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A NEW ESTIMATE OF DISCOURAGED AND ADDITIONAL WORKER EFFECTS ON LABOR PARTICIPATION BY SEX AND AGE IN OECD COUNTRIES*

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Abstract

This article proposes a new approach to estimate the effect of the unemployment rate on the labor participation ratio by sex and age. OECD labor participation ratios are estimated within an unobservable component model with the Kalman filter. This allows for treating the trend of the participation rate as a stochastic time varying parameter. This improves the quality of the econometric results by allowing for a better identification of changes in the trend than the most common alternatives using determinist and logistic trends. Moreover the use of cross-section OECD circumvents the problem of the lack of long time series data. We find that OECD labor participation ratio are sensitive to the labor market situation in all sex and age categories and that the discouraged worker effect dominates the additional worker effect although the latter is clearly present for women.

Keywords: labor force participation; unemployment; flexion effects; additional/discouraged worker effect; OECD; cross-section estimation; Kalman filter

JEL code : J21, C13, C31, C32

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1. Introduction

The aging population raises problems of sustainability of social (health care and pension) systems in most OECD countries because of the increase of the dependence ratio, *i.e.* the ratio between inactive and active people. A correct quantification of these sustainability issues crucially relies on the accuracy of labor force projections and hence on the estimation of the labor force participation ratio by sex and age.

The participation ratio can generally be decomposed into a trend and a cyclical component. The trend component captures all the structural determinants that affect the choice to take part in the labor force. These may reflect cultural changes such as the women emancipation or the willingness to increase the educational level of young people. They may also reflect structural reforms on the labor market such as the elevation of the retirement age or the changes in the characteristics (such as eligibility conditions, payment rates, tax treatment, benefit duration, etc.) of various social programs including unemployment insurance and assistance, social assistance, employment-conditional benefits, family benefits, childcare support, and support for sole parent households, etc.

Since the seminal work of Dernburg and Strand (1966) and Strand and Dernburg (1964), several studies have observed that the labor force participation follows a cyclical pattern related to the situation on the labor market. In the event of the slowdown of the economic activity and thus of the increase in the unemployment rate, two opposite effects may appear. The "discouraged worker" effect arises because some potential workers become discouraged. They renounce finding a job and they leave the labor force because they estimate their chances of finding one as too small. Symmetrically, in periods of recovery, some inactive people decide to look for a job because they see their hiring prospects as improved. The "additional worker" effect on the contrary brings additional worker when the unemployment increases because the household's "secondary" workers enter the labor force under the pressure of the loss of work by the "primary" worker. We refer to the combination of these two phenomena as "flexion" of the labor force participation ratio.

Since the middle of the 1960s, relatively few empirical studies have tried to quantify these flexion effects. The first econometric studies conducted on American data by Dernburg and

Strand (1966) and Strand and Dernburg (1964) show that the discouraged worker effect is stronger than the additional worker effect: at the macroeconomic level, the labor force participation increases – respectively drops – when the unemployment rate drops – respectively increases. Using French data, Salais (1971) and Bloch et al. (1986) reach the same conclusion. Noticing that the unemployment rate has substantially increased in the 1980's and 1990's relatively to the 1960's and 1970's, Jacquot (1997) investigates if flexion phenomena can have long lasting effects. Using an Error Correction Model (ECM), he concludes that a permanent increase of the French unemployment rate leads to a permanent reduction of the labor participation ratio. Again on French data, Chauvin and Plane (2001) estimate participation ratio equations for each sex and age class. The labor participation ratio is specified as a function of the unemployment rate but also of share of early retirement schemes and of the percentage of women working part-time. These authors also introduce a more realistic logistic trend than the linear trend used by Jacquot (1997), to account for the unexplained variation of the participation rate. This study finds that flexion effects mainly concern the youngest and oldest age groups. This is consistent with the fact that these groups are particularly sensitive to labor market integration issues which entice young people to study longer and elderly workers to use early retirement pension schemes when the situation on the labor market deteriorates.

Using a more microeconomic approach, a literature focuses on the additional worker effect using the framework of labor market transition proposed by Hansen (1961). Some studies test if the probability of transition of women into the labor force is correlated to the probability that her husband is unemployed while controlling for various other explanatory variables: e.g. Lundberg (1985) or Maloney (1991). Others focus on the link between the flow in or out the labor force (mainly women) and the stock of unemployed people (mainly men): e.g. Tano (1993). Most of these studies conclude to a small but significant additional worker effect for women whereas Maloney (1991) reaches the conclusion of no effect.

The relatively small number of empirical evaluations of flexion phenomena using time series of participation ratio has several explanations. An important one is the data limitation. In many countries labor force data are only available on an annual basis, often for a short period of time and not always consistent over time and across age and sex groups. Second, measuring the trend of the participation ratio brings technical difficulties. Reflecting an amalgam of heterogeneous structural effects, this trend accounts for phenomena that are not directly observable or at least extremely difficult to relate statistically to time series data. In the literature, the trend is generally modeled deterministically as a linear or a logistic function of time. The determinist trend is easy to estimate but is not very realistic since it is in contradiction with the fact that the participation rate has an upper and a lower bound: it cannot go below 0 or above 100%. Such a trend is thus inconsistent for participation rate projections. The logistic trend is theoretically preferable since it allows for the estimation of an upper and a lower bound. However, it has the disadvantage of being difficult to estimate because of its nonlinearity and its use is often limited by the shortness of the available annual data sample. Moreover, a logistic trend varies monotonously either upward or downward and thus rules out the possibility that the trend of the participation ratio fluctuates over time.

To provide consistent labor force projection, it is essential to accurately measure the effects of the unemployment rate variations on the participation rate. Moreover it is important to compute different estimations for various categories of individuals in order to account for the heterogeneity in labor participation behavior in particular according to the age and sex group. The present research proposes a new method to estimate the labor participation ratio by sex and age that improves existing approach in two directions. First, we extend the number of observations by using for each social group cross-section data including 12 OECD countries. Second, we specify the trend of the labor participation rate as a stochastic time varying parameter that we estimate simultaneously with the flexion effect within a space-state model using the Kalman filter[1]. This specification has the advantage of providing an estimation of the trend of the participation ratio that is empirically more consistent and of improving the accuracy of the estimation of flexion effects. It has recently been used by one of the co-author on aggregate Euro Zone data (Lemoine et al., 2010). The present study extends the methodology to time series cross-section data by sex and age.

Section 2 describes the data used for the empirical evolution. Section 3 presents the model and the econometric approach used. Section 4 presents the results whereas Section 5 concludes.

[1] In the recent years, this econometric method has been widely used for the estimation of the Time-Varying NAIRU introduced by Gordon (1997) (for a survey see Heyer et al., 2007).

2. Data description and statistical properties

For this study, the labor force participation and unemployment rates were calculated from *OECD Labor force Statistics* available on www.oecd.org. Due to data availability and consistency issues, we discarded certain OECD countries in particular small and East-European countries. At the end, we retain a panel of 12 countries (sample between squared brackets): Belgium (BE) [1983-2006], Canada (CA) [1976-2006], Denmark (DK) [1983-2006], Finland (FI) [1963-2006], France (FR) [1968-2006], Germany (GE) [1970-2006], Italy (IT) [1978-2006], Japan (JP) [1968-2006], Netherlands (NL) [1972-2006], Spain (SP) [1972-2006], United Kingdom (UK) [1984-2006], United States (US) [1960-2006]. For each sex, there are six age categories: 15-19, 20-24, 25-54, 55-59, 60-64 and older than 65 (65+).

For each country, data are not fully consistent over time due to the changes in survey methodology and definition that are detailed in OECD (2009). In most cases, these modifications are unlikely to affect our statistical analysis because they do not generate apparent breaks in the data. On the contrary, a clear break appears for the German reunification in 1991, the modifications of the Italian survey in 1983 and the introduction of the continuous labor force survey in the Netherlands in 1987. Introducing dummies variables in the econometric analysis, we controlled if these breaks affect our statistical results.

Moreover, Japanese data before 1968 and Italian data before 1978 were discarded because of data inconsistency. In the first case, people older than 55 years old are included in the 25-54 labor force. In the second one, there are unexplainable variations for most groups in 1977 that are not present in the data from other source such as the Bureau of Labor Statistics. Finally, the Netherlands are excluded from the econometric estimation involving the group age 65+ because the participation rate of people older than 65 is not available.

Cross section unit root tests[2] support the hypothesis that the unemployment rate and the labor participation ratio series are non stationary. Under the hypothesis of the independence of the individuals of the panel, the Levin, Lin and Chu (LLC), Breitung, Fisher Phillips Perron (F-PP), Im, Pesaran et Shin (IPS), Fisher Augmented Dickey Fuller (F-ADF) and the Hadri tests

[2] For a description of panel unit root tests see Hurlin and Mignon (2007).

generally conclude that the unemployment rate and the labor participation ratio are integrated of order 1 at a 5% risk (shaded boxes in Table 1).

Table 1. Unit roots test

	LLC	BREITUNG	IPS	F-ADF	F-PP	HADRI
PR_W_15_19						
PR_W_20_24						
PR_W_25_54						
PR_W_55_59						
PR_W_60_64						
PR_W_65+						
PR_M_15_19						
PR_M_20_24						
PR_M_25_54						
PR_M_55_59						
PR_M_60_64						
PR_M_65+						
U						

Key: Shaded boxes correspond to the case where the null hypothesis of unit root is not rejected for a risk of 5% (with constant and linear trend for the participation ratio; with constant and no trend for the unemployment rate). PR: labor participation ratio, U: unemployment rate, W: women, M: men. LLC: Levin, Lin and Chu, F-PP: Fisher Phillips Perron, IPS: Im, Pesaran and Shin, F-ADF: Fisher Augmented Dickey Fuller.

3. Model and estimation procedure

We assume that the evolution of the labor participation ratio can be decomposed between the evolutions of its trend and of the unemployment rate (flexion effect) according to the following space-state model:

$$PR_{i,t} = trend_{i,t} + \beta_i U_{i,t} + \eta_{i,t} \qquad \forall (i,t) \in [1, N_g] \times [1, T_i] \qquad (1)$$

$$trend_{i,t+1} = trend_{i,t} + \varepsilon_{i,t} \qquad \forall (i,t) \in [1, N_g] \times [1, T_i] \qquad (2)$$

$$\begin{pmatrix} \eta_{i,t} \\ \varepsilon_{i,t} \end{pmatrix} \rightarrow N.I.D\left(0, \begin{pmatrix} V_{i,t} & C_{i,t} \\ C_{i,t} & \rho V_{i,t} \end{pmatrix}\right) \qquad (3)$$

Where $i \in [1, N]$ is the country index, $t \in [1, T_i]$ the time index, *PR* is the labor force participation ratio, *U* the unemployment rate, *trend* a stochastic temporal trend, η the residual of the measurement equation (or signal), *V* its variance, *ε* the residual of the state equation (or noise), *ρ* the signal-to-noise ratio (SNR) and *C* the covariance between *η* and *ε*.

The measurement Equation (1) is the equation of the participation ratio whereas the state Equation (2) describes the motion of the trend as a random walk. Equation (3) assumes that the residuals are Normally and Independently Distributed (N.I.D). This model can be estimated with a random coefficient (or time-varying parameter, unobservable component) econometric method such as the Kalman filter approach[3]. The higher the SNR, the higher the stochastic variation of the trend. In theory, the SNR can be estimated by the Kalman filter, but in practice the results may be disappointing. In some cases, the maximum likelihood estimation does not converge. In others, it leads to a very low value and thus to an unwanted "constant time-varying" parameter described as a "pile-up problem" by Stock and Watson (1998). Here the results would become identical to the use of a simple linear trend estimated with the Ordinary Least Square (OLS) estimator. Lastly, the estimated SNR is so high that the variation of the trend captures all the variance of the participation ratio. In all these cases, the SNR has to be constrained in accordance with a smoothness criterion, which requires that the trend be relatively smooth in order to be consistent with a long-term concept. Then a sensitivity analysis can be performed in order to evaluate how the estimated parameters are sensitive to a change in the value of the SNR.

Because of the non stationarity of the data, we expect that Equation (1) can be interpreted as a cointegration relation between the unemployment rate, the participation ratio and its trend and that the short-term adjustment process can be written as an Error Correction Model (ECM):

$$\Delta PR^{*}_{i,t} = \alpha_i \Delta PR^{*}_{i,t-1} + \gamma_i \Delta U_{i,t} + \mu_i .(PR^{*}_{i,t-1} - \beta_i U_{i,t-1}) + \upsilon_{i,t} \quad (4)$$

Where $PR^{*}_{i,t} = PR_{i,t} - trend_{i,t}$ is the gap between the participation ratio and its trend, υ a N.I.D residual.

The estimation procedure was conducted in 4 steps:

1. For comparison purposes and to test the validity of the estimation on cross-section data, we first estimated Equation (1) with the OLS estimator assuming a determinist trend. We added the dummy variables described above. Applying the Hsiao's homogeneity test (see Appendix 1), we first tested if the use of cross-section data is validated by the data. In particular, we tested if the assumption of a common flexion effect (*β*) across countries is

[3] See Durbin and Koopman (2001) for an exhaustive presentation of these econometric models and techniques.

acceptable. The test rejects the hypotheses of a homogenous panel for the women in the 15-19, 20-24 and 25-54 age categories and for men between 15-19 years old. Examining the flexion effect heterogeneity across individuals for the categories that were found heterogeneous (women in the 15-19, 20-24 and 25-54 age categories and men between 15-19 years old), it appears that the panel could be divided into two homogenous groups[4]. Group 1 is constituted of continental Europe and Latin countries plus Japan (BE, ES, FR, GE, IT, JP) and is characterized by relatively low flexion effects. Group 2 is constituted of Anglo-Saxon and Scandinavian countries (CA DK FI FR UK US) and is characterized by relatively high flexion effects. For these two groups, the Hsiao's homogeneity test accepts the homogeneity of the panel for nearly every age and sex category (see Appendix 1). In order to ease the presentation of the results, we retain these two groups for all sex and age categories (even those that appeared homogenous in the complete panel).

2. Consistent with the non-stationarity of the data, we tested with the Pedroni test the existence of cointegration relation between the variables. Although the different variants of the Pedroni test provides slightly divergent results, the hypotheses of cointegration relation between the participation ratio and the unemployment rate is often rejected (see details in Appendix 2). This implies that one cannot exclude that the OLS estimation of Equation (1) is a spurious regression.
3. We estimated model (1) to (3) using the Kalman filter. As the estimation of the SNR does not provide consistent results, we calibrated it at 30%. We chose this level because it provides the most stable estimation of flexion effects across country groups and sex and age categories. For each country group and each sex and age category, we estimated the model with different SNR level: 10%, 20%, 30%, …, 90%, 100%. For each SNR and each category, we get the estimation of the flexion effect (β). On average, the level of 30% appears as a local optimum for the maximum likelihood estimator that provides the smallest deviation from the median estimation of the flexion effect. In other words, computing the gap between the flexion effect of a given SNR and the median estimated flexion effect of the category and summing all categories for each SNR level, the sum computed with the 30% SNR is the smallest (see Appendix 3).

[4] To avoid ambiguity and repetitions, "group" refers to the countries groups whereas "category" refers to the sex and age categories.

4. The use of the Kalman filter approach implies by construction a cointegration relation between the unemployment rate (*U*) and the gap between the participation ratio and its trend (*PR**). This is confirmed by the results of the cointegration tests (see Appendix 4), and it is therefore valid to estimate the short run dynamic according to the ECM (4).

4. Results

All the econometric estimations were programmed and performed with the E-views 7 software. The data used and programs used are available upon request. The results of the Kalman filter estimation of Step 3 are presented in Table 2. The dummy variables are not included in the estimation since we expected that the time varying trend account for the various breaks in the data. This seems correct since the inclusion of the dummies variables affects only marginally the estimation of flexion effects.

Except for the 65+ category, the adjusted R^2 are relatively high for a long-term relation: between 0.2 and 0.88. The low R^2 for the 65+ category is not surprising given that its participation ratio is very low and often erratic. We suspect data inconsistency because of the very exceptional character of this population: during the period under study, people above 65 rarely worked and therefore were not exhaustively accounted for in national labor force surveys. For the sake of exhaustivity, we report the econometric results for this category but they should be interpreted with caution.

For every category, we find a statistically significant sensibility of the labor participation ratio to the labor market situation. In general, the discouraged-worker effect dominates the additional worker effect: an increase in the unemployment rate decreases the labor participation ratio. Women between 25-54 living in Latin and European continental countries or in Japan (Group 1) are the only exception. A one point-increase in the unemployment rate leads to a 0.45 point-increase in their labor participation rate, suggesting that the additional worker effect is stronger than the discouraged-worker effect. To the best of our knowledge, this result has never been highlighted in previous studies working on aggregate data. It confirms the results found previously by certain microeconomic studies. The socio-cultural status of women seems a reasonable explanation. The “traditional” housewife role of women is typically more present in these countries during the period under study than in Anglo-Saxon and Scandinavian countries that were generally pioneers in the movement of women emancipation. Our result suggests that this traditional conception of the family where only the man works is not sustainable in period of economic crises: the woman has to look for a job to compensate the loss of the job of her partner. But when the economic situation improves, the dominant conception of the division of tasks within the households dominates and many women choose to quiet working. Of course, further studies in particular sociologic ones should be considered to fully validate this hypothesis. But the latter is supported by the OECD labor force data. The average difference over the 1984-2006 period between men and women participation ratios is respectively 6 and 8 percentage points in Finland and Denmark while it exceeds 30 points in Spain, Italy and Japan. France from Group 1 and the United Kingdom and the United States from Group 2 are on the same intermediary position with a difference around 18 points.

Table 2. Labor participation ratio estimation by sex and age

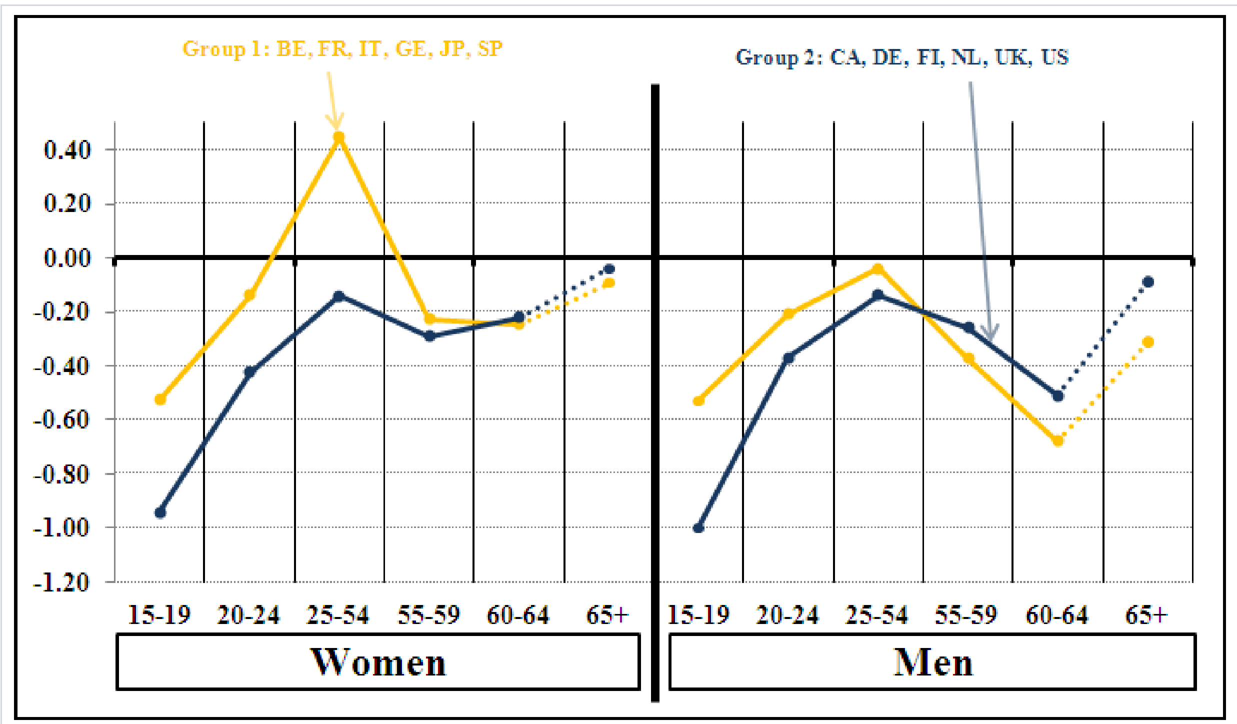
Group 1: BE, FR, IT, GE, JP, SP													
	Women						**Men**						
	15-19	**20-24**	**25-54**	**55-59**	**60-64**	**65+(*)**	**15-19**	**20-24**	**25-54**	**55-59**	**60-64**	**65+(*)**	
U	**-0.53** (-74)	**-0.14** (-17)	**0.45** (76)	**-0.23** (-37)	**-0.24** (-50)	**-0.09** (-46)	**-0.53** (-70)	**-0.21** (-32)	**-0.04** (-15)	**-0.37** (-53)	**-0.68** (-71)	**-0.31** (-61)	*β*
R^2 *adj*	0.88	0.26	0.88	0.65	0.77	0.75	0.87	0.57	0.23	0.80	0.88	0.84	
SNR	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	
N	204	204	204	198	204	204	204	204	204	198	204	204	
Group 2: CA, DE, FI, NL, UK, US													
	Women						**Men**						
	15-19	**20-24**	**25-54**	**55-59**	**60-64**	**65+(*)**	**15-19**	**20-24**	**25-54**	**55-59**	**60-64**	**65+(*)**	
U	**-0.94** (-61)	**-0.42** (-41)	**-0.14** (-22)	**-0.29** (-20)	**-0.22** (-17)	**-0.04** (-10)	**-1.00** (-66)	**-0.37** (-36)	**-0.14** (-45)	**-0.26** (-24)	**-0.51** (-36)	**-0.09** (-12)	*β*
R^2 *adj*	0.78	0.65	0.40	0.27	0.22	0.10	0.79	0.57	0.63	0.31	0.51	0.10	
SNR	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	30%	
N	135	135	138	138	138	115	135	135	138	138	138	115	

Note: When negatively-signed, the discouraged-worker effect is stronger the additional worker one. Student statistics between brackets. (*) Due to data unavailability, the Netherlands are excluded from the 65+ age category.

Figure 1 reproduces the flexion effects of Table 2 by sex and age. Leaving out the 65+ category, flexion effects across age tend to have a bell-shaped form. In absolute value, the discouraged worker effect is stronger for the young and old categories (15-24 and 55-64) than for the prime and middle age category (25-54). This result is not surprising since young and old people are the categories that suffer the most from discrimination on the labor market while they generally have more alternative than the prime and middle age population to avoid working when the situation on the labor market is unfavorable. Young people can prolong their studies whereas old workers can benefit in many countries from early retirement pension schemes. On the contrary, people in the 25-54 age category have little social support allowing them for leaving the labor force. Leaving the labor force also generally implies the loss of unemployment benefits. In the prime and middle age category, flexion effects are lower (in absolute value) for men than women. This suggests that the pressure to remain active is stronger for men. This is consistent with his traditional role of primary worker of the family. Not surprisingly this effect is stronger in Japan and Latin and European continental countries reflecting a more paternalistic conception of the family.

As mentioned previously, the flexion effect is the highest in absolute term for young people (15-24 years) and more particularly for the youngest men (15-19). Strikingly, this result is quite homogenous across the two countries groups for women and men. A one point increase in the unemployment rate induces a 0.53 point decrease of the participation ratio for women and approximately a one point decrease for men. This result reflects the fact that young people are the ones having the most difficulties of integration in the labor market and that they can generally count on the support of their family if they cannot find a job. These tend to discourage them from looking for a job when the situation on labor market degrades. The discrimination problem of young people on the labor market is recurrently pointed out by empirical and theoretical labor economics researches. They have a deficit of human capital which induces them to delay their entry into the labor force by prolonging their studies (see Kodde, 1988 for a theoretical and empirical analysis). Moreover, they are likely to suffer the most from their position of outsiders (Lindbeck and Snower, 1988). Since the less qualified people are the most affected by unemployment, it is rational for young people to withdraw from the labor force and to get additional training in period of crisis when they have little chances to get a job. The parental and governmental economic supports to students also delay the emergency of finding a job. Moreover, by improving their human capital, they increase their chances of finding a better job during the economic recovery.

Figure 1. Flexion effects by sex and age



Note: The dashed line for the 65+ category reflects that this result should be seen as indicative given the poor quality of the data.

As for young people, but to a lesser extent, flexion effects are higher for the seniors (55-64) than for the prime and middle age category (25-54). Here as well, the segmentation of the labor market through discrimination against the elderly is likely to explain why older workers get discouraged to look for a job during recessions. The fact that the wage increases with seniority and that employers often perceive the productivity of elderly as lower than younger employees increases the difficulties of finding a job for the 55-64 population. Moreover, in many countries, the creation of early pension schemes and the introduction of special clauses in the unemployment benefit legislation (such as the exemption of job search for people above a certain age) give an incentive to leave the labor force in period of crises (see e.g. Blöndal and Scarpetta, 1997). From one country group to another, flexion effects for the 55-59 and 60-64 categories are very close although one can observe a small gap in the case of men.

Reiterating our reserves about the quality of the data for the 65+ category (and thus using dashed lines in Figure 1), the flexion effects for this age category is small but statistically significant. Strikingly, the gap between country groups for men and women in the 65+ category is the same as the gap in the 55-64 category.

We now compare the two groups of countries. For the age categories between 15 and 54 and for both sex, flexion effects are more negative in Anglo-Saxon and Nordic countries (Group 2) than in the Group 1 countries (Latin, European continental countries and Japan). This suggests that discouraged worker effects are stronger than additional worker effects in Group 2 relatively to Group 1. This is consistent with the more paternalistic conception of the family in Group 1 countries. Moreover, we see that the gap between the two groups tends to decrease with age especially for men (for which the curves even cross in Figure 1). This suggests that the additional worker effect becomes relatively stronger with age in Group 1 compared to Group 2. Detailed investigations comparing the labor and retirement legislations between countries would be helpful to fully understand this phenomenon (for a comparison of retirement systems in OECD countries see Cornilleau et al., 2008).

We now present the result of Step 4. Whereas the Pedroni's cointegration test was previously rejected (see Appendix 2), it is now validated when we use a stochastic trend (see Appendix 4). The risk of spurious regressions is now avoided and it is justified to estimate the adjustment dynamic as an ECM (Table 3). The coefficient μ of the effect of the gap between the participation ratio and its long term value is negative and highly significant (t-Student always above 10 in absolute value) which is another support of the existence of a cointegration relation between the variables. Considering all groups and categories, the absolute value of μ is between 0.59 and 1.11. In all cases, the short term flexion effect (γ) is concordant with the one found previously in the long term relation (β): the sign and the importance of the correlation between the variation of the unemployment rate and the variation of the participation ratio is similar to the link we found in level (compare the coefficient γ in Table 3 with the coefficient β in Table 2).

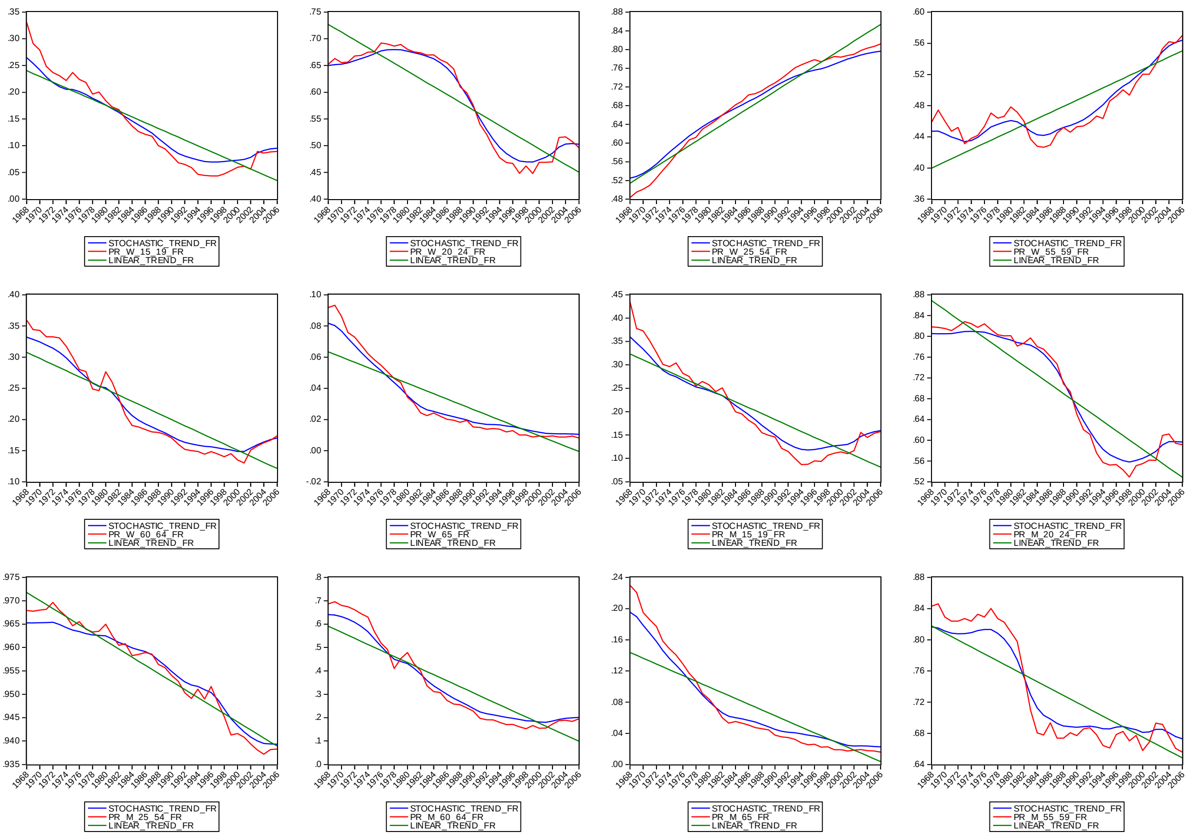
Table 3. Adjustment dynamic of the labor participation ratio by sex and age

Group 1: BE, FR, IT, GE, JP, SP													
	Women						Men						
	15-19	20-24	25-54	55-59	60-64	65+(*)	15-19	20-24	25-54	55-59	60-64	65+(*)	
ΔPR^*_{t-1}	**-0.27**	**-0.46**	**-0.29**	**-0.45**	**-0.42**	**-0.47**	**-0.30**	**-0.45**	**-0.50**	**-0.35**	**-0.37**	**-0.43**	α
	(-4.8)	(-8.6)	(-5.4)	(-8.7)	(-8)	(-11.1)	(-5.6)	(-8.9)	(-13.5)	(-5.5)	(-6.7)	(-9.2)	
ΔU	**-0.42**	**-0.14**	0.40	**-0.18**	**-0.27**	**-0.10**	**-0.50**	**-0.27**	**-0.04**	**-0.40**	**-0.76**	**-0.31**	γ
	(-7.3)	(-2.1)	(9)	(-3.9)	(-7.4)	(-6.4)	(-8.3)	(-5.1)	(-1.7)	(-6.5)	(-9)	(-7.7)	
μ	**-0.69**	**-0.85**	**-0.59**	**-0.75**	**-0.85**	**-1.09**	**-0.76**	**-0.80**	**-1.04**	**-0.74**	**-0.74**	**-1.11**	μ
	(-10.7)	(-13.7)	(-10.3)	(-13.7)	(-14.3)	(-17.9)	(-11.4)	(-13.5)	(-20.1)	(-10.7)	(-11.5)	(-16.6)	
R^2 *adj*	0.44	0.52	0.45	0.53	0.54	0.67	0.47	0.54	0.74	0.41	0.48	0.63	

Group 2: CA, DE, FI, NL, UK, US													
	Women						Men						
	15-19	20-24	25-54	55-59	60-64	65+(*)	15-19	20-24	25-54	55-59	60-64	65+(*)	
ΔPR^*_{t-1}	**-0.36**	**-0.39**	**-0.40**	**-0.36**	**-0.46**	**-0.51**	**-0.37**	**-0.49**	**-0.42**	**-0.44**	**-0.41**	**-0.49**	α
	(-7.4)	(-5.7)	(-6.3)	(-5.3)	(-9.0)	(-9.4)	(-8.0)	(-9.7)	(-6.8)	(-8.1)	(-8.4)	(-8.4)	
ΔU	**-1.19**	**-0.71**	**-0.22**	**-0.41**	**-0.24**	**-0.08**	**-1.23**	**-0.58**	**-0.17**	**-0.35**	**-0.66**	**-0.12**	γ
	(-11.6)	(-10.4)	(-5.5)	(-4.7)	(-3.5)	(-4.2)	(-12.4)	(-9.5)	(-8.5)	(-5.5)	(-8.0)	(-2.8)	
μ	**-0.98**	**-0.96**	**-0.79**	**-0.71**	**-0.90**	**-1.07**	**-0.95**	**-1.04**	**-0.93**	**-0.78**	**-0.93**	**-0.96**	μ
	(-12.6)	(-12.3)	(-10.2)	(-9.8)	(-14.1)	(-15.3)	(-12.8)	(-15.4)	(-11.8)	(-11.3)	(-13.7)	(-12.8)	
R^2 *adj*	0.69	0.61	0.50	0.46	0.66	0.71	0.70	0.72	0.57	0.61	0.70	0.65	

Not only the Kalman filter estimation improves the quality of the econometric regression in particular the quality of the cointegration relation, the use of a stochastic trend provides a more realistic estimation of the trend. As an illustration, Figure 2 compares the estimated linear and stochastic trends in the case of France, but the use of another country would provide a similar diagnostic. The linear trend has the big disadvantage to be constant over the all estimation period which is generally inconsistent with the data. This is particularly striking in the cases where the trend in the labor participation ratio inverts over time (for instance young people in France). The use of such a trend to compute labor data projection would provide quite unrealistic forecasts. On the contrary, the stochastic trend seems to capture the variability of the trend over time without ruling out the cyclical effect. In many cases, the inclusion of a stochastic trend is likely to provide more consistent results than the logistic trend which imposes a high and low level for the trend of the participation ratio. The stochastic trend is capable to capture several breaks in the trend. For instance the trend for the French women in the 20-24 category increases from 1968 to 1978 under the influence of women emancipation. Then it decreases until 1998 as does the series for men of the same age. This evolution is consistent with the implementation of various educational policies aiming to increase the educational level of the population in particular the official objective that 80% of the young age category gets an A-level education. After 1998, the trend goes up again.

Figure 2. Linear versus stochastic trends and participation ratios for France



5. Conclusion

The main objective of this study was to propose a new method to estimate the labor participation ratio by sex and age that improves existing approaches by increasing the number of observations through the use of cross-section data and by specifying the trend of the labor participation ratio as a stochastic time varying parameter. The extension of the data base allowed for improving the quality of the estimation. The use of a stochastic trend is theoretically preferable and provides results that are more consistent with the trend path of the observed participation ratio. It also improves the econometric results by validating the hypothesis of cointegration that was most of the time rejected when using a deterministic approach.

Economic results are also very interesting. They are consistent with previous studies while improving their robustness through the use of cross-section data. Flexion effects primarily affect young people, and to a lesser extent workers above 55. Dividing the data in two groups of countries allowed us for showing a result that had never been highlighted before: the additional worker effect dominates the discouraged worker effect for prime and middle age women (25-54) in Latin and continental Europe countries and Japan.

A possible extension to this study would be to account for additional explanatory variables that could help to explain the variation of the trend in the participation ratio such as the share of early retirement schemes or the share of women working part-time. Chauvin and Plane (2001) have shown that these data are important to explain the French labor participation of the 55-59 age category and of women.

Appendix 1. Hsiao homogeneity tests

For a panel of N_g countries we estimate:

$$\Delta PR_{i,t} = f + \beta \Delta U_{i,t} + dummies + \delta_{i,t} \qquad \forall (i,t) \in [1, N_g] \times [1, T_i] \tag{5}$$

For each country i, we estimate:

$$\Delta PR_{i,t} = f_i + \beta_i \Delta U_{i,t} + dummies + \eta_{i,t} \qquad \forall (i,t) \in [1, N_g] \times [1, T_i] \tag{6}$$

We test successively three hypotheses:

- $H_0 : \beta_i = \beta \text{ and } f_i = f, \ \forall i \in [1, N_g]$
- $H_0 : \beta_i = \beta, \ \forall i \in [1, N_g]$
- $H_0 : f_i = f, \ \forall i \in [1, N_g], with\ \beta_i = \beta, \ \forall i \in [1, N_g]$

Hsiao tests - P.value (BE, FR, IT, GE, JP, SP, CA, DE, FI, NL, UK, US)

	Women						Men					
	15-19	20-24	25-54	55-59	60-64	65+ (*)	15-19	20-24	25-54	55-59	60-64	65+ (*)
$H_o : f, \beta = f_i, \beta_i$	<0.01	<0.01	<0.01	0.19	0.06	0.47	<0.01	0.79	0.26	0.38	0.43	0.78
$H_o : f_i, \beta = f_i, \beta_i$	0.02	<0.01	<0.01				<0.01					

Hsiao tests - P.value (BE, FR, IT, GE, JP, SP)

	Women						Men					
	15-19	20-24	25-54	55-59	60-64	65+	15-19	20-24	25-54	55-59	60-64	65+
$H_o : f, \beta = f_i, \beta_i$	0.89	1	1	0.03	0.15	0.52	1	1	1	0.14	0.59	0.36
$H_o : f_i, \beta = f_i, \beta_i$				0.03								

Hsiao tests - P.value (CA, DE, FI, NL, UK, US)

	Women						Men					
	15-19	20-24	25-54	55-59	60-64	65+ (*)	15-19	20-24	25-54	55-59	60-64	65+ (*)
$H_o : f, \beta = f_i, \beta_i$	0.21	0.05	<0.01	0.73	0.22	0.54	0.21	0.73	0.04	0.75	0.31	0.78
$H_o : f_i, \beta = f_i, \beta_i$			0.13						0.01			

A grey case indicate that the hypothesis of homogeneity is rejected at a 5% level

Appendix 2. Pedroni cointegration tests

Cointegration test (DE BE CA DK ES US FI FR IT JP NL GB)

Pedroni with constant

	Within dimension				Between dimension		
	v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
PR_M_15_19							
PR_M_20_24							
PR_M_25_54							
PR_M_55_59							
PR_M_60_64							
PR_M_65+							
PR_W_15_19							
PR_W_20_24							
PR_W_25_54							
PR_W_55_59							
PR_W_60_64							
PR_W_65+							

Cointegration test (BE, FR, IT, GE, JP, SP)

Pedroni with constant

	Within dimension				Between dimension		
	v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
PR_M_15_19							
PR_M_20_24							
PR_M_25_54							
PR_M_55_59							
PR_M_60_64							
PR_M_65+							
PR_W_15_19							
PR_W_20_24							
PR_W_25_54							
PR_W_55_59							
PR_W_60_64							
PR_W_65+							

Cointegration test (CA, DE, FI, NL, UK, US)

Pedroni with constant

	Within dimension				Between dimension		
	v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
PR_M_15_19							
PR_M_20_24							
PR_M_25_54							
PR_M_55_59							
PR_M_60_64							
PR_M_65+							
PR_W_15_19							
PR_W_20_24							
PR_W_25_54							
PR_W_55_59							
PR_W_60_64							
PR_W_65+							

A grey case indicate that the hypothesis of a cointegration relation is rejected at a 5% level

Appendix 3. Sensitivity analysis to the choice of the SNR

β parameter estimation for different SNR (BE, FR, IT, GE, JP, SP)

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PR_M_15_19	-0.7	-0.6	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-0.4
PR_M_20_24	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
PR_M_25_54	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_55_59	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.1
PR_M_60_64	-0.8	-0.7	-0.7	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6	-0.6
PR_M_65+	-0.4	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2
PR_W_15_19	-0.7	-0.6	-0.5	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4
PR_W_20_24	-0.1	-0.1	-0.1	-0.1	-0.2	0.0	-0.2	-0.2	-0.2	-0.2
PR_W_25_54	0.7	0.5	0.4	0.0	0.4	0.4	0.4	0.3	0.3	0.3
PR_W_55_59	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
PR_W_60_64	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
PR_W_65+	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1

Difference between β_{SNR} and $Median_{SNR}(\beta_{SNR})$ for each SNR

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PR_M_15_19	**-0.2**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_20_24	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_25_54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_55_59	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.3**
PR_M_60_64	**-0.2**	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_65+	**-0.2**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_15_19	**-0.2**	**-0.1**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
PR_W_20_24	0.1	0.0	0.0	0.0	0.0	**0.1**	0.0	0.0	0.0	0.0
PR_W_25_54	**0.4**	**0.2**	0.1	**-0.4**	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_55_59	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_60_64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_65+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

β parameter estimation for different SNR (CA, DE, FI, NL, UK, US)

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PR_M_15_19	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0
PR_M_20_24	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.3	-0.3	-0.3
PR_M_25_54	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
PR_M_55_59	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2	-0.2
PR_M_60_64	-0.7	-0.6	-0.5	-0.5	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
PR_M_65+	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9	-0.9
PR_W_15_19	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4	-0.4
PR_W_20_24	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.2	-0.2
PR_W_25_54	-0.4	-0.3	-0.3	-0.3	-0.3	-0.2	-0.2	-0.2	-0.2	-0.2
PR_W_55_59	-0.4	-0.3	-0.2	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.1
PR_W_60_64	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1
PR_W_65+	-0.06	-0.04	-0.04	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03

Difference between β_{SNR} and $Median_{SNR}$ (β_{SNR}) for each SNR

	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
PR_M_15_19	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_20_24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_25_54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_55_59	**-0.1**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_M_60_64	**-0.3**	**-0.1**	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1
PR_M_65+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_15_19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_20_24	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_25_54	**-0.1**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_55_59	**-0.2**	**-0.1**	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_60_64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PR_W_65+	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix 4. Pedroni cointegration tests

Cointegration test (BE, FR, IT, GE, JP, SP)

Pedroni with constant

	Within dimension				Between dimension		
	v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
HPA15_19	0.07						
HPA20_24	0.34						
HPA25_54	0.3						
HPA55_59	0.4				0.12		
HPA60_64	0.15						
HPA65							
FPA15_19							
FPA20_24	0.35				0.11		
FPA25_54					0.16		
FPA55_59	0.14						
FPA60_64	0.38				0.08		
FPA65	0.08						

Cointegration test (CA, DE, FI, NL, UK, US)

Pedroni with constant

	Within dimension				Between dimension		
	v-stat	rho-stat	PP-stat	ADF-stat	rho-stat	PP-stat	ADF-stat
HPA15_19	0.18				0.11		
HPA20_24	0.36						
HPA25_54	0.33						
HPA55_59	0.38						
HPA60_64	0.24						
HPA65	0.39						0.16
FPA15_19	0.4	0.05			0.07		
FPA20_24	0.11				0.05		
FPA25_54	0.3			0.09	0.26		
FPA55_59	0.12						
FPA60_64							0.06
FPA65	0.36				0.06		0.1

A grey case indicate that the hypothesis of a cointegration relation is rejected at a 5% level

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