion has increased demand for personal services and, thus, demand for labor in these positions.

Appendix A. Aggregate elasticity of substitution between goods and personal services

The aggregate demand for personal services is:

$$q_s = M_Y q_s^Y(p_s) + M_O q_s^O(p_s) \tag{14}$$

where Y and O refer to Young and Old respectively. M_X is the number of persons X and $q_s^X(p_s)$ the demand from a person of population X. From Eq. (14), we get

$$\frac{dq_s}{dp_s}\frac{p_s}{q_s} = \frac{p_s}{q_s}\left[M_Y \frac{dq_s^Y(p_s)}{dp_s} + M_O \frac{dq_s^O(p_s)}{dp_s}\right]$$

or

$$\epsilon^{aggregate} = \frac{M_Y q_s^Y}{q_s}\epsilon^{young} + \frac{M_O q_s^O}{q_s}\epsilon^{old} \quad \text{with} \quad \epsilon^X = \frac{dq_s^X}{dp_s}\frac{p_s}{q_s^X}.$$

[34] A woman is considered to belong to the active population if she is employed or actively searching for a job (unemployed). The share of the active female labor force is thus defined as the number of active women divided by the female working-age population.

[35] In the web appendix we report the descriptive statistics on the variables used for the regressions (see http://thepthida.sopraseuth.free.fr, https://sites.google.com/site/morenogalbiseva).

Table 3
Elasticity of substitution between goods and personal services (all expenditures on personal services). Budget Household Survey 2006.

	Dependent variable: demand for all personal services			
	All senior households		All young households	
	(1)	(2)	(3)	(4)
Log *y*	0.124***	0.133***	0.337***	0.332***
	(0.000929)	(0.000927)	(0.000848)	(0.000834)
Log *ps*	**−0.565****	**−0.574****	**−1.081****	**−1.095****
	(0.00170)	(0.00171)	(0.00236)	(0.00237)
Geographical dummies	Yes	No	Yes	No
Observations	2370	2370	1801	1801
R-squared	0.041	0.018	0.109	0.092
VIF	16.63	1.01	13.77	1.00

Standard errors in parentheses: ***$p < 0.01$.

Table 4
Elasticity of substitution between goods and personal services (house cleaning). Pooled sample. Budget Household Survey 2006.

	Dependent variable: Demand for house cleaning services			
	All senior and young households		All senior and young households	
	(1)	(2)	(3)	(4)
Log *y*	0.196***	0.201***	0.217***	0.222***
	(0.000632)	(0.000628)	(0.000725)	(0.000721)
Log *ps*	**−1.263****	**−1.261****	**−1.412****	**−1.417****
	(0.00139)	(0.00139)	(0.00297)	(0.00298)
Log *ps* · *senior*	**0.349****	**0.350****	**0.528****	**0.538****
	(0.000556)	(0.000556)	(0.00321)	(0.00321)
Log *y* · *senior*			−0.0353***	−0.0371***
			(0.000623)	(0.000624)
Geograph. dummies	Yes	No	Yes	No
Observations	4164	4164	4164	4164
R-squared	0.092	0.081	0.093	0.081
VIF	15.01	1.27	17.06	22.93

Standard errors in parentheses: ***$p < 0.01$.

The aggregate elasticity of substitution between goods and personal services $\epsilon^{aggregate}$ is a weighted average of the elasticities of substitution of young (ϵ^{young}) and old (ϵ^{old}) consumers. The weight of ϵ^{old} *is*

$$\frac{M_O q_s^O}{q_s} = \frac{M_O q_s^O}{M_Y q_s^Y + M_O q_s^O} = \frac{1}{\frac{M_Y q_s^Y}{M_O q_s^O} + 1}. \quad (15)$$

If, in a geographical area with a large fraction of old workers (M_O is large compared to M_Y), the weight in front of ϵ^{old} in Eq. (15) tends to be 1, then the aggregate elasticity of substitution between goods and personal services ϵ tends to be that of senior consumers ϵ^{old}.

Appendix B. Robustness tests on the estimation of the elasticity

B.1. All expenditures on personal services

For each household, we aggregate here all annual expenditures on domestic services (house cleaning, child care, shopping, domestic health care, gardening and other tasks) declared by the household as well as the aggregate number of hours worked by the personal service employees. Due to the low number of households declaring strictly positive expenditures, we are obliged to consider a composite of services and we are unable to estimate the elasticities of substitution individually for each type of personal service. To compute the hourly price paid by households for personal services, we follow the same procedure as for the cleaning services.[36] Results are reported in Table 3.

B.2. Pooled sample

In Table 1, even if our estimations reveal that the elasticity of substitution between goods and personal services is always larger for young households than for senior households, in some cases, the coefficients remain quite close. In order to test if the estimated elasticities are significantly different for young and senior households, we consider a pooled sample including all of them. First, we add an interacted term resulting from multiplying the hourly price of services and a dummy taking the unit value when considering a senior household (columns 1 and 2 of Table 4). Secondly, we introduce an interacted term resulting from multiplying the income and the dummy variable of seniors (columns 3 and 4 of Table 4). We implement both regressions in the presence and in the absence of geographical dummies. The value and significance of the estimated coefficients remains fairly similar, suggesting that collinearity is not a major problem.

In columns 1 and 2, the interacted term log *ps* · *senior* arises as positive and significant. To determine the particular elasticity associated with seniors, the coefficient of the individual variable must be added to that of the interacted variable. We find that the coefficient associated with log p_s is significant above one[37] (in absolute terms) at a significance level of 1%. When adding this coefficient to that of the interacted variable, we obtain a value below one, confirming the idea that goods and personal services are complements for seniors and must then be substitutes for young households, since the average estimated elasticity over the pooled sample is above 1.

In columns 3 and 4, we introduce two interacted terms log *ps* · *senior* and log *y* · *senior*. Again, the coefficient associated with p_s is significant above one.[38] As in columns 1 and 2, when added to the coefficient associated with log *ps* · *senior* the obtained value is below 1 implying the complementary relation between goods and personal services for seniors. The coefficient associated with the income variable arises as positive and significant. However, when interacted with the senior dummy, the interacted term displays a negative and significant coefficient, suggesting that, for seniors, the demand for services is relatively less dependent on the level of income with respect to the pooled sample (probably because for many seniors there is a need for personal services). In spite of the stability of the value and significance of the coefficients between columns 3 and 4, note that the introduction of the interacted term log *y* · *senior* induces a multicollinearity problem that does not disappear even when we eliminate the geographical variables.[39]

Appendix C. Definition of jobs

Farmers, civil servants, the military and clergymen are excluded. All jobs related to these categories are dropped from the sample.

Some occupations are characterized by high employment and a vague definition. Following Goos and Manning (2007), each of the following jobs is defined as the specific occupation in a particular industry (15 sectoral activities): secretary; clerks in financial departments and

[36] First, since we deal with yearly expenditures, in order to compute the hourly cost we are obliged to assume that the number of hours worked by the personal service employee in one year is six times the number of hours worked in two months. Secondly, to deal with the problem of missing data in the number of hours, we compute the average number of hours hired by different categories of household classified according to their yearly expenditure. This average number of hours is then imputed to the households of the corresponding spending category if the number of hours is missing. Finally, to compute the hourly price paid by households for personal services, we divide yearly expenditure by yearly hours (declared or imputed). We drop observations associated with extreme observations.

[37] Actually −1 does not belong to the confidence interval associated with −1.263 or −1.261 which confirms that the coefficient is significantly above 1 in absolute terms.

[38] Again, −1 does not belong to the confidence interval associated with −1.412 or −1.417.

[39] Since the samples are different, and constant terms differ between estimations in columns 3–4 of Table 4 and estimations in Table 1, the estimated coefficients from Table 4 will necessarily be different from those in Table 1.

Table 5
Change in log employment ($d\ln N$) over 1993–2010 for occupations ranked by their median 1993 wage ($\ln W_{1993}$).

	$\ln W_{1993}$	$d\ln N$
(a) Top paying jobs		
Flying personal	10.13204	.0465518
Managers in big firms, administrative, financial or sale department	10.006	−.006904
Technical managers in big firms	9.954719	.0624228
Engineer and executive managers	9.87817	.2712399
(b) Middling occupations		
Office clerk in accounting and financial department, transportation industry	8.834143	−.0116572
Office clerk in accounting and financial department, food industry	8.836745	.0167217
Office clerks, misc, intermediate good industry	8.838068	−.00573
Skilled worker in weather-stripping	8.839276	−.0208104
Skilled worker in extraction	8.839276	−.1188045
Secretaries, engineering industry	8.839276	−.0439425
Unskilled worker in sorting, wrapping and delivery activities, engineering industry	8.844096	−.0244403
Secretaries, car industry	8.847156	−.0353632
Secretaries, food industry	8.853665	−.0379203
(c) Lowest paying jobs		
Cleaners, financial industry	7.699993	−.1208007
Transportation services in health industry	7.740664	.0678637
Cleaners, consumption goods industry	7.775527	−.0386493
Housework employees in private homes	7.783224	.0086223
Child care	7.824046	.0827386
(d)		
Top 10%	9.618954	.0466335
Middling occupation (45–55%)	8.827257	−.0040566
Bottom 10%	8.074184	.0277598
Service occupations	8.30726	.0376211

accounting; cleaners; clerks in various departments; unskilled workers in mechanical works, monitoring and assembly line; courier, messenger; warehouseman, unskilled workers in shipping and transportation; unskilled worker in sorting, wrapping and delivery activities; drivers; executive workers in small firms in finance or administration; storekeeper.

The 15 sectors are: Food industry; Consumption Goods; Car industry; Engineering industry; Intermediate goods; Energy; Construction; Trade and repairing; Transportation; Financial activities; Real estate; Services to firms; Services to private individuals; Education, health, social services; and Administration.

Some jobs may have disappeared, while new ones are emerging. The French LFS modified the job classification in 2003 in order to take into account the changes in occupations. We paid attention to having a consistent definition of jobs throughout the 18 years of our sample. There are no new occupations that cannot be included in the pre-2003 classification.

Appendix D. Descriptive statistics on job polarization

Table 5 ranks occupations from highest-paid to lowest-paid. For each occupation, Table 5 presents the average log change in employment and wages. Among the fastest expanding occupations (panel (a) of Table 5) are managers and executives but also the lowest-paid jobs (panel (c)) such as child care and transportation services. The biggest declines in employment (panel (b)) are observed for middling occupations such as secretaries, office clerks and some skilled workers in specific industries. Panel (d) of Table 5 presents the average change in log employment over 1993–2010 for the top 10% jobs (ranked by the median 1993 wage), bottom 10% and middling jobs (identified as jobs in the 45–55% percentiles of the 1993 wage distribution). The table confirms the fast employment growth at the top and bottom of the job quality ladder while middling occupations have been characterized by a decline in employment. Furthermore, most of the employment growth observed at the bottom of the wage distribution comes from service occupation jobs.

Appendix E. Data for regressions

In the sample survey, 96 departments are considered. In all regressions, departments are weighted by their total population. Jobs included in service occupations are: waiter/ waitress; hotel staff; receptionist; accompanying services; janitor; cleaner in services for private individuals; gardener; cleaner and staff in private homes; child care, family worker; auxiliary nurse; workers in hospitals; ambulance driver; manicure, beautician (employee); hairdresser (employee); manicure, beautician, hairdresser (self-employed); worker in various services to private individuals.

For want of an accurate description of the tasks involved in each job, we choose among the list of 452 occupations a set of jobs considered as "routine". In order to establish this list, we look at routine jobs identified in Autor and Dorn (2013) and Spitz-Oener (2006). The following occupations are considered as "routine jobs": typist, keyboarder; operator on computer; office clerk in accounting and financial department in all industries; office clerk in misc. departments in all industries; unskilled workers in mechanics; unskilled workers in extraction; unskilled workers in wrapping, delivery. We check that these jobs are characterized by a 1993 median range that lies in the middle of the 1993 wage distribution (40–60% range).

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