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"The age structure change of population and labour productivity impact."

Olfa Frini
ISCAE Manouba University Tunisia; ECSTRA Carthage University Tunisia

Khoutem Ben Jedidia
ISCAE Manouba University

Abstract

Paper explores population ageing macroeconomic effects on labour market productivity. It examines the effect of labour force participation rate by age ranges: young adulthood (15-29 years), prime age (30-49), and old age (50-64) on the aggregate labour productivity. Using Tunisian data during 1965-2014, a cointegration long-run relationship with a progressively adjustment process towards equilibrium is found. Age-productivity profile does not follow an inverted U shape. Labour productivity edges down for young worker and keeps the rise for older. Ageing seems did not lead a low performance for the Tunisian labour market. The retirement age delay beyond 60 years-old is advised to gain more in productivity and enhance economic growth.

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Contact: Olfa Frini - frini.olfa@planet.tn, Khoutem Ben Jedidia - khoutembj@yahoo.fr.
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1° Introduction

The extent of population ageing may be dramatic for the economy by affecting the labour market features through the slowdown of labour force population growth and eventually its contraction.[1]The labour force ageing might influence the worker mobility, employment, productivity and, consequently, the labour market performance and flexibility.
Several studies have looked at how individual productivity changes with age to put in evidence an inverted U-shaped profile, where significant decrease takes place from around the age of fifty years.[2] However, looking at the aggregate labour productivity changes with age is also an important subject since results related to individual effects cannot be automatically assumed to apply collectively.[3]

In this respect, with a macroeconomic perspective, we aim to assess ageing effect on the labour market performance through mainly labour productivity. More precisely, we focus our empirical analysis on the labour force unlike previous studies which focus on the total population[4], or on the working-age population[5] or on the employees.[6] So, to estimate the age structure effect, we split up the aggregate labour force participation rate into three age ranges: young adulthood (15-29 years), prime age (30-49), and old age (50-64). Further, we target to inspect the outcomes of the intended policy of postponement age retirement by extending it to 65 years-old instead of 60 years-old. In addition, to fulfil the lack of such research on Arab countries, we apply our empirical study on Tunisian case during 1965-2014 as it is well launched in the ageing process.
Our methodology applies times series modelling approach using the cointegration technique to exhibit a long-run equilibrium relationship between variables and the Error Correction Model to capture the short run adjustment mechanism.

In what follow, we begin by a literature review in section 2. In section 3, we examine the demographic evolution of the Tunisian labour market. Then, we specify the empirical model and identify variables in Section 4. In Section 5, we expose the econometric methodology and display the results. Finally, in Section 6, we draw major conclusions and propose policy implications.

2° Literature review

There are macroeconomic and microeconomic effects of ageing on labour market. On macroeconomic level, ageing reduces the relative size of labour force as a share of total population. From this view, labour is becoming relatively scarce while capital becomes relatively more abundant. This precipitates changes in the relative price of labour and leads to a higher capital intensity. This labour force change affects economic growth (Kelly and Schmidt 1995).
As per capita output $(\frac{Y}{N})$ (where Y denotes the output and N is the total population) is a function of capital (K), labour (L) and total factor productivity (A) as follow:

$$(\frac{Y}{N}) = \mathrm{A}\, f\,(\frac{L}{N}, \frac{K}{L}\frac{L}{N}) \qquad (1)$$

[1] Cadiou *et al.* (2002), Cheng (2003), Peng (2005, 2006), and Bloom and Sousa-Poza (2013).
[2] E.g. Haltivanger *et al.* (1999) and Mahlberg and Prskawetz (2013).
[3] Lindh and Malmberg (1999), Mukesh *et al.* (2007), Brunow and Hirte (2006, 2008), and Van Ours and Stoeldraijer (2010).
[4] E.g. Barro and Sala-i-Martin (1992) and Lindh and Malmberg (1999).
[5] Mankiw, Romer and Weil (1992).
[6] Brunow and Hirte (2006).

Therefore, when the total population (N) evolution changes, the labour (L) varies and the output growth will reflect this change (Bloom and Williamson 1998). Considering the working-age population as an explanatory variable (WAP) (Mankiw *et al*. 1992, and Barro and Sala-I-Martin 1995), the labour ratio $\frac{L}{N}$ can be expressed as a multiplication of two components:

$$\frac{L}{N} = \left(\frac{L}{WAP}\right)\left(\frac{WAP}{N}\right) \qquad (2)$$

Henceforth, the per capita output expression (1) becomes a function of labour force participation rate $\left(\frac{L}{WAP}\right)$ as follow:

$$\frac{Y}{N} = \frac{Y}{L}\left(\frac{L}{WAP}\right)\left(\frac{WAP}{N}\right) \qquad (3)$$

This expression highlights the effects of labour force participation rate and, therefore, its age structure on economic growth.

On microeconomic level, the conventional view of the age-productivity profile assumes that productivity follows an inverted U shape; a rising as workers enter prime age and then a declining as they approach retirement (Mukesh *et al.* 2007). This negative impact of ageing may be explained by the swiftness of the introduction of the new technologies (Bös and Weizsäcker 1989) as well as by the ageing of knowledge stock and skills of older workers and the depreciation of their qualification. Further, the financial incentives to acquire new skills decline gradually with age what impairs productivity. The older worker was consistently rated worse than the average worker when it comes to health care cost, flexibility in accepting new assignments, and suitability for training (Barth *et al.* 1993).[7] Moreover, the increase of health and infirmity incidence reduces labour productivity. In contrast, young workers show better ability and adaptability to learn new skills and adequacy with new jobs.

Furthermore, the increase of the share of elderly in the working-age population tends to reduce the geographical mobility and the national migration, all things being equal (GreenWood 1997). The reduced voluntary mobility between jobs and geographical mobility of older workers, generally, reduces employment and productivity, by less matching people to jobs in which their skills may be used efficiently to narrowing disparities in economic performance across regions. With a large proportion of older workers, the vertical mobility becomes weakly influenced by the decrease in the promotion opportunities (Keyfitz 1993). In addition, this decline in mobility reduces the adaptation of the working-age population to the market structure's shifts. Hence, ageing of worker raises the issue of mobility and flexibility of the labour market that being so, influence the economic dynamism.

This concave relationship is, however, not indisputable; the older labour force may have higher average level of work experience and a positive effect on productivity (Disney 1996, and Dixon 2003). Older workers were consistently rated as having more positive attitudes, being more reliable and possessing better skills than the average worker. Learning stimulates the productivity related to seniority (Aubert and Crépon 2003). Furthermore, older workers, generally, have stable relationships with their employers, while young workers frequently change jobs and employers (Gregg and Wadsworth 1999). The decline in voluntary job mobility reduces the turnover costs to employers, including recruitment and initial training costs which drives a favourable impact on overhead labour costs and profitability (Dixon 2003).

In sum, there is no agreement about ageing-productivity nexus due to the diversity of skill requirement and individual capacities. In fact, this relationship depends on the work

[7]This assertion is established by Barth *et al.* (1993) basing on a survey of human resource executives in 406 organizations.

nature, the education level, and the physical demands. The diminishing labour productivity at older age is particularly strong for work tasks where physical abilities, learning, and swiftness of carrying out the tasks are needed. Nevertheless, for jobs where experience and verbal abilities are important, older workers maintain a relatively high productivity level.

3° Tunisian demographic change and its aftermaths on labour market

3-1° Demographic shifts and age structure

During 1966-2015, a drastic demographic change has occurred in Tunisia as a result of the decline of both mortality and fertility rates; respectively from 35-40 %° to 5.9 %° and from 8 children per woman to 2.4. The life expectancy, which hardly exceeded 40 years in 1950 reaches 75.1 years (77.8 years for woman and 74.5 years for man) in 2015. [8] Accordingly, a deep change in population age structure toward an irreversible ageing process has occurred. The age groups proportion of 0-4 and 5-14 have become less important. They shifted from respectively 18.6% to 8.5% and from 27.9 % to 14.9%. In contrast, the share of working-age population 15-59 has increased from 48 % to 64.4%. However, the remarkable change has tackled the proportion of the aged over 60 years-old which had more than doubled to rise from 5.5 % to 12.2%. These demographic changes have entailed changes in the size labour force and in its age structure. The growth rate of labour force is dropping from 1.8 % during 2004-2009 to 0.8% during 2014-2017. Simultaneously, the labour force average age is gradually rising; the modal age class had evolved from 25-29 years-old in 2004 to 30-34 years-old in 2014. Over the period 1984-2014, the share of young labour force (15-29 years-old) had significantly shrinking (from 49.8 % to 30.3%) while the prime-aged adults share (30-49 years-old) had strongly increased (from 33.7% to 52.7%). At the same time, the share of older (50-64 years-old) had slightly risen (16.5% to 17%). Accordingly, the share of young employed population had declined (from 35.6 % to 29.7%) while that of both prime-aged adults and old age had increased (respectively from 46.7% to 52.7% and from 17.6 % to 17.6%). Employed population is becoming more aged; the modal age class evolves from 20-24 to 30-34 years-old.[9]

3-2° Labour productivity trend

Over the past fifty years, labour productivity grown has irregularly evolved (as shown in diagram 1 in Appendix). The long-term productivity growth (over 1980-2010) has been estimated by about 2.25 %. In post-revolutionary period 2011-2014, labour productivity has reached the lowest levels due to the economic and social instability, the low growth and job creation, and the sit-ins that have crippled the productive units. In 2013, the loss of productivity was about -0.6 % as the job creation was higher than economic growth (3.5 % against 2.8 %).[10]

4° Model and data specification

4-1°Empirical model specification

Basing on the previous literature notably the augmented Solow model based on the work of Mankiw *et al.* (1992), we specify our aggregate model of productivity. Like in Alexander (1993) and Wakeford (2004) works, we concentrate our empirical analysis on the average labour productivity as marginal productivity or output per hour of labour data are not available in Tunisia. We define it as a real GDP divided by total employment (Prod). It reflects labour productivity in terms of personal capacities of workers or the intensity of their effort. Its change

[8] Source of all quoted statistics is the Tunisian annual statistics of the National Institute of Statistics (NIS) from 1957-2015.
[9] Source of all quoted statistics is NIS employment 1966, 1984, 2004, 2011, 2014.
[10]Data sources are the Tunisian Institute of competitively and quantitative study (ITCQS) 2014.

displays the combined effect of changes in both capital and technical efficiency as well as the influence of economics of scale.
In order to assess the ageing influence on labour productivity, we estimate the labour force age structure, as it is wholly economically involved in the labour market unlike the working-age population. In contrast to previous works, we are interested in labour force rate by age structure to better capturing the age effect over time.[11] We define the labour force participation rate by age as the ratio of the labour force of an age range per the overall labour force. Explicitly, we distinguish three broad age ranges: young adulthood (15-29), prime-age adults (30-49) and old age (50-64). Thus, we treat three labour force participation rates that of young (YL), adults (PL) and elder (AL) as below.

$$\mathrm{YL} = \frac{Labour\ force\ \ aged\ 15-29}{Total\ labour\ force};\ \mathrm{PL} = \frac{Labour\ force\ \ aged\ 30-49}{Total\ labour\ force};\ AL = \frac{Labour\ force\ aged\ 50-64}{Total\ labour\ force}.$$

These add up to unity so, we leave the prime-age adults (30-49) out as baseline group in order to avoid linear dependency among these variables. Indeed, as proved by the several check tests our variables treated do not exhibit either correlation or multicollinearity problems.[12]
We note that we consider 65 years-old as the retirement age instead of 60 years-old in order to foresee the impact of the delay of the retirement age such as the government's will. Fearing that elderly who continue to work are likely to be the most productive and those who leave are the least productive, a robustness test is undertaken by estimating the model with the older workers aged 50-59 years-old. As the same result is found we, so, presume that the report of the age retirement is not selective and would not artificially raise the apparent productivity.
In addition, given that the proportion of younger employees are more important than that of the older ones [13]; we consider that the relationship between the aged ranges are not be substantially driven by the unemployment of the younger. Besides, since we estimate an aggregate model, we, thus, put in evidence the profile of the aggregate labour productivity by age change of the cohorts not of the individual.
Further, we do not distinguish labour force by gender since we are interested in labour productivity as a whole.

For economic indicators we estimate the influence of education, trade openness, investment, wage and unemployment. Through education (E), we may check a part of the human capital effect on productivity growth (the stock or accumulation of knowledge effect), and with the age structure we are able to capture the other part of the human capital (the transfer and implementation of new knowledge) through training or experience accumulated. As a measure we consider the enrolment rate at the secondary level for three reasons. Firstly, the education data for the employees is not available for all the period of study. Secondly, the enrolment rate is only available for population aged 5-11 years-old, which is not suitable for our case study. Thirdly, in order to win freedom degree and overcome the multicollinearity

[11]Barro and Sala-i-Martin (1992), Mankiw, Romer and Weil (1992), Lindh and Malmberg (1999), and Brunow and Hirte (2006).
[12]The Durbin-Watson test is inconclusive, as the test statistic value lies between dL and dU (dL =1.260<DW=1.541< dU=1.828) for the reference model. Aware that the Durbin-Watson test is not strong enough in a statistical acceptance, we had deepened our autocorrelation check by applying the Breusch Godfrey test, which presents a probability greater than 10 percent (p-value of (0.19) for model 1) and a low R^2. Thus, we do not reject the null hypothesis of non-autocorrelated errors and we can conclude that model is free of autocorrelation. It is worth noting that the same evidence is observed for the second model.
[13] The proportion of the younger employee population is 45.58% in 1984, 39.83% in 1994, 32.65% and 29.45% in 2010 vs 15.28 %, 12.91%, 13.3% and 16.81% for the older employees population.

problem, we select only the secondary level which gives us a statistically significant result. This selection is in coherence with the low average human capital level of the employees.[14]
We consider trade openness (OP) to look into technology diffusion effect on productivity.
Following Mankiw *et al.* (1992), we evaluate the long-run gain in productivity of the capital accumulation (K) by considering the gross fixed capital formation (GFCF) at constant domestic prices.
Likewise, we investigate the long run dynamics association between labour productivity and wages which always has been an essential economic and legal concern, by using the industrial guarantee minimum wage (for the regime of 40 hours) (W).
Besides, given the deep ambivalence afflicted to the connection between productivity growth and employment we estimate the unemployment rate (U) in order to check out their association.[15]
Finally, the baseline equation to estimate takes the following form:

$$Prod_t = \alpha + \beta_1\, YL_t + \beta_2\, PL_t + \beta_3\, AL_t + \beta_4\, E_t + B_5\, OP_t + \beta_6\, W_t + \beta_7\, K_t + \beta_8\, U_t + Z_t$$

Where, z_t is the error term.

In order to deepening our empirical analysis, we estimate another model (model 2) with a time variable (DATE) considering the structural changes occurred subsequent to the 14th January revolution.

4-2°Data construction

Our study is based on annual time series covering the period 1965-2014 gathered from two data sources NIS and ITCQS. Due to the data unavailability, we construct our series for labour force participation rate according to the three relevant age ranges and for education enrolment rate by level. For the labour force participation rate by age range, we firstly calculate the size of labour force corresponding to each age range considered then we divide it per the total labour force.
Concerning education, we reconsider our data series computed in our previous empirical work (as indicated in note1 in Appendix)[16]. For the trade openness, as generally defined, we sum import and export then divided them by the GDP per capita at constant domestic prices. The GFCF per capita at constant price measuring the capital accumulation (K) is computed by dividing GFCF per capita at current price per the consumption price index (base 1990) to avoid prices effects. Finally, we define DATE the dummy time variable equal to one if upper to 2010 and zero otherwise.

All variables are expressed in logarithm so that coefficients can be interpreted as elasticities. The main statistical characteristics of the variables used are summarized in Table I (in Appendix). This model specification does not imply a heteroskedasticity problem as the homoskedasticity is not rejected by the results of ARCH test (P-value of 0.14 for model 1 and of 0.66 for model 2). Also, it does not imply a non-normal error as the Jarque-Berra test on the estimated residual does not reject the normality (P-value is of 0.64 for model 1 and of 0.32 for model 2).

5° Econometric methodology and Estimation results

Prior applying any times series analysis, we test the reliability of our times series data by testing the unit roots existence. Both reports results of Augmented Dickey-Fuller and Philip-Perron

[14] The average number of years study of employees has evolved from 1.6 to 7.5 years during the period of study.
[15] E.g. Blanchard *et al*. (1995) and Gordon (1997).
[16] Frini and Muller (2012).

tests used (Table II, in Appendix) show that all considered variables can reasonably be considered as being I(1). In this respect, a cointegration VAR model which required variables integrated of the same order is proper.

5-1° Cointegration test result

In order to determine the cointegration ranks, we use Johansen and Jesulius (1990) maximum eigenvalue test on the model with no trend in the cointegration relation and the presence of a constant in the VEC. The choice is justified by the fact that such long-run equilibrium relationship between series does not have trends. The maximum Eigen value test result (Table III in Appendix) rejects the null hypothesis of no cointegration relationship at one percent level.[17] It indicates a unique cointegration equation binding variables together in a long-run equilibrium relationship characterized by a common trend.[18]

$$\underset{}{Prod} = 1.559 - \underset{[2.90]}{1.937YL} + \underset{[5.62]}{0.365AL} + \underset{[13.26]}{0.791E} - \underset{[5.25]}{0.243W} + \underset{[8.00]}{0.281K} + \underset{[8.78]}{0.467OP} + \underset{[11.15]}{1.142U} + Z_t$$

Where, z_t is the error term. t-statistics are presented in parentheses.

Long-run results disclose that both economic and demographic factors influence aggregate labour productivity. The age structure impact on the average labour productivity is significant and non-monotonic in contrary to previous research. The labour productivity edges down at young age and rises at old age. Against to the conventional approach, the age-productivity profile (for the cohort) does not follow an inverted U shape. As in Disney (1996), Dixon (2003), Cardoso *et al.* (2011), and Göbel and Zwick (2013), the older workers are productive. Indeed, like the prime-aged adult the old age have a remarkable positive effect on aggregate productivity and exhibit experience returns. Over time, the older workers have efficiently adapted to technological changes by having experienced a greater growth in tasks with intense use of cognitive abilities (Autor *et al.* 2003). They have skills and capacities based on experience that many young lack. Indeed, similar to findings in Mahlberg *et al.* (2013), young workers weaken labour productivity level. Despite of young workers are assumed to be more able to become accustomed with technical progress, they require time to acquire high skilling (learning and training). Some years of experience are required to highlight the educational skills and to get significant education return. The job performance does not decrease when experience and verbal abilities are important like in Tunisia where productive system does not require a high technological development since it is dominated by the services sector.

Thus, this evidence allows us to predict that labour productivity will not be adversely altered by the ageing process.

In coherence with theoretical expectations higher educational attainment help to maintain productivity as the labour force ages. A potential productivity gain is embodied in workers who accumulated human capital as emphasized by the human capital theory. Education or training raises workers productivity by imparting useful knowledge and skills. They become more receptive to new approaches in production and management.

Likewise, investment in physical capital implies long-run productivity gains. It provides more capital per unit of labour, facilitates the effective use of new and powerful technologies, and raises the workers productivity. In addition, it could be pinpointed that the advent of new

[17]Two cointegration vectors are found for model 2. Comparing with the basis regression, model 2 exhibits the same results (note 2 in Appendix).

[18] E.g. Blanchet (1993) and Börsch-Supan (2003, 2005).

technology in the long-run, which in turn replaces labour, increases productivity. Thus, opposite to the empirical results of Mankiw *et al.* (1992), our result underlines a smaller weight to physical capital but a larger weight to human capital in explaining variation in output per worker.
In line with Alcala and Ciccone (2004)'s interpretations, this potential productivity gains through physical and human capital accumulation is reinforced thanks to trade openness. Moreover, the result highlights a less volatile and more persistent positive correlation between productivity and unemployment like in Gordon (1997)'s study. Such result conforms the neoclassical view suggesting that a decline in labour demand increases productivity given the technical progress and the wage setting. However, the wage policy is found not in favour of productivity enhancement. The Tunisian policy of "low wages" promotes the rotation of the workforce and, consequently, presents a negative influence on the labour productivity in the long-run.
Interestingly, at long-run the structural and political change leads to a positive effect on productivity evolution (model 2).

5-2° Error correction test result

Our attention is now directed toward the adjustment mechanisms of the long-run relationships across variables.[19] The Error Correction model results (in Table IV for model 1 and table V for model 2, in Appendix) show that the short-term productivity evolution tends to join the long-term equilibrium. The adjustment towards equilibrium is swift with a coefficient of -0.204 for model 1 (and of -0.318 for model 2). In the short-run, labour productivity appears as independent of its lagged value, of labour age structure, and of economic factors. However, lagged education influences labour productivity with an instantaneous negative effect. This may be owing to three major reasons: (1) a labour force endowed with few education years requires long time to acquire skill and experience to be productive, (2) an inconsistent education system with labour market requirement (Frini and Muller 2012) and (3) the inability of the labour market to absorb the skilled labour force as is revealed by the high unemployment rate of higher educated. [20]
The short-run negative effect of the change induced by the revolution (model 2) emphasizes the dramatic economic situation subsequently to the sit-ins and strikes which had occurred chiefly in the productive sectors (the mining industry).

Hence, the relationship between demographic, economic and labour productivity variables is not instantaneously but progressively; it is a long-run process. Labour productivity progress requires time for that the workers adapt and acquire new skills and so improves their productivity.

6° Conclusion

With a macroeconomic perspective, this paper highlights the impact of population ageing on the labour market performance especially on labour productivity. A shift in the age structure brings about a change in labour aggregate productivity. It depicts that changes in the relative size of different age ranges (young adulthood (15-29 years), prime age (30-49), and old age (50-64)) have a noteworthy impact on the aggregate labour productivity. Interestingly, in contrast to the widespread belief, older workers, as a whole, are found as having more positive attitude, being more reliable and possessing better skills than young workers. The age-productivity profile does not follow an inverted U shaped; it declines for young workers, and raises when they enter the prime-adult age and when they approach retirement.

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[19] Engle and Granger (1987).

[20] Over 1966-2011, the unemployed rate of graduates has increased from 0.8% to 33.1%.

However, the unfavourable scenario may come true with the arrival of the “baby-boom generation” to the retired age after about a decade if policy-makers do not manage the situation. Policies that affect labour market regulation and wage setting practices, retirement, pension’s rules, health system, training and education will be particularly critical to improve labour productivity. The delay of the retirement age beyond 60 years-old as foreseen by the government is advised to gain more in productivity and enhance economic growth. They should invest in worker health and fostering work environments that encourage the continued productive participation of older workers. Also, firms will have to expand their training programs to invest more in older employees and to reorient the programs to meet the needs of those workers and to strengthening the effectiveness of the professional training system.

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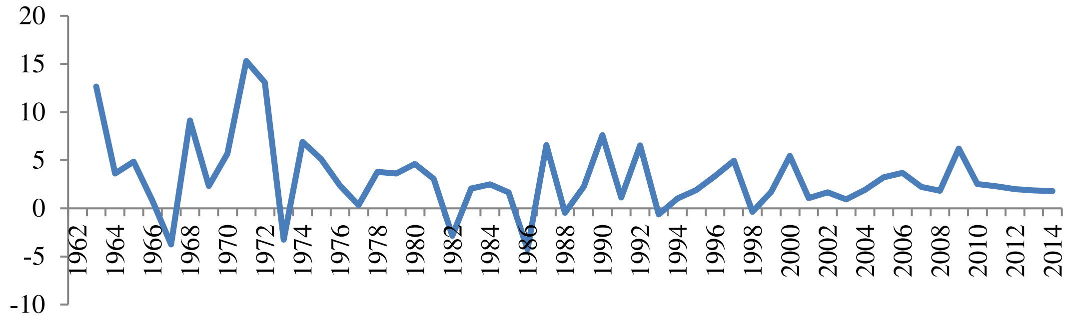
Appendix

Diagram 1: Tunisian labour productivity growth trend (1962-2014)



Sources: the Tunisian Institute of competitively and quantitative study (ITCQS) 2014.

Note1

For computing overall enrolment by level, we had considered the data based on annual enrolment surveys, typically conducted at the beginning of the schooling year (in September), by the Ministry of Education. We first calculated for each schooling level the pupils number enrolled. Then, using census data provided by the (ITCQS) we accounted the population size corresponding to each official school age group. Last, we estimated the schooling enrolment rates by dividing the number of enrolled pupils at the considered education level, independently of their age, by the population size of the officially corresponding age group. Accordingly, the gross secondary enrolment rate is computed by dividing the number of enrolled pupils at this level, independently of the age, by the population size of the officially corresponding age range13-20 years-old.

Table I: Descriptive Statistics Variables

	PROD	*YL*	*AL*	*K*	*OP*	*E*	*W*	*U*
Mean	6197.701	43.132	14.041	3333.049	78.699	44.223	119.536	15.338
Median	5927.270	43.475	14.259	3217.178	83.675	41.000	112.706	15.526
Maximum	10726.93	51.119	17.199	6084.093	114.295	70.400	388.440	16.048
Minimum	2576.720	31.384	11.191	1104.089	31.786	17.730	14.560	13.993
Std. Dev.	2219.955	5.180	1.681	1338.208	20.324	19.346	91.595	0.629
Observations	49	49	49	49	49	49	49	49

Table II: Unit Root Tests* (*The Probability value of the unit roots tests (P-value))*

	Augmented Dickey Fuller (ADF)			Phillips Perron (PP)		
Model	Model (1)	Model (2)	Model (3)	Model (1)	Model (2)	Model (3)
Level						
Prod	1.000	0.479	0.496	1.000	0.577	0.516
YL	0.179	1.000	0.901	0.316	0.998	0.899
AL	0.295	0.290	0.066	0.181	0.257	0.901
E	0.986	0.752	0.980	0.999	0.381	0.815
W	0.995	0.273	0.987	0.999	0.432	0.968
K	0.961	0.236	0.157	0.981	0.661	0.607
OP	0.970	0.146	0.384	0.973	0.125	0.535
U	0.421	0.033	0.654	0.660	0.033	0.081
First difference (Δ)						
Prod	0.117	0.000	0.000	0.000	0.000	0.000
YL	0.074	0.095	0.000	0.002	0.000	0.008
AL	0.000	0.162	0.001	0.000	0.000	0.000
E	0.026	0.001	0.008	0.000	0.001	0.008
W	0.029	0.011	0.018	0.002	0.000	0.001
K	0.000	0.004	0.020	0.000	0.004	0.018
OP	0.000	0.000	0.000	0.000	0.000	0.000
U	0.000	0.000	0.000	0.000	0.000	0.000

* Model (1) with no intercept and no deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$

Model (2) with intercept and no deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \upsilon + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$

Model (3) with intercept and deterministic trend: $\Delta X_t = (\rho - 1)X_{t-1} + \lambda + \delta t + \sum_j^k \theta_j \Delta X_{t-j} + \varepsilon_t$

Both the ADF and the PP tests take the unit root as the null hypothesis H_0: ρ =1. This null hypothesis is tested against the one side alternative H_1 ρ <0.

Table III: Maximum Eigenvalue Test

***Model 1** (Base regression)*			***Model 2***		
H_0: r or fewer cointegration vectors	***Eigen Value***	***P-value****	***H_0: r or fewer cointegration vectors***	***Eigen Value***	***P-value****
None*	0.866	0.000	None *	0.584	0.022
At most 1	0.673	0.048	At most 1 *	0.428	0.049
At most 2	0.409	0.117	At most 2	0.335	0.281
At most 3	0.287	0.255	At most 3	0.586	0.095
At most 4	0.373	0.192	At most 4	0.198	0.176
At most 5	0.282	0.387	At most 5	0.210	0.188
At most 6	0.205	0.298	At most 6	0.289	0.189
At most 7	0.368	0.825	At most 7	0.191	0.287

Max-eigenvalue test indicates 1 cointegrating eqn (s) at the 0.05 level for model 1
Max-eigenvalue test indicates 2 cointegrating eqn (s) at the 0.05 level for model 2
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Table IV: Vector Error Correction base regression (Model 1)

	D(Prod)	D(YL)	D(AL)	D(E)	D(W)	D(K)	D(OP)	D(U)
Error Correction term ECT1	**-0.204**	-0.020	-0.040	0.175	-0.762	0.060	0.603	0.373
	(-2.363)	(-1.205)	(1.012)	(2.031)	(-3.632)	(0.267)	(2.410)	(2.878)
Regressors								
D(Prod (-1))	0.050	0.030	-0.026	-0.058	-0.161	0.145	0.048	-0.129
	(0.344)	(0.106)	(-0.391)	(-0.401)	(-0.452)	(0.378)	(0.114)	(-0.586)
D(YL(-1))	-0.712	-0.077	-0.053	1.302	-2.9 75	1.973	0.181	-0.565
	(0.800)	(-0.440)	(-0.129)	(1.465)	(-1.375)	(0.846)	(0.070)	(-0.422)
D(AL(-1))	-0.207	0.003	0.821	-0.139	0.041	-0.160	0.285	0.120
	(-0.836)	(0.073)	(7.153)	(-0. 562)	(0.069)	(-0.546)	(0.396)	(0.322)
D(E(-1))	**-0.397**	-0.017	0.012	0.649	-0.531	-0.065	0.396	0.235
	(-2. 602)	(-0.565)	(0.179)	(4.267)	(-1.432)	(-0.163)	(0.895)	(1.024)
D(W(-1))	0.036	0.003	0.009	0.024	0.195	-0.119	-0.190	-0.067
	(0.599)	(0.310)	(0.336)	(0.407)	(1.286)	(-0.757)	(-1.091)	(-0.744)
D(K(-1))	-0.007	0.012	0.003	-0.030	0.125	0.439	-0.105	0.068
	(-0.124)	(0.349)	(0.129)	(-0. 483)	(0.854)	(2.618)	(-0.565)	(0.709)
D(OP(-1))	0.064	0.037	0.006	-0.025	-0.023	0.175	0.285	0. 160
	(1.059)	(0.248)	(0.218)	(-0.410)	(-0.155)	(1.096)	(1.609)	(1.741)
D(U(-1))	-0.103	-0.019	0.038	-0.098	-0.599	-0.090	0.477	0.227
	(-0.851)	(-0.815)	(0.683)	(-0.813)	(-1.896)	(-0.284)	(1.357)	(1.215)
C	0.043	-0.019	0.001	0.011	0.075	0.021	0.023	-0.005
	(4.673)	(-0.581)	(0.322)	(1.215)	(3.303)	(0.885)	(0.856)	(-0.365)
R^2	**0.542**	0.170	0.675	0.452	0.355	0.359	0.201	0.231

Notes: Student's t is in parentheses.

Note2: Model (2)

First cointegration equation Model 2

$$Prod = 5.627 - 7.279\ YL + 0.326\ AL + 0.563\ E - 0.312\ W + 0.299\ K + 0.401OP + 0.366U + 0.356\ DATE + Z_t$$

[8.92] [4.59] [16.25] [10.09] [15.07] [13.13] [2.35] [8.56]

Table V: Vector Error Correction (Model 2)

	D(Prod)	D(YL)	D(AL)	D(E)	D(W)	D(K)	D(OP)	D(U)	D(DATE)
Error Correction term ECT1	**-0.318**	-0.033	0.002	0.212	-0.977	0.059	0.846	1.544	-0.020
	(-2.496)	(-1.292)	(0.492)	(1.678)	(-2.962)	(0.177)	(2.244)	(2.516)	(-1.189)
Regressors									
D(Prod (-1))	0.002	0.012	-0.023	-0.125	0.092	0.110	-0.187	-0.735	-0.140
	(0.176)	(0.397)	(-0.326)	(-0.833)	(0.236)	(0.277)	(-0.419)	(-1.011)	(-0194)
D(YL(-1))	2.139	0.033	-0.129	1.094	0.394	2.641	-2.178	-3.804	-1.323
	(2. 06)	(0.160)	(-0.261)	(1.062)	(0.146)	(0.969)	(-0.710)	(-0.761)	(-0.914)
D(AL(-1))	-0.362	-0.029	0. 803	0.164	-0.704	0.121	1.083	3.066	1.470
	(-1.129)	(-0.530)	(6.018)	(0.591)	(-0.971)	(0.164)	(1.307)	(2.273)	(1.510)
D(E(-1))	**-0.417**	-0.016	-0.011	0.571	-0.405	-0.157	0.283	0.453	-0.253
	(-2.743)	(-0.540)	(-0.156)	(3.777)	(-1.028)	(-0.392)	(0.628)	(0.617)	(-0.533)
D(W(-1))	-0.009	0.003	-0.023	0.083	0.145	-0.014	-0.138	-0.017	0.080
	(0.136)	(0.702)	(-0.527)	(1.185)	(0.789)	(-0.076)	(-0657)	(-0.051)	(0.206)
D(K(-1))	-0.030	-0.005	-0.008	-0.037	0.102	0.414	-0.0884	0.158	0.196
	(-0.470)	(-0.425)	(-0.279)	(-0.594)	(0.613)	(2.450)	(-0.467)	(0.510)	(0.584)
D(OP(-1))	0.041	0.005	-0.012	-0.025	-0.045	0.169	0.322	0.5701	0.170
	(0.642)	(-0. 038)	(-0.396)	(-0.391)	(-0.268)	(0.991)	(1.679)	(1.826)	(0.631)
D(U(-1))	0.004	-0.004	-0.034	0.370	0.029	0.540	0.425	0.334	0.537
	(0.017)	(-0.086)	(-0.267)	(1.389)	(0.041)	(0.765)	(0.535)	(0.258)	(0.377)
D(DATE)	**-0.133**	-0.004	0.015	-0.103	-0.142	-0.215	-0.015	0.055	-0.183
	(-1. 894)	(-0.254)	(0.379)	(-1.231)	(-2.084)	(-0.967)	(-0.062)	(0.135)	(-0.381)
C	0.043	-0.001	0.002	0.013	0.069	0.024	0.027	0.011	0.018
	(4.741)	(-0.602)	(0.547)	(1.514)	(2.899)	(0.995)	(1.007)	(0.250)	(0.414)
R^2	**0.553**	0.501	0.667	0.478	0.296	0.379	0.199	0.226	0.102

Notes: Student's t is in parentheses.