LUND UNIVERSITY
School of Economics and Management

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Population aging and enrollment ratios in tertiary education: does population aging elevate the enrollment ratio in OECD countries?

Kiminori Isaka
aeg10kis@student.lu.se

Abstract: This study examines possibility of positive contribution of population aging to enrolment ratios in tertiary education of 32 OECD countries from 1970 onward. It estimates an equation with fertility, life expectancy, GDP per capita, schooling age population for tertiary education and expenditures to education. In the equation, the variables reflect demand, supply and constraints on education identified in literature review. The result unexpectedly indicates negative or negligible impact of population aging on the enrollment ratio for countries likely suffering from educational supply constraint. Positive relationship between population aging and the enrollment ratio is suggested only for less developed OECD countries with a little educational supply constraint. The results overall urge reconsideration of the assumption of recent population aging simulations that population aging stimulates human capital accumulation in developed countries.

Key words: Population aging, enrollment ratio, tertiary education, educational supply constraint, OECD, human capital accumulation

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1 Introduction

1.1 Threat of population aging

Population aging is one of the biggest concerns in the world. Share of people aged 60 and older will increase from 11% in 2009 to 22% in 2050 (Bloom et al. 2010b). Europe and North America will have higher share of the elderly than the other regions while Asia, Latin America and Caribbean will face quicker increase of the share (Ibid). Existing researches show that population aging can engender many worrisome consequences. First, serious population aging, like one seen in the countries above, burdens public finance. For some OECD countries, health care spending and public pension spending per GDP can increase by 3.4% and 3.3% in average, which corresponds to exacerbation of the primary balance by 6.8% (OECD 2001). Second, serious population aging gets rid of work forces, possibly leading to 0.7% downward pressure to annual GDP per capita for OECD countries (Bloom et al. 2010a). Third, economic models project decline of saving for some OECD countries (Cutler et al. 1990; Kim and Lee 2008). The dissaving comes from a life cycle behavior of a person: people work and save in their middle age, and consume while possibly dissaving or burdening public finance in their old age. The dissaving leaves economic deficit to a society, and, in Sweden, the deficit may require 3% increase of the productivity to be compensated for (Bengtsson and Scott 2011). What is worse, even the productivity can lower by serious population aging because middle-aged people, who are generally more productive than elderly people, are becoming less and less (National Institute for Research Advancement 2010). Researches indicate negative impact of population aging on economic growth.

Owing to the possibility of the heavy impact on economy, many economic simulations of population aging have been conducted (Batini et al. 2006; Kotlikoff et al. 2007; MacKellar et al. 2004). The simulations have currently directed their eyes toward a possible positive aspect of population aging for economic growth: its stimulation of human capital accumulation. Population aging can stimulate human capital investment through extending lifespan and bolstering returns to investment in human capital (Riphahn and Trübswetter 2006; Ehrlich and Lui 1991). In fact, economic simulations that take stimulation of human capital accumulation by population aging into account tend to produce very optimistic results against effect of population aging to economic growth, even positive contribution in total (Fougere and Mérette 1999; Ludwig et al. 2012; Sadahiro and Shimasawa 2002).

However, the stimulation of human capital accumulation by population aging lacks in empirical supports. Assuming existence of the stimulation may be invalid in reality. In particular, educational institutions may not provide education to poor people by prioritizing enrollment of affluent students. In that case, population aging should not spur human capital accumulation very much. Empirical studies on relationship between human capital accumulation and population aging are needed in order to assess validity of the current economic simulations of population aging.

1.2 Objective

Aiming at examining validity of economic simulations of population aging that incorporates positive contribution of population aging to human capital accumulation, this study looks into relationship between life expectancy and enrollment ratio in tertiary education by panel data analysis of 32 OECD countries from 1970 onward. Life expectancy is certainly a main cause of population aging. When life expectancy has positive correlation with the enrollment ratio, population aging likely has positive impact on the enrollment ratio. This simple examination however has not been implemented in existing studies of the enrollment ratio very much because of their focus on other macro economic factors such as GDP and public spending to education. This study will fill the blank by focusing on life expectancy.

Moreover, this study investigates correlation between the enrollment ratio and two other demographic variables: fertility and change of schooling age population for tertiary education. The former is another significant determinant of population aging; therefore, examination of the variable is crucial for an integrative assessment of effect of population aging. The latter in turn reflects degree of educational supply constraint. The supply constraint would make difference between reality and economic simulations since the latter tends to ignore the supply constraint. Thus, inquiry into relationship between enrollment ratio in tertiary education and change of the schooling age population would help this study discuss validity of the assumption of positive contribution of population aging to human capital accumulation.

Research questions based on the objective above are: Does population aging stimulate increase of enrollment ratio in tertiary education? Is the assumption of simulations of population aging that the aging stimulates human capital accumulation valid?

1.3 Methodology

For the examination of positive relationship between population aging and human capital accumulation, an econometric analysis of 32 OECD countries from 1970 onward is conducted. With grouping of the countries, the number of the final observations ranges from 150 to 500. The latter value is much larger than the number of observations in existing studies of enrollment ratio or participation rate. Meanwhile, variables used in this study cover not only demographic variables but also economic variables such as GDP capita and policy variables like expenditures to family. While this study motivates the choice of the variables by reviewing the previous studies, its uniqueness lies in integration of three types of factors affecting enrollment ratios: demand factors, supply factors and constraints on education. While they tend to be discussed independently in existing studies, this study integrates them into one equation. The equation is then tested against the observations above. Finally, with some refinement, the equation enables separation of temporary shocks to enrollment ratio in tertiary education and permanent determinants of the enrollment ratio.

1.4 Scope and limitation

With respect to the scope and limitation, this study limits its focus on analysis of enrollment ratio in tertiary education. While results of the analysis may be valid for enrollment ratios in other stages of education, they would not provide valuable indications for educational attainment because consideration of drop rate or repeating the same grade is necessary for the graduation rate. Lack of consideration of them limits scope of this study to enrollment ratios in various stages of education.

Meanwhile, the use of OECD countries may further limit applicability of this study to other countries. OECD countries are at least relatively wealthy. Situation in much poorer countries such as Sub-Saharan countries is likely very different from them. Therefore, results of this study should be applied mainly to wealthy and economically growing countries.

Finally, while this study discusses effect of population aging, it does not use the direct indicator of population aging, average age of population of a country, because it is fairly difficult to obtain the data. This study instead reckons effect of population aging from its determinants, fertility and life expectancy. This study believes that it is the best way to discuss effect of population aging.

1.5 Outline of the thesis

The following section reviews previous studies in determinants of human capital accumulation. Demand factors, supply factors and constraints on education are identified in the section. Section 3 integrates the three categories of factors and makes an equation of enrollment ratio to be estimated. The equation is constructed based on the constraints on education. Variables there however reflect interaction among the constraints, demand factors and supply factors. In turn, Section 4 describes the methodology and data sources. Particular attention is given to reasoning behind its choice of the human capital indicator and unit root tests as well as to some cautions for possible spurious regressions with stationary variables. Section 5 then depicts results of the empirical study. This study detects causes of enrollment ratio of tertiary education in OECD countries together with Granger causality tests in Section 6. Then, Section 7 comes back to examination of its research questions while summarizing contributions of this study. Section 8 concludes the study.

2 Previous studies in determinants of educational attainment or participation

Here, this study reviews previous studies in determinants of educational attainment or enrollment ratios. It begins the review with literatures without explicit consideration of demography. Those models would be good starting points for grasping what factors are used for analyses of educational attainment and enrollment ratios. After that, this study introduces literatures inquiring into family backgrounds. Family backgrounds are crucial factors of educational attainment, so it should not be ignored. The family background literatures also contain discussion of effect of fertility on human capital accumulation. Tradeoff between quality and quantity of children is highlighted in the discussion. Then, depiction of literatures dealing with other demographic aspects such as schooling age population and life expectancy follows. The papers on life expectancy are particularly important because it would be the most significant medium to lead population aging to educational attainment or enrollment ratios. Finally, whereas the above literatures mainly consider factors affecting demand for education, supply side of education is discussed. Discussion of how educational supply is determined is conductive to identification of constraints on educational expansion, which, if exist, may inhibit population aging from stimulating educational attainment and/or enrollment ratios. Empirical strategies will be formulated based on the discussion overall.

2.1 Non-demographic factors

Agasisti (2009) looks into determinants of entry rates in university education of 14 European countries from 1993 to 2003. The entry rates are defined by proportion of people who enter the education for the first time according to his data source (OECD 2005). For determinants of the entry rates, five factors are considered: nation’s economic wealth expressed by GDP, human capital level of the adults, returns to university education, resources into university education and earning inequality. While it is expected that almost all the factors above positively affect the entry rate in university education, earning inequality can be taken as both a barrier and stimulation of the education: earning inequality represents big opportunity by education whereas it also indicates that some people may be too poor to enter schools. Therefore, effect of the earning inequality can be ambiguous. He includes the earning inequality in his models in order to derive policy suggestions regarding income inequality issues. The results of the analysis overall indicate importance of increase of nation's economic wealth, public expenditures into education, subsidies for family and students, and earning inequality, for increase of entry rates to university education. All the specifications on the other hand do not find the significance of human capital level of adults and returns to education.

Another study conducting international panel data analysis of human capital accumulation is Winter and Wirz (2002). They examine enrollment ratios to university education of the same 14 European countries as those in the previously mentioned article. They however target dissimilar periods, 1980-1996, and contain somewhat different independent variables from those of Agasisti (2009): public expenditures to education total, the expenditures just for higher education, a dummy variable for existence of tuition fees, and dummies depicting extent of strictness of entry exam in high school system. It can be said that they try to account the educational outcome for difference of educational system rather than difference of economic situation across countries. In the results, they find statistical significance of the variables of tuition fees with the negative value and of public expenditures for education total with the positive value. While they cast caution to interpretation of the dummy variable of tuition, the results overall suggest significance of governmental supports for education. On the contrary, a variable for returns to the education does not develop statistical significance same as that in Agasisti (2009).

In all, the two literatures with focus on non-demographic factors suggest importance of economic wealth; tuition fees; public expenditures to education, family and children; and earning inequality, for determining educational participation. Return on education on the other hand may not be significant for educational participation.

2.2 Family backgrounds and fertility

Björklund and Salvanes (2010) present excellent review of studies in relationship between family background and educational attainment. This study mentions about four important findings of the review. First, the contribution of family backgrounds is quite large: family backgrounds account for around half of variation of educational attainment. That is, individual educational attainment is largely determined by family background, not by other economic factors such as macroeconomic fluctuation. Second, parental education can be attributed to, without control variables, about one third of the family background correlation. In other words, they explain approximately 50*0.33=17% of educational attainment. Yet, it should be noted that parental education without control variables can contain influence of not only direct effect of the educated parents but also indirect effect of them through for example their relatively high income. In fact, the correlation, especially that of mother's education, becomes small when other factors than parental education are controlled for. Third, family size is not correlated with educational attainment with statistical significance while birth order has statistically significant negative correlation with it. Those mean that children in large family do not have disadvantages in attaining education against ones in small family, though children borne later in each family have lower educational attainment than the siblings borne earlier. Björklund and Salvanes (2010) motivate the negative coefficient of the birth order by fewer time and money allocated to the latecomers, higher possibility of divorce after the first birth or whatever. Finally, examination of short-term influence of parental and maternity leave presents inconclusive results. Whereas some of the studies show positive effect of the parental leave or of time spent for children by the parents to the children's educational attainment, others do not. Although the findings are suggestive, they basically pertain to individual level and may not necessarily be true for macro level educational attainment.

Next, this study focuses on family size or fertility. Although Björklund and Salvanes (2010) above identifies negligible effect of family size to educational attainment, there are both theories and evidence indicating positive impact of low fertility on investment in children's human capital. From a theoretical viewpoint, Grimm (2003) explains mechanisms between fertility decline and human capital accumulation with endogenous fertility models, which incorporate choice of number of children by parents. In the models, parents face tradeoff between quality and quantity of children. When cost per child increases and/or the cost per quality of children decreases, parents maximize their utility by decreasing quantity of children and instead heightening their quality. The society then moves toward less fertility and higher human capital of the children. Like this, decline of fertility has strong association with improvement of quality of children in theoretical models.

As empirical evidence for positive impact of low fertility on investment in children's human capital, Lee and Mason (2010) find that proportion of expenditures into children's human capital to average labor income increases when fertility declines. That is, larger amount of expenditures is allocated to children's human capital as the number of children decreases. Although they adopt very small cross sectional analysis—sample size just 19—and they do not control for other factors than the expenditures and fertility, the result is suggestive. Increase of social expenditures into children according to fertility decline seems true, though its impact on children's educational attainment may be negligible considering the no identification of positive effect of family size to educational attainment in Björklund and Salvanes (2010).

2.3 Cohort size and class size

Meanwhile, Bound and Turner (2007) identify negative effect of large cohort to their educational attainment in U.S. after mid-1950s. They conduct state-level bivariate regressions of the number of college enrollment and number of Bachelors on college age population. The regressions indicate that large cohort has fewer Bachelors per person, size of which is corresponding to a 4% decline of Bachelors per person for 10% increase of the cohort size from the previous year. They explain the significant decline by lack of educational supply or the supply constraint. Although there is possibility where the decline was caused by bad preparation of the large cohort for entering colleges—large cohorts indicate possession of less educated parents as well as large class size that may degrade efficiency of compulsory education—, they refute the possibility by presenting small effect of the possible bad preparation. Thus, the lower educational attainment of the large cohort would be due to the supply constraint.

Related to cohort size, effect of class size to educational attainment is very delicately investigated by Wößmann (2005). He examines how scores of The Third International Mathematics and Science Study (TIMSS) in 17 Western European countries change according to class size. In the analysis, he deals with missing data and confounding factors of relationship between class size and the scores in a very delicate way. For instance, he controls for peer effects—children in the same classroom may learn each other and their performance is not independent—, and sorting effects—schools may gather a particular quality of students into small class or large class—, by introducing dummy variables for schools, implementing instrument variable methods and so on. The class size should have effect independent of other confound factors to the test scores by those deliberate specifications. The results however consistently show no effect or very small effect of class size to student's performance on the TIMSS. He concludes that policies to reduce class size would not be cost effective considering expensiveness of the policies, while warning that the effect of class size may depend on interaction among the size, quality of the teacher and quality of the students.

2.4 Life expectancy

Next, this study moves on to review of three literatures discussing effect of life expectancy to human capital accumulation. First, Zhang and Zhang (2005) estimate an equation where economic development depends on initial GDP per capita, initial educational attainment and initial life expectancy at birth. The equation is then applied to cross sectional analyses of secondary school enrollment ratios in 1990 of data of Barro and Lee (1994). The results depict that the educational attainment and logarithm of the life expectancy in 1960 positively correlate with the secondary school enrollment ratios in 1990 with statistical significance. The size of the positive correlation of the life expectancy does not differ even when some variables such as governmental consumption are added, while it becomes much larger when the sample is limited to countries relatively developed in 1960. The result submits relevance to this study, where effect of life expectancy to human capital accumulation of developed countries will be examined.

Second, Castelló-Climent and Doménech (2008) uses a similar model to Zhang and Zhang (2005) for examination of relationship between human capital accumulation and life expectancy. Their uniqueness however lies in the use of human capital Gini index, which was calculated in their previous research. They regress the secondary enrollment ratios in 1985 of the updated data of Barro and Lee (Barro and Lee 2001) on the human capital Gini index, dummy variables accounting for some regions and outliers, and life expectancy at birth in 1985 that is not in the logarithm form and not in 1960 differently from Zhang and Zhang (2005). While controlling for initial economic wealth and initial educational attainment, they find that the life expectancy always possesses statistically significant positive coefficients to the enrollment ratio. Also, the human capital Gini index in 1960 has negative correlation with the enrollment ratios in 1985, though the negative correlation of the Gini index vanishes by introduction of the life expectancy at birth in 1985. The results overall suggest no direct contribution of the human capital inequality to the enrollment ratios and short-term positive relationship between life expectancy and enrollment ratios.

Last but not least, Jayachandran and Lleras-Muney (2009) take a micro approach to investigate influence of rapid increase of life expectancy of the girls in Sri Lanka from 1946-1953. The rapid increase of life expectancy was caused by sharp drop of maternal mortality, so they use maternal mortality as a substitute for life expectancy in their regressions of educational attainment. In the analyses, they regress literacy rates and years of schooling of the young cohorts on the interaction term between the female dummy variable and three year lagged maternal mortality rates. They also control for difference of years, gender, districts and ages by dummy variables. The results show that decrease of maternal mortality was associated with increase of literacy rates and years of schooling of the girls regardless of the specifications, though some of the specifications do not present the statistical significance. Although this study finds the results somewhat inconclusive due to the statistical insignificance of the maternal mortality in some specifications, the nonexistence of positive values of the maternal mortality for the different specifications would be noteworthy. The three studies introduced in this section indicate robust positive influence of life expectancy to educational indicators in both short term and long term.

2.5 Consideration of supply factors of education—economics of higher education

While this study has discussed factors affecting mainly demand for education, factors determining educational supply are also crucial. Lack of the educational supply is detected by the research of Bound and Turner (2007) referred to in Section 2.3. When the demand satisfaction is inhibited by lack of the supply, the demand factors may not perform their full potential and not develop statistical significance in the empirical studies. Inquiry into how educational supply is determined would be very important for the right specification of empirical models for educational indicators.

The supply factors that can be identified from the discussion until now would be just expenditures into education. This study next discusses literatures of economics of higher education since the literatures illuminate supply factors as well as factors possibly constraining educational expansion.

First, Weiler (1987) sets up an equation of educational supply with budget of educational institutions, the number of the faculties and the tuition level. Although he warned incompleteness of the variables, the institution's budget, the tuition level and the number of the faculties can be regarded as factors determining the supply. Yet, he recommends estimating supply and demand equations simultaneously with the maximum likelihood method due to the large biases that he demonstrates in estimates of the ordinary least square method just with the demand equation.

Second, this study comes back to the literature of Bound and Turner (2007), the study of influence of cohort size to educational attainment. They explain high persistency of educational supply or the number of enrollment of educational institutions with theories of economics of higher education. Low enrollment of students indicates low share of revenues from the enrollment, like tuition fees, in total revenues. In that case, further enrollment of students does not add much to the revenues or just dilutes resources allocated to each student. The institutions resultantly do not choose expansion of the enrollment. On the other hand, for the institutions with high enrollment, share of the enrollment revenues would be high, encouraging them to bring more students in. In all, institutions with low enrollment do not increase their enrollment very much while those with high enrollment hope to enroll more. The number of enrollment of the former educational institutions shows considerable persistency. They also point out that the number of enrollment varies according to objectives of the institutions. Some institutions aim at quality of education while other institutions embrace access to education. In fact, elasticity of increase of cohort size to increase of enrollment is very high for community college and private colleges: 0.82 and 0.99 respectively.

Existence of such a college seems the most important factors removing the supply constraint.

Finally, Winston (1999) presents three characteristics of educational institutions, the last of which can lead to constraints on educational expansion: positive feedback of quality, rigid hierarchy among the institutions and selectivity in students. Educational institutions often provide subsidies to qualified students in order to attract them and generate sophisticated output with them. The more sophisticated output can produce more revenues, and the institutions can provide not only higher quality but also higher subsidy to invite much more qualified students. The more much qualified students would devise better output, so overall there is positive feedback in quality of the institutions. The positive feedback eventually leads to rigid hierarchy among the institutions: high quality institutions become better while low quality institutions become worse. Finally, in order not to fall down the hierarchy, the institutions tend to select students with deliberate criteria. The selectivity in students can be considered as a main source of constraint for educational expansion.

Overall, mitigation of educational supply constraint seems to happen due to educational institutions aiming at access to education or ones driven by high shares of revenues from enrollment. The other institutions focus on quality of students and would not change their supply according to change of the demand. The educational institutions for the mitigation of the supply constraint can be captured by public expenditures into education since they should partly contain spending to such an institution. Also, number of private educational institutions may be a good candidate for the supply variable considering their superior responsiveness to increase of the demand.

2.6 Constraints on educational expansion

However, there are still other factors that hinder expansion of education than lack of supply from educational institutions. This study lists two more factors for the constraints on the potential demand: monetary cutoffs by tuition fees and quality cutoffs by admission criteria. The two constraints are indicated from the literatures of economics of higher education above, but not discussed intensively. The two cutoffs can be regarded as voluntary cutback of educational supply, while the supply constraint argued in Bound and Turner (2007) can be considered chiefly as involuntary lack of the supply. In order to make difference of the educational constraints clear, this study defines the supply constraint as involuntary lack of supply from educational institutions. However, the three constraints can influence each other. For example, educational institutions may heighten the quality cutoff when they suffer from the supply constraint in the face of explosion of the schooling age population. It would be difficult to completely differentiate them, but the classification helps this study specify econometric models for educational expansion in two ways. First, this study will prepare variables according to the three constraints. For instance, growth of GDP per capita should contribute to overcoming income cutoff. Subsidy for family or children should also mitigate the income cutoff. Likewise, this study motivates variables in the models by their relationship with the three educational constraints. As the second way to make the most of the classification of the educational constraints, this study tries to separate countries or years of the econometric study by ocular inspection of the variables related to the educational constraints. Details of ways for the separation as well as the specification according to the educational constraints will be exhibited in the next section.

3 Theoretical framework

This study moves on to development of a theoretical framework for the econometric studies of relationship between population aging and enrollment ratio in tertiary education. The basis of the framework will be described in the form of an equation, which encompasses all of the three factors of educational expansion discussed in the previous section: demand factors, supply factors and constraints on education. This study motivates variables in the equation especially according to the constraints, which in turn hints how to detect the educational constraints. Hypotheses to be tested in the econometric studies will be defined in the end.

3.1 Basic frame—an equation encompassing demand factors, supply factors and educational constraints

The basis of the theoretical framework can be written with the following equation:

$$dEN_t = dQ_t + dM_t + dD_t \qquad (1)$$

, where t is time, dEN means change of an enrollment ratio, dQ, dM, and dD describe improvement of quality, monetary, and supply-demand situations surrounding candidates for the education respectively. dQ takes not only elevation of quality of the candidates but also change of quality cutoff set by educational institutions into account. In turn, dM considers change of both the income cutoff and income of the candidates. The last educational constraint, involuntary lack of educational supply, would affect not only dD but also dQ and dM because lack of educational supply can nullify increase of all of the demand, income and quality of the candidates. Thus, all of dQ, dM and dD connote influence of the involuntary supply constraint. However, this study reckons that the involuntary supply constraint is particularly evident in dD. Increase of dQ and dM is basically associated with characteristics favored by educational institutions: quality and money. Educational institutions will therefore act toward satisfaction of dQ and dM, and the supply constraint does not matter for the variables. On the other hand, dD just describes increase of demand unrelated to quality and money. Educational institutions will not prioritize such a demand. Therefore, the supply constraint would work particularly for dD. Degree of the supply constraint can be evaluated by examining variables related to dD as done in Bound and

Turner (2007)—they use increase of cohort size, which has negligible effect on quality of the cohort, for discussing educational supply constraint.

While the three constraints for educational expansion are implicitly embodied in the equation, the demand factors and supply factors discussed in the previous section are also related to dQ, dM and dD. The demand factors relevant to dQ, the quality situation, are parental or previous human capital, and possibly fertility and class size. Although other family backgrounds would considerably determine quality of the candidates as suggested in Björklund and Salvanes (2010), indicators of them are difficult to obtain. In turn, subsidy to family and educational institutions should contribute to dM, the monetary situations, by increasing income of their parents as well as lowering the monetary cutoff. Economic wealth should also lead to improvement of dM by the same reasons. However, when the increase of economic wealth exacerbates income inequality, it may inhibit children of some households from attending schools by depressing their income. Direction of influence of economic wealth and income inequality on dM may depend on countries. Meanwhile, change of life expectancy, cohort size for the education, returns to education and unemployment would mainly affect dD, the demand-supply situation, situation unrelated to quality and monetary situations. While increase of cohort size and aggravation of temporary unemployment has short-term influence, increase of life expectancy and of long-term return to education affects an enrollment ratio in long-term. However, in order to discuss sheer effect of increase of life expectancy to enrollment ratios, controlling for factors related to quality would be of necessity because increase of life expectancy may reflect increase of smartness or quality of the candidates. Without controlling for factors related to quality, life expectancy will not describe only effect of extension of lifespan to dD and dEN. The same discussion can be applied to a variable of economic wealth—quality of the candidates can increase along with economic development. Advancement of quality of the candidates should be captured by other variables in order to emphasis sheer effect of life expectancy, GDP capita and so on.

In turn, the supply factors would have different implications from ones of the demand factors: the supply factors influence dQ, dM and dD through mitigation of educational constraints. In addition, the influence differs according to types of the organizations of the supply. First, increase of expenditures and/or teachers of private educational institutions are mainly associated with mitigation of educational supply constraint since Bound and Turner (2007) show that private educational institutions tend to catch up with expansion of the cohorts very well. Thus, the increase should largely affect dD, the most vulnerable component to the supply constraint. Second, expenditures and teachers of public institutions that aim at universal education would have similar effect to ones of private educational institutions, but the expenditures should attain higher contribution to dM by growing the number of cheap educational institutions, which would not occur with increase of private educational institutions. Finally, effect of increase of expenditures and teachers of other public institutions should be smaller than that of the other type of public educational institutions mentioned above because such an educational institution tends to focus on quality of students rather than quantity of students, as suggested by their laggardness to expansion of the cohort (Bound and Turner 2007). Supply constraint and dD would not be improved very much by expenditures to other public institutions than ones for universal education.

As shown above, the supply factors would just give rise to alleviation of the three constraints on education. Meanwhile, the demand factors reflect increase of educational demand by the factors under influence of the educational constraints, which in turn must have already been alleviated by the supply factors. As a result, the demand factors just by themselves can tell effect of all of the three factors. The supply factors may not necessarily be needed in order to know how large demand factors have contributed to enrollment ratios. In addition, a few of the demand factors such as GDP capita can contribute to mitigation of the educational constraints. The supply factors may further lose their significance in existence of such a demand factor. Owing to the possible insignificance of the supply factors in the equation above, this study does not stick to inclusion of the supply factors.

Like this, all of the demand factors, supply factors and educational constraints are embodied into dQ, dM and dD. This study assigns particular variables to them in the next section.

3.2 Adjustment of the basic frame

Although this study elucidated importance of control of improvement of quality of the candidates for shedding light on genuine effect of life expectancy and GDP per capita, it is fairly difficult to obtain historical indicators of the quality. Therefore, this study adjusts the basic frame with an assumption regarding dQ that can be described with the following equation:

$$dQ_t = \alpha + \beta * dQ'_t \quad (2)$$

, where α is constant that denotes constant improvement of quality situation of the candidates, β is a coefficient of dQ' and dQ' is improvement of dQ specifically to the period—not constant. Moreover, this study suspects that dQ' is decreasing in level of enrollment ratios for tertiary education, the target of the econometric analysis. That is:

$$dQ'_t = \gamma * EN_{t-1} \quad (3)$$

, where γ is a coefficient expected to be negative. By the assumptions, 'difference' of an enrollment rate is finally associated with its 'level'. The two assumptions would not be unreasonable. When it comes to constant improvement of the quality situation, methods of education have been developed day by day so have knowledge taught in educational institutions been. At the same time, children likely take over at least some degree of knowledge from their parents, as assumed in many economic models (Ehrlich and Lui 1991; Tamura 2000; Zhang and Zhang 2005). Annual improvement of the quality situation from previous periods can be expected, though it must not be completely constant. With respect to the second assumption, the annual improvement of the quality situation may face plight as level of the enrollment ratio as well as the stage of the education become high. Since high quality students must have been enrolled in educational institutions by priority, further enrollment requires quality improvement of lower qualified students. The quality improvement should be difficult because they should be poor at learning as reflected in their quality. Moreover, high level of enrollment ratios can suggest that quality cutoff by educational institutions has been already low such that there is little room of the further reduction. Constant improvement of the quality situation should not be easy especially when educational level becomes high. On the other hand, the improvement would not be hard for the secondary or primary education because its content tends to be easy and they tend to become compulsory. Although studies of Castelló-Climent and Doménech (2008), and of Zhang and Zhang (2005) indicate that higher level secondary enrollment ratios in the past led to higher level of the recent enrollment ratios, this study thinks that the results come from the use of the secondary enrollment ratios or the use of level of the enrollment ratios, not the difference. For the moment, this study expects that dQ' should be decreasing in level of enrollment ratios for tertiary education. Estimation of the result reveals the truth.

The same reasoning as done above would be applicable to increase of life expectancy and economic wealth. That is, positive effect of them to an enrollment ratio should be decreasing in their level. For life expectancy, forced retirement may limit higher returns to education by increase of life expectancy. Elevation of economic wealth in turn may not trickle down to the candidates subject to monetary cutoff as economic wealth becomes high. Therefore, dD and dM can be rewritten by:

$$dD_t = \beta_1 * dLE_t + \beta_2 * LEt_{t-1} + dD'_t \quad (4)$$

$$dM_r = \beta_3 * dGDPcap_t + \beta_4 * GDPcap_{t-1} + dM'_t \quad (5)$$

, where β_1 to β_4 are coefficients, LE means life expectancy, GDPcap is GDP capita, and dD' and dM' are improvement of the quality and monetary situation by other factors than LE and GDPcap respectively. With those assumptions, the equation 1 becomes:

$$dEN_t = \alpha + \beta * \gamma EN_{t-1} + \beta_1 * dLE_t + \beta_2 * LE_{t-1} + dD'_t + \beta_3 * dGDPcap_t + \beta_4 * GDPcap_{t-1} + dM'_t \quad (6)$$

However, it is possible that the constant term α, which is prepared for constant improvement of the quality situation, accounts for constant improvement of the other two situations, especially when significant factors related to the two situations are omitted. The constant term requires careful interpretation according to specifications.

When it comes to the dependent variable, dEN_t, this study uses enrollment ratio or ratio of students enrolled in educational institutions to the schooling age population. This study does not use the absolute level of enrollment because it can be largely determined by cohort size and may nullify importance of other factors. Meanwhile, use of the enrollment ratio makes interaction among the cohort size, quality and monetary situation very clear. Suppose that educational facilities have fixed quality cutoff, monetary cutoff and supply capacity, and that cohort for the educational facilities have income and quality distributions that stay the same over time. Then, increase of the cohort size decreases the enrollment ratio because the educational facilities do not have enough supply capacity to cover the increase. The decline of the enrollment ratio will be mitigated when educational institutions reinforce their supply capacity, but the enrollment ratio will never exceed the previous enrollment ratio. Owing to the fixed income and quality distribution of the cohorts, and fixed quality and monetary cutoffs of educational institutions, the same proportion of the cohort as before will be enrolled. That is, the enrollment ratio is the same as before at most even when the supply capacity is strengthened. Increase of cohort size itself should have negative or no effect for the enrollment ratio. In order for educational expansion to happen, one of the following four conditions is necessary: decline of quality cutoff, that of monetary cutoff, increase of quality of the candidates and that of their income.

Life expectancy would face the same issue for educational expansion. Even when it increases proportion of a cohort who wants to attend schools, it would not bolster enrollment ratios without attracting wise or affluent students or making educational institutions lower the cutoffs. It can be easily imagined that increase of life expectancy has difficulty to boost an enrollment ratio.

3.3 Empirical strategy and hypotheses to be tested

In the empirical studies, this study firstly tries to identify educational supply constraint by examining relationship between enrollment ratio in tertiary education and change of the cohort size. As argued above, the supply constraint would be reflected the most by dD, change of demand-supply situation. dD in turn must be largely affected by cohort size. Thus, examination of the relationship between the cohort size and enrollment ratio should let this study detect the supply constraint as it does for Bound and Turner (2007). When it finds the supply constraint, it investigates countries with the constraint separately from ones without the constraint. This study believes that the separation clarifies sheer roles of increase of life expectancy and of population aging to increase of the enrollment ratio.

In the econometric analyses of the two types of countries according to the supply constraint, this study sets two hypotheses. First, life expectancy has positive correlation with enrollment ratio in tertiary education for countries with little educational supply constraint while it has no effect to the enrollment ratio of countries with the constraint. Second, increase of cohort size influences the enrollment ratio more negatively in the constrained countries than in the unconstrained countries. This study describes its methodology for examining the hypotheses as well as the data sources in the next section.

4 Method and data

This study applies the theoretical framework depicted in Section 3 to panel data analysis of enrollment ratio in tertiary education. As to the sample, this study targets 34 OECD countries from 1970 onward: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. However, this study excludes Australia and Canada from the 34 OECD countries owing to unreliability of the data. The unreliability of the data as well as sources of the data will be depicted in detail in Section 4.2.

In the analyses, this study firstly takes ocular inspection of the enrollment ratio and of increase of the cohort size relevant to tertiary education of the remaining 32 OECD countries. The ocular inspection will let this study classify the countries according to educational supply constraint, which will in turn lead to illumination of significance of effect of the supply constraint to the enrollment ratio. After separating countries, order of integration of the variables for each sample will be examined with panel unit root tests. At least the dependent variable needs to be in order of integration zero, I(0), or variables need to hold cointegration relationship for proper estimation of relationship between the variables. With necessary conditions confirmed, this study will move on to instrumental variable estimations of the equation 6 discussed in Section 3.2. Endogeneity of the variables in the equation is strongly suspected, so instrumental variable approach must be required for identifying sheer causal relationship between them. However, direction of causality is still not perfectly clear by the estimation. Thus, this study will finally conduct Granger causality tests (1980) so as to discuss direction of causality among the variables.

In the following, this study motivates its choice of the dependent variable proper for the objective and of panel unit root tests appropriate for the sample. It also describes the data sources and recent researches of spurious regressions related to I(0) variables. In the end, weaknesses of instrumental variable estimations of this study are discussed.

4.1 Relevance of enrollment ratio in tertiary education to this study

An enrollment ratio in tertiary education is suitable for this study in light of its objective. As described in Introduction, this study aims at discussing validity of the assumption of population aging simulations that population aging will stimulate human capital accumulation. The population aging simulations in turn associate the human capital accumulation with economic growth. Thus, indicators that lead to accumulation of human capital relevant to economic growth must be ones necessary for this study. Enrollment ratios in various stages of education have been widely used in economic growth regressions (Sianesi and Reenen 2003). Although use of the enrollment ratio in growth regressions is often criticized because it describes flow of human capital, not the stock (Ibid; Wößmann 2003), the enrollment ratio is also used for calculating a very popular variable of human capital stock for growth regressions, years of schooling (Sianesi and Reenen 2003; Barro and Lee 2010). As a result, increase of enrollment ratio in tertiary education would increase the human capital stock, and determinants of enrollment ratio must be applicable to the stock. Moreover, an enrollment ratio in tertiary education or number of students of tertiary education is adopted to indicators of competitiveness such as EU regional competitiveness indicators (Annoni and Kozovska 2010) and global competitiveness index (Schwab 2011). Furthermore, other human capital indexes constructed based on income based or cost based approaches (Le et al. 2003) tend to reflect importance of tertiary education. Even ones who oppose to use of the years of schooling indicator need to admit importance of tertiary education for competitiveness or future economic growth. Because of the importance for human capital accumulation relevant to economic growth, enrollment ratio in tertiary education is crucial for establishing positive relationship between population aging and human capital accumulation postulated in recent economic simulations, and must be the first choice of this study, which discusses the positive relationship.

However, there might be another channel where population aging causes economic growth through human capital accumulation. For instance, population aging may stimulate off-the-job training of work forces and incite economic growth. Yet, it is unlikely that population aging spurs off-the-job training of relatively old people without inducing participation in formal education of mainly young people. It can be said that population aging does not lead to any kinds of human capital accumulation when it does not stimulate enrollment ratio in tertiary education.

4.2 Data sources

An enrollment ratio in tertiary education of OECD countries is available from the World Development Indicators (WDI) (World Bank 2012). The enrollment ratio extends from 1970 to 2009 or 2010. Estonia, Germany, and Slovak Republic incur severe missing values of the data while the missing values in the other countries are just a few. As to detail of the indicator, the enrollment ratio is gross: the numerator is total enrollment regardless of age while the denominator considers population of the cohort at relevant age to tertiary education. The indicator therefore contains enrollment of old and middle aged people. As a result, independent variables of this study describe their effect on educational participation of not only young people but also old and middle aged people, which in turn makes interpretation of the variables a little difficult. This study admits the deficiency by inclusion of enrollment of old and middle aged people, and leaves consideration of factors affecting enrollment of old and middle aged people to future studies.

Meanwhile, this study picks up several more variables from the WDI. They are: life expectancy at birth, total fertility rate, unemployment rate of youth, unemployment rate in total and long-term unemployment. Also, this study creates from the data a variable describing returns to tertiary education in unemployment by taking difference between unemployment rate of graduates of secondary education and that of graduate of tertiary education. The difference of the unemployment rates should become larger when tertiary education becomes more important. This study suspects that the indicator can substitute for indicators of monetary returns to tertiary education, which are difficult to obtain in long-term. Expenditures to education are also stored in the data by being estimated by the World Bank. This study divides the expenditures by GDP at local currency of the same data, WDI, and will use the educational expenditures per GDP as a variable describing change of educational expenditure similarly to Agasisti (2009).

In turn, data of GDP per capita are taken from OECD Stat Extracts (OECD 2012). There, GDP per capita is calculated at constant prices in purchasing power parity (PPP). The use of purchasing power parity would be appropriate for describing difference of monetary situation surrounding the enrollment ratio over time and countries because it considers difference of price level by years and countries. Without considering difference of the price level, GDP per capita of countries with high price level becomes high whereas many people there may not have enough money to attend schools. The use of GDP capita in PPP lets the GDP indicator properly reflect improvement of the monetary situation across the countries. The OECD database additional gives private expenditures to education at local currency. The private expenditures to education are divided by GDP at local currency of the WDI so that the index is comparable with the educational expenditure per GDP from the WDI.

Next, schooling age population for tertiary education comes from historical educational data of UNESCO (UNESCO 2012). The UNESCO historical educational data also provide the number of teachers in tertiary education. This study takes rate of change of both the cohort size and number of teacher and puts them in the regressions. By taking the rate of the change, difference of size of countries will be nullified.

While basic demographic variables have already been prepared, this study additionally includes two indicators in the dataset: government expenditures to family and children per GDP and income Gini index as a measure of income inequality. The former derives from Eurostat (2012). As evident from the name of the data source, the data are only available for EU countries. In turn, the source of the data of the latter is United Nations University (2008). While various types of Gini index are stored in the data, this study deletes observations with credibility level as bad as 3, where the income concept and quality of the survey are problematic or unknown. In addition, this study just includes observations where underlying ways to measure the income inequality are almost identical. For example, for the observations of the United States, this study chooses Gini indexes calculated with monetary income obtained from the census. Gini indexes calculated with other income concepts such as income in total, which contains income from assets, are excluded. The final observations then amount to 514. However, they still encompass different measures of income inequality such as one by disposal income and one by earnings. It is recommended that the Gini indexes be used with individual coefficients rather than with the pooled estimators, though this study gives up it because of its bad effect on strengths of instruments for the instrumental variables estimation.

The variables collected are summarized in Table 4.1 with description of degree of the missing data. Although this study has collected variables related to most of the factors described in the theoretical framework, their time periods do not perfectly match each other. Furthermore, some values of some indicators are doubtful enough for this study to cut them. The enrollment ratios in Australia and Canada are the representatives. The enrollment ratio of the former increased from 40 to 66 in one year, from 1992 to 1993, which is in fact comparable with increase of the enrollment ratio from 1970 to 1992. Moreover, it experienced two more jumps of the values after 1993. The observations are implausible. When it comes to the enrollment ratio of Canada, it also depicts considerable jump of the values. In addition, the number of the observations is originally small. Those reasons make this study decide to cut all the observations. As a result of the cut of the enrollment ratio, the two countries will not be subject to analyses of this study. Details of the exclusion of the other values are depicted in the Appendix (Table A.1).

Table 4.1. Variables collected and degree of the missing data

Variables almost without missing data	Enrollment ratio in tertiary education, Life expectancy at birth, Total fertility rate, Schooling age population for tertiary education, Educational expenditures per GDP
Variables with moderate missing data	Unemployment rate of youth, Unemployment rate in total, Long-term unemployment, Returns to tertiary education in unemployment rate, Private educational expenditures per GDP The number of teachers in tertiary education
Variables with serious missing data	Government expenditures to family and children per GDP, Income Gini index

4.3 Unit root tests for unbalanced panel with moderate T and N

Because the number of years (T) of this study is relatively long, at maximum 40, the regressions require a variable with order of integration zero, I(0), at least for their dependent variable. For identifying order of integration of panel data, several unit root tests have been developed and tested. First, Maddala and Wu (1999) develop a Fisher type ADF unit root test that makes use of p-values of individual ADF tests of the cross section. They show that their Fisher type ADF unit root test is superior to the panel unit root tests of Im et al (2003) in large number of T over 50. Second, Choi (2001) additionally develops several Fisher type unit root tests. Their Fisher type unit root tests, though suffering from slightly severer size distortion, generally demonstrates higher power than the panel unit root tests of Im et al. when T is over 50. However, the number of years of this study is smaller than that advocated in those studies, sometimes around 20. The panel unit root test of Im et al. performs higher power in T=25 than the Fisher type test of Maddala and Wu (Maddala and Wu 1999). Moreover not only the Fisher type tests but also the test of Im et al (2003) can be used for panel data with missing data, which is not dealt with by the panel unit root tests of Levin et al. (2002) (Statacorp LP 2012). Although the test of Im et al (2003) undergoes higher size distortion when trend term exists (Maddala and Wu 1999), the existing studies above overall motivate this study to prioritize the panel unit root tests of Im et al.

4.4 Spurious regressions with an I(0) variable in the dependent variable

Since Granger and Newbold (1974), it has become a fundamental principle that regressions between I(1) variables show considerably high rejection rates of the null hypothesis for the coefficient. Such a regression with higher rejection rates than usual settings is called spurious regression. Researchers have currently investigated existence of the spurious regression phenomena in regressions containing I(0), stationary variables. First, Granger et al. (2001) detects existence of spurious regressions even between I(0) variables that are generated by autoregressive (AR) process. The rejection rates of the t-statistics become higher as the AR coefficients of both the variables approach one, the value where the variables turns to I(1) variables. On the other hand, spurious regressions do not happen when the coefficient of either of the I(0) variables is 0. Another notable point of their paper is that the rejection rates decrease when large T and/or an autocorrelation consistent estimator is used. Second, Stewart (2011) examines spurious regressions in equations where at least the dependent variable is I(0) generated by AR process. He at first confirms that R-squared and estimated coefficients of the regressions do not incur spurious correlations. Discussion of the R-squared and the coefficients of regressions with an I(0) variable in the dependent variable should be valid. However, he demonstrates spurious correlation of T-ratios and F-statistics of the regressions by using Monte Carlo simulations (Ibid) There, he encounters the same tendency of the spurious regressions as one in Granger et al. (2001): severer spurious regressions for the regressions with higher AR coefficient of the I(0) variable and no spurious regressions for ones with the AR coefficient 0. In other words, regressions encompassing I(1) variables always become spurious regressions except the case where the other variable is white noise. Even large T does not mitigate the problem; rather, large T tends to worsen the spurious regressions for the case of regressions including I(1) variables in the independent variables(Ibid).

As solutions to spurious regressions, use of autocorrelation consistent estimators and correction of autocorrelation of residuals are recommended by Granger et al. (2001), McCallum (2010), and Martínez-Riveraa and Ventosa-Santaulària (2012). Both the solutions are useful even for regressions with I(1) variables if the variable do not have constant or drift term (McCallum 2010; Martínez-Riveraa and Ventosa-Santaulària 2012). This study therefore tries to use autocorrelation consistent estimators while eliminating autocorrelation of residuals of the regressions.

4.5 Weaknesses of instrumental variable estimations of this study

While this study deals with panel data, it does not adopt the fixed effect or random effect estimators because of limited options for conducing instrumental variable estimations left to this study. It attempts to apply instrumental variable estimations for variables of GDP per capita, life expectancy and fertility since endogeneity of those variables are strongly suspected. Examples of literatures demonstrating causation from human capital accumulation or investment to those variables are Ljungberg and Nilsson (2009) for GDP per capita in PPP, Fuchs et al. (2010) for life expectancy, and Bagavos (2010) for fertility. In turn, instrumental variable estimations necessitate examination of validity of the instruments by various statistics such as the partial R squared of Shea (1997). However, there are no available commands to this study that allow use of all of the various statistics, the fixed effects and robust standard errors, last of which is important for preventing spurious correlations. In detail, a command for instrumental variable estimation of panel data in Stata, xtivreg, is unable to assign standard errors robust to heteroscedasticity and autocorrelation for the regressions. The other commands of Stata for panel instrumental variable estimations cannot be installed because of problems arisen from administrative rights of the computers. On the other hand, commands in Eviews allow use of robust standard errors, but a variety of statistics for testing validity of instrumental variables are not available there for panel data (Quantitative Micro Software, LLC 2010. p.78). Only the ivregress command of Stata, which cannot attach the fixed effects or random effects to the regressions, enables implementation of both various instrumental variable tests and correction of heteroscedasticity. Although it does not still correct for autocorrelation for the standard errors of panel data, this study will eventually nullify correlation of the residuals. Moreover, this study controls for many variables so that the variables included fully account for individual effects that could have been embodied by the fixed effects. For those reasons, this study uses the command ivregress of Stata while abandoning the fixed effects or random effects.

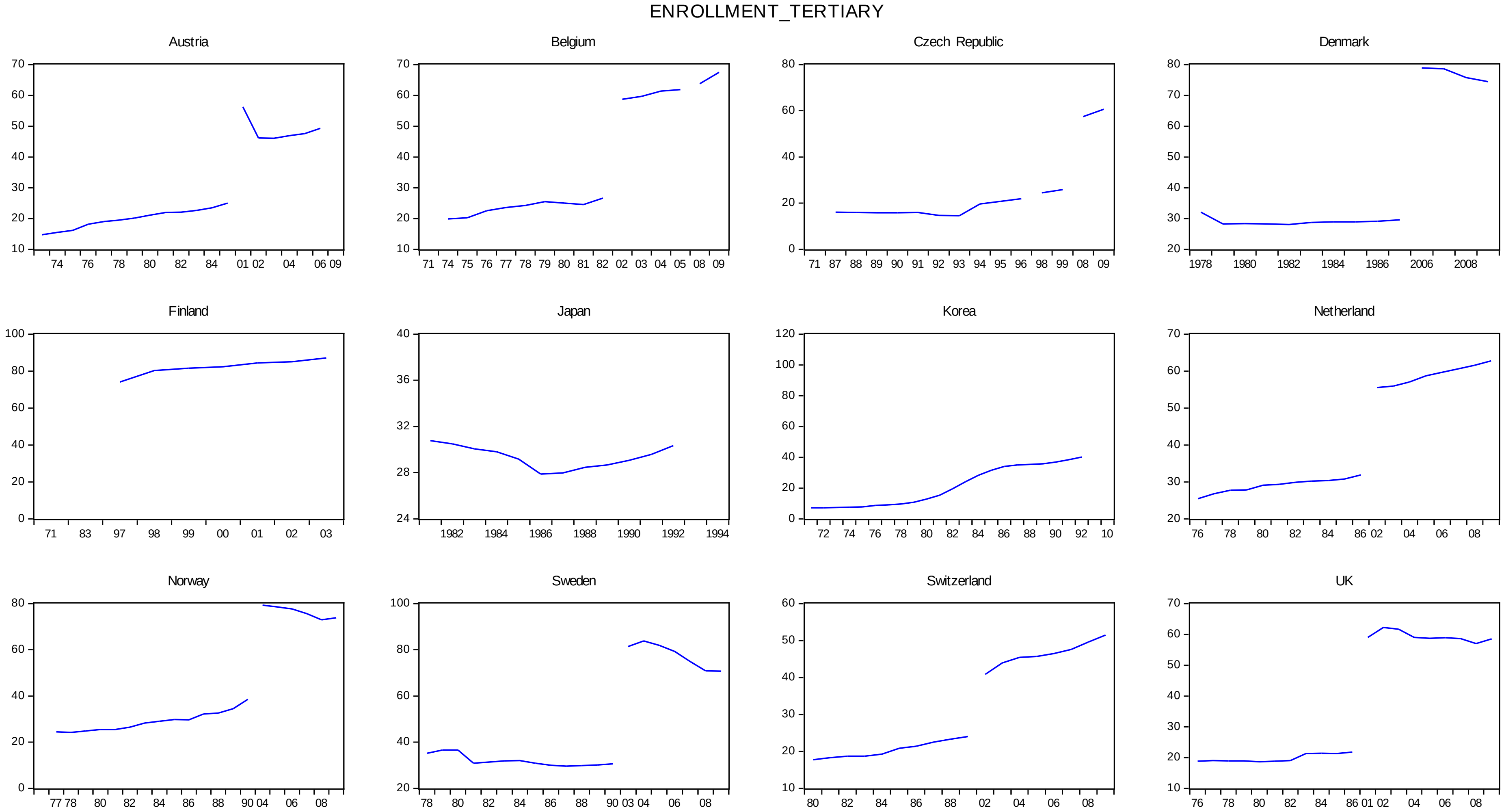
As another weakness, this study gives up inclusion of individual time trend because the inclusion tends to spoil validity of the instrumental variables by adding more instruments little correlated with the variables instrumented. Consideration of individual effects as well as that of individual time trends will be left to future researches.

5 Results

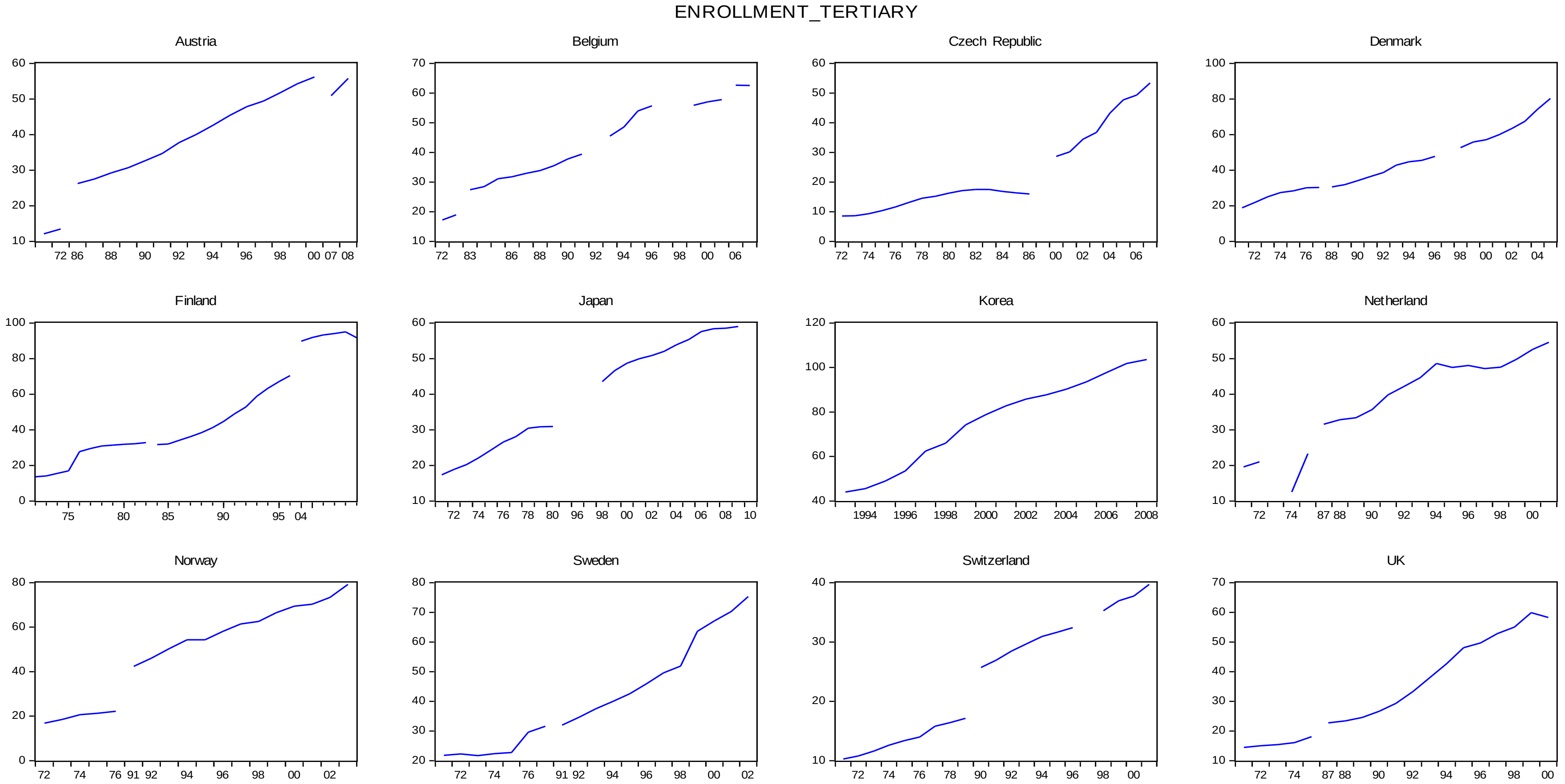
5.1 Ocular inspection and possible educational supply constraint

Graph 5.1 and 5.2 depict time series behavior of enrollment ratio in tertiary education in some OECD countries. While Graph 5.1 pertains to the years where the countries experience increase of the cohort size relevant to the tertiary education, Graph 5.2 includes just years with negative or zero rate of change of the cohort size. Difference of the two graphs is striking. While the enrollment ratio was apparently stagnated in the face of the cohort increase, it presents constant increase in the decrease or no change of the cohort size. Difference of the mean and median between the two periods amounts to above 1% of enrollment ratio, which is statistically significant according to the t-test (For values of the mean, median and standard deviation, see Table A.2 of Appendix). The significant difference of behavior of the enrollment ratio according to change of the cohort size may represent educational supply constraint in those countries. On the other hand, the enrollment ratio in the other OECD countries was not sluggish in the cohort increase (Graph 5.3 and 5.4). Some of them such as Turkey and Portugal show even stagnation of the enrollment ratio in the cohort decrease. Other factors than cohort size should be more important for those countries. However, difference of the mean and median between the two periods (Table A.2 of Appendix) in the likely unconstrained countries is still statistically significant. Detailed examinations by econometrics analyses are needed to determine whether cohort size is a critical factor of the enrollment ratio in those countries or not.

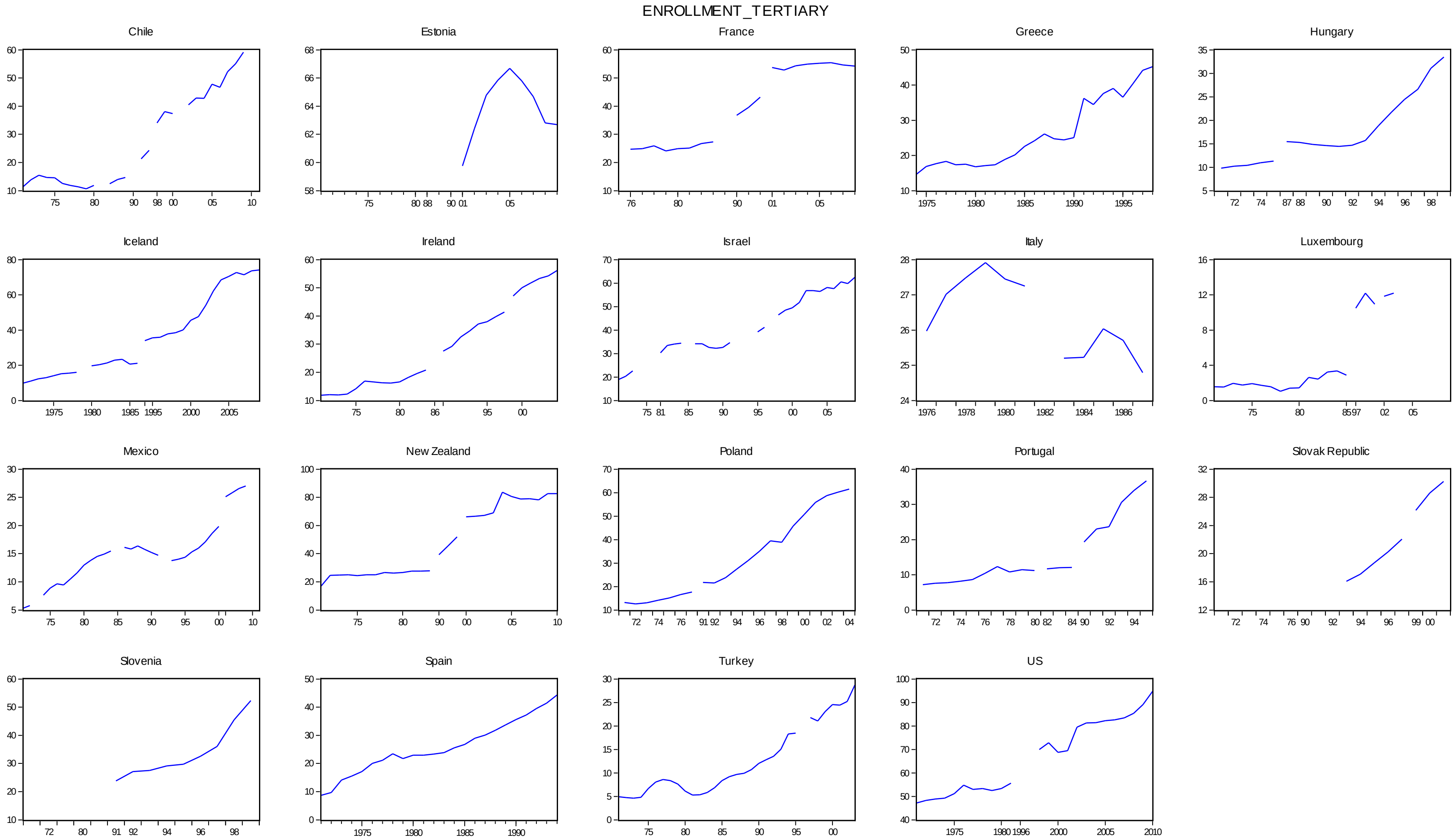
Graph 5.1. Enrollment ratio in tertiary education in some OECD countries when schooling age population for the tertiary education increases



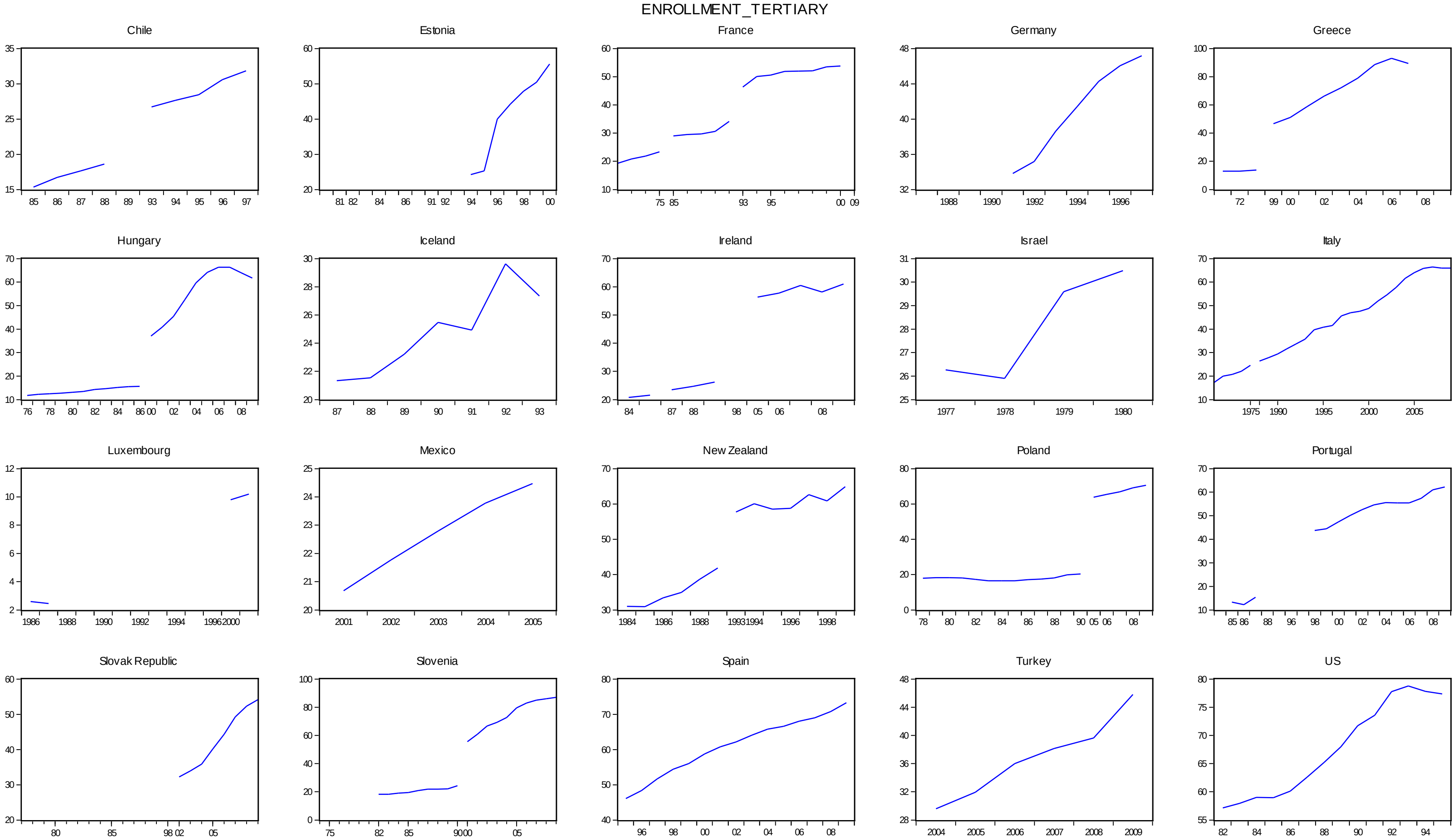
Graph 5.2. Enrollment ratio in tertiary education in the countries of Graph 5.1. when schooling age population for the tertiary education decreases



Graph 5.3. Enrollment ratio in tertiary education in the other OECD countries than those in Graph 5.1. when schooling age population for the tertiary education increases(Data of Germany is missing due to no increase of the cohort)



Graph 5.4. Enrollment ratio in tertiary education in the other OECD countries than those in Graph 5.1. when schooling age population for the tertiary education decreases



5.2 Unit root tests according to countries

According to the indications of the ocular inspection of the enrollment ratio, this study analyzes four categories of the OECD countries separately: countries that likely suffer from educational supply constraint (‘Constrained’), ones that may be free from the supply constraint (‘Unconstrained’), some of the Unconstrained that can be classified into middle-class countries (‘Middle-class’) and the others in the Unconstrained, which are economically advanced (´Advanced´). The breakdown of the countries in the four categories is shown in Table 5.1. The difference between the Advanced countries and Middle-class countries are made by following the classification of Barro and Lee (2010). In the dataset, they classify countries into “Advanced Economies” or others. The latter countries are further separated according to regions where they are located such as East Asia and the Pacific. Imitating Barro and Lee (2010), this study categorizes some of the Unconstrained countries that belong to the “Advanced Economies” in Barro and Lee (2010) as ‘Advanced countries’, and the others of the Unconstrained countries as ‘Middle-class countries”.

Table 5.1. Breakdown of the three categories of the countries investigated

Constrained countries	Austria, Belgium, Czech Republic, Denmark, Finland, Japan, Korea, Netherland, Norway, Sweden, Switzerland, United Kingdom
Unconstrained countries	Chile, Estonia, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Luxembourg, Mexico, New Zealand, Poland, Portugal, Slovak Republic, Slovenia, Spain, Turkey, United States
Middle-class countries (Some of the Unconstrained)	Chile, Estonia, Hungary, Israel, Mexico, Poland, Slovak Republic, Slovenia, Turkey
Advanced countries (The others of the Unconstrained) (not estimated)	France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, New Zealand, Portugal, Spain, United States

Although this study classifies the countries into the four types, it gives up analyses of the Advanced countries due to difficulty to find proper instrumental variables for the models. It instead infers relationship between demographic variables and the enrollment ratio of the Advanced countries by comparison of results of the analyses between the Unconstrained and the Middle-class countries.

For all the categories of the countries except the Advanced countries, this study firstly conducted the panel unit root tests of Im et al (2003). The results for main variables of this study are shown in Table 5.2 (for the complete results, see Table

A.3 of Appendix with Table A.4 presenting the result for the other variables), while Table 5.3 depicts their descriptive statistics. This study selects the main variables because they are mostly free from the missing values. It attempts to add the other variables after analyzing the main variables. Pertaining to results of the unit root test, the dependent variable, difference of enrollment ratio in tertiary education (dEnroll), is I(0) for all the three categories of the countries. Thus, relationship between the dEnroll and the independent variables can be estimated without caring about cointegration among the variables. However, some of the other main variables are I(1). Although this study attempts to include the I(1) variables, lags of life expectancy, GDP per capita and the enrollment ratio, in order to control for those factors, statistical significance of them would require care especially when autocorrelation of the residuals exists as discussed in Section 4.4.

Table 5.2. Results of the panel unit root tests of Im et al (2003) for main variables

	Constrained	Unconstrained	Middle-class
Enrollment ratio in tertiary education (Enroll)	I(1)***	I(1)***	I(1)**
difference of Enrollment ratio in tertiary education (dEnroll)	I(0)***	I(0)***	I(0)**
Life expectancy (LE)	I(1)***	I(1)***	I(1)***
Logarithm of GDP capita (GDPcap)	I(1)***	I(1)***	I(1)***
Change of cohort size (%) (COHORT)	I(0)***	I(0)***	I(0)***
Total fertility rate (TFR)	I(0)***	I(0)***	I(0)**
Educational expenditures per GDP (EXP)	I(1)***	I(1)*** or TS in 0 diff**	I(0)*** or TS in 0 diff**

TS: Trend stationary; diff: difference;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

Table 5.3. Descriptive statistics of main variables of this study

		Constrained	Unconstrained	Middle-class
Enroll	Obs	459	662	283
	Mean	39.170	34.400	29.583
	SD*	21.102	21.426	19.196
dEnroll	Obs	440	620	261
	Mean	1.454	1.458	1.476
	SD*	2.005	2.062	2.009
GDPcap	Obs	485	687	221
	Mean	10.038	9.811	9.382
	SD*	0.437	0.493	0.399
EXP	Obs	461	682	282
	Mean	5.240	4.298	4.257
	SD*	1.303	1.377	1.429
LE	Obs	612	1016	455
	Mean	74.459	72.547	69.877

	SD*	4.395	5.498	6.156
TFR	Obs	612	1017	459
	Mean	1.943	2.349	2.667
	SD*	0.512	1.054	1.310
COHORT	Obs	470	786	355
	Mean	-0.354	0.477	0.825
	SD*	2.083	2.056	2.203

*SD: Standard Deviation

5.3 Results of estimation of the equation 6

Now that this study confirms necessary conditions for proper estimation, it moves on to estimation of relationship between population aging and enrollment ratio in tertiary education. Table 5.4 presents results of regressions of dEnroll on differenced series of life expectancy (dLE) for the Constrained countries. It should be noted again that this study does not use fixed and random effects owing to the limitations of the estimation options described in Section 4.5. The dLE is basically instrumented because the Woodridge score tests (Woodridge 1995) for exogeneity of variables point to rejection of the null hypothesis of the exogeneity at the 5% confidence interval. That is, the dLE is endogenous and should be instrumented. For instruments of the dLE, this study chooses the second lag and fourth lag of LE. Lags of level of variables are often used as instruments for their differences in dynamic panel data analysis as represented by Anderson-Hsiao estimator (Anderson and Hsiao 1982) and Blundell-Bond GMM estimator (Blundell and Bond 2000). Reasoning behind the use is that lags of level of variables tend to obtain high correlation with their differences while they are often predetermined and should not correlate with the contemporary dependent variable. In terms of the two instruments of this study, the second lag and fourth lag of LE should not correlate with dEnroll as indicated by the equation 6 in Section 3.2: they can correlate with $dEnroll_{t-1}$ and $dEnroll_{t-3}$, but not with $dEnroll_{t}$. Moreover, the two variables lead to the highest F-statistics of the 1st stage regression that are calculated based on a partial squared of Shea (1997) in various combinations of instruments. The F-statistics are much higher than 10, a rule of thumb to be overcome for avoiding weak instruments (Baum et al. 2003; Staiger and Stock 1997). Furthermore, the two instrumental variables accomplish very high minimum eigenvalue statistics derived from the Cragg-Donald statistics (Stock and Yogo 2005) such that the statistics exceed the critical values corresponding to 10% rejection rates of the Wald test (Table 5.5). In detail, the critical values are calculated so as for the values to reflect deviation of the rejection rates of the Wald test with the instrumental variables from the rejection rates 5% (Ibid). The nearer the rejection rates of the Wald test with the instrumental variables approach to 5%, the stronger the instruments are. Thus, the instruments would be very strong according to the minimum eigenvalue statistics. However, the Woodridge score tests for over identifying restriction of the instrumental variables indicate that the error terms are correlated with the instruments. Other instruments also do not pass the Woodridge score tests. This study suspects that the situation is caused by the no control of the other variables. The equation 6 whole should be tested.

While the instrumental variable estimations are not reliable very much due to the likely correlation with the error terms, the results themselves are noteworthy. Positive correlation between dLE and dEnroll is identified in the regressions without constant and time trend terms. The instrumental variable regression (IV) particularly shows a high correlation, almost twice higher than that of ordinary least square estimation. On the other hand, the two regressions that contain constant and trend terms depict negative correlations between dLE and dEnroll. Also, the statistical significance of dLE declines as the constant and trend term enter. The same tendencies are detected for the other two categories of the countries (not described). Although positive effect of dLE to dEnroll already disappeared, control of other factors may make results change.

Table 5.4. Results of bivariate regressions between dLE and dEnroll in the Constrained countries (N=440)

Dependent variable	dEnroll(difference of enrollment ratio in tertiary)			
Method	OLS	IV	IV	IV
Intercept			1.883 (0.257)***	-38.438 (18.559)**
dLE	2.579 (0.412)***	4.804 (0.597)***	-2.122 (1.980)**	-1.872 (1.790)*
year				0.020 (0.009)
Variable instrumented		dLE	dLE	dLE
Wald statistics	.(a)	.(a)	3.91**	8.19**
R-squared	0.003	0.003	0.003	0.011
Root Mean Standard Error (MSE)	2.333	2.440	2.041	2.017
First stage regressions (of dLE)				
Instruments added		L2.LE, L4.LE	L2.LE, L4.LE	L2.LE, L4.LE
F-statistics		35.980***	35.980***	35.028***
Minimum eigenvalue statistics		61.919	61.919	61.919
Over identifying restriction test				
Woodridge´s score		66.6591***	4.34894**	17.021***
Exogeneity test				
Woodridge´s score		29.7406***	5.28486**	4.00402**

Standard errors in parentheses; (a): Not obtained due to nonexistence of the constant; ’*’: statistically significant at 10 percent; **’: statistically significant at 5 percent;

'***': statistically significant at 1 percent

Table 5.5. Critical values for the minimum eigenvalue statistics of Table 5.4

Size of nominal 5% Wald test	10%	15%	20%	25%
Critical values*	19.93	11.59	8.75	7.25

*The critical values come from Stock and Yogo (2005)

Next, this study estimates the whole specification of the equation 6 in Section 3.2. Table 5.6 and 5.7 depict the result of the estimation and that of tests for the estimation. Please note that not both dLE and differenced series of GDP capita (dGDPcap) are necessarily instrumented according to suggestions of the Hausman test for exogeneity. The Woodridge test for the exogeneity was not used this time. The Woodridge test can be conducted just for regressions with robust standard errors, but such a regression does not allow examination of exogeneity of several variables at the same time—exogeneity of each dLE and dGDPcap cannot be examined with the Woodridge test simultaneously. The Hausman test must be used for separate examination of exogeneity of the variables.

Table 5.6. Results of IV estimation of the equation 6 for the three categories

Dependent variable		dEnroll	
Countries	Constrained	Unconstrained	Middle-class
_cons	-109.414	-87.162	-67.428
	(31.580) ***	(29.051) ***	(101.556)
year	0.066	0.053	0.024
	(0.016) ***	(0.016) ***	(0.050)
dLE	-0.202	-5.999	1.717
	(0.308)	(2.497) ***	(1.666)
L1.LE	-0.162	-0.102	0.027
	(0.052) ***	(0.065)	(0.069)
dGDPcap	-14.107	5.314	41.527
	(12.154)	(3.800)	(18.931) **
L1.GDPcap	-0.691	-0.822	2.062
	(0.486)	(0.319) ***	(1.478)
COHORT	-0.443	-0.190	-0.241
	(0.047) ***	(0.079) **	(0.166)
L1.Enroll	-0.011	0.005	-0.031
	(0.010)	(0.008)	(0.022)
Variable instrumented	dLE, dGDPcap	dLE	dGDPcap
obs	420	539	175
Wald statistics	121.990 ***	60.420 *** 60.830	***
R-squared	0.188	0.009	0.147
Root MSE	1.830	2.522	2.234

Standard errors in parentheses; '*': statistically significant at 10 percent;

': statistically significant at 5 percent; '*': statistically significant at 1 percent

Table 5.7. Results of tests for the instrumental variable estimation in Table 5.6

Countries	Constrained	Unconstrained	Middle-class
		First stage regressions	
Instruments added	L2.GDPcap	L4.LE, L11.LE	L2.GDPcap
F-statistics			
for dLE		7.413 ***	
for dGDPcap	27.097 ***		8.039 ***
Minimum eigenvalue statistic	55.013	13.407	12.432
Correspondent size of 5% Wald test	5~10%	10~15%	10~15%
		Over identifying restriction test	
Woodridge´s score	.(a)	2.044	.(a)
		Exogeneity test with both dLE and dGDPcap instrumented	
Instruments added	L4.LE L2.GDPcap	L4.LE, L11.LE L2.GDPcap	L4.LE, L10.LE L2.GDPcap
Wu-Hausman Statistics			
for dLE	2.4699	5.8174***	1.6491
for dGDPcap	3.8843**	0.1127	7.7138***

(a): not over identified; '*': statistically significant at 10 percent;
': statistically significant at 5 percent; '*': statistically significant at 1 percent

In turn, the instrumental variable estimations of the equation 6 for the Unconstrained countries and Middle-class countries possibly suffer from bias of the estimates. Their first stage regression F-statistics are lower than 10, the benchmark of weak instruments described above. What is worse, their minimum eigenvalue statistics are relatively low such that it does not arrive at 10% size of the Wald test. Discussion of the coefficients of the two categories requires caution.

When it comes to the results, signs of the statistically significant coefficients basically accord with the hypotheses. It is especially noteworthy that the Constrained countries present more negative value for change of the cohort size (COHORT) than the other two countries. Also, positive and high correlation of the dGDPcap in the Middle-class countries is remarkable since it, together with the positive value of the lag of the level (L1.GDPcap), suggests potent role of economic growth there for increase of the enrollment ratio. Yet, life expectancy variables show negative sign with statistical significance in the Constrained countries and Unconstrained countries. The result was not expected. The negative coefficient of L1.LE in the constrained countries may however be spurious correlation because LE is I(1). The spurious correlation is strongly doubted particularly because the residuals of all the models correlate with their lags. In turn, the negative coefficient of L1.LE can be motivated by the possibility that increase of expenditures related to high expectancy crowds out educational expenditures. Control of expenditure variables should be needed in order to look into the possibility.

5.4 Results of estimation of an augmented model of the equation 6

Since this study has identified deficiencies of the previous models, it attempts other specifications by adding four variables. The first variable is the expenditure into education per GDP (EXP), importance of which for examining the negative value of life expectancy variables is described above. The second variable is difference and the 1st lag of total fertility rate (dTFR, L1.TFR). Although importance of fertility for educational enrollment is inconclusive in existing studies, this study adds the demographic indicator because it significantly reinforces R-squared of models. Finally, this study includes autoregressive (AR) terms of the model, such as $dEnroll_{t-1}$, in the specification above. The addition can be motivated by the high possibility of autocorrelation of the residuals of the previous models. The addition actually mitigates correlations of the residuals of the models very much. Then, by the AR term, the equation 6 can be rewritten with:

$$dEnroll_t = \alpha_0 + \alpha_1 * dEnroll_{t-1} + \alpha_2 * dX_t + \alpha_3 * X_{t-1} \qquad (7)$$

, where α_0, and α_1 are certain values, α_2 and α_3 are vectors of constant while X is a vector of variables. In the equation 7, the differences of the variables, dX_t , can be considered as shocks to the dEnroll. The shocks temporally affect dEnroll but the effect disappears in long-term when the coefficient of the AR term, α_1, is less than 0 and α_3=0. However, when $\alpha_3 \neq 0$, the shocks dX_t will permanently influence dEnroll through X_{t-1}, though the direction of the influence may differ according to signs of those variables. For example, increase of GDP per capita may temporary increase dEnroll but the increased level of the GDP might put downward pressure on dEnroll in the next period. In this case, total effect of GDP per capita to dEnroll can be little. Finally, without the shocks or change of dX_t, the level variables, X_{t-1} and the constant α_0 will determine basic values of dEnroll.

This study simply estimates the equation 7 with AR(1) (L1.dEnroll) and AR(2) (L2.dEnroll) terms by OLS or IV. Whereas it is well known that regressions with AR term and the fixed effects or random effects produce biased estimate of the AR term without both large N and large T (Marno 2008, p.377-8), the AR term does not suffer from the bias when the pooled estimators are used (Galyao and

Montes-Rojas 2010; Han et al. 2010). Thus, this study would be able to estimate genuine coefficients of the AR terms.

The result of the augmented models by L1.dEnroll, L2.dEnroll, lag of EXP (L1.EXP), dTFR and L1.TFR is described in Table 5.8 with results of related tests in Table 5.9. This study does not include dEXP because it does not find proper instruments for the variable—increase of enrollment ratio in tertiary education should increase expenditures to education, so dEXP should be instrumented. However, just L1.EXP can control for change of expenditures to education and liberate L1.LE from its inclusion of possible influence to the expenditures. The exogeneity tests suggest that almost all of the differenced terms become exogenous by introduction of those variables. What is better, autocorrelation of the residuals is largely solved by introduction of the AR terms. Only the model of the Middle-class countries holds the autocorrelation of the residuals with the 5th and 6th lag.

Table 5.8. Results of IV estimation with AR terms, previous level of expenditure to education, and fertility variables

Dependent variable			dEnroll			
Countries	Constrained		Unconstrained		Middle-class	
_cons	-183.089		-46.533		77.035	
	(35.532)	***	(21.871)	**	(73.328)	
year	0.101		0.026		-0.044	
	(0.018)	***	(0.011)	**	(0.039)	
dLE	-0.276		0.141		-0.549	
	(0.323)		(0.416)		(0.642)	
L1.LE	-0.154		0.010		0.013	
	(0.045)	***	(0.035)		(0.044)	
dGDPcap	-17.750		2.440		3.498	
	(12.664)		(2.761)		(3.677)	
L1.GDPcap	-0.537		-0.522		1.370	
	(0.554)		(0.310)	*	(0.785)	*
COHORT	-0.329		-0.058		-0.161	
	(0.059)	***	(0.074)		(0.100)	
L1.Enroll	-0.040		-0.006		-0.023	
	(0.011)	***	(0.009)		(0.012)	**
L1.dEnroll	0.284		0.181		0.236	
	(0.060)	***	(0.075)	**	(0.092)	**
L2.dEnroll	0.127		0.108		0.189	
	(0.061)	**	(0.068)		(0.087)	**
dTFR	-1.311		-0.172		-5.829	
	(1.792)		(1.844)		(3.113)	*
L1.TFR	0.633		-0.395		-0.775	
	(0.406)		(0.159)	**	(0.235)	***
L1.EXP	0.282		0.110		-0.054	
	(0.107)	***	(0.095)		(0.154)	

Variable Instrumented	dGDPcap				
obs	378	460		157	
Wald statistics	186.620 ***	125.040	***	145.900	***
R-squared	0.350	0.162		0.410	
Root MSE	1.651	1.954		1.570	

Standard errors in parentheses; ’*’: statistically significant at 10 percent;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

Table 5.9. Results of tests for the instrumental variable estimation in Table 5.8

Countries	Constrained	Unconstrained	Middle-class
First stage regressions			
Instruments added	L2.GDPcap		
F-statistics for dGDPcap	19.465***		
Minimum eigenvalue statistic	50.328		
Correspondent size of 5% Wald test	5~10%		
Over identifying restriction test			
Woodridge´s score	.(a)		
Exogeneity test with dLE, dGDPcap and dTFR instrumented			
Instruments added	L2+L4.LE L2.GDPcap L2.TFR	L2+L11.LE L2.GDPcap L2+L3.TFR	L4+L11.LE L2.GDPcap L3.TFR
Wu-Hausman Statistics			
for dLE	0.0394	2.3972	0.0938
for dGDPcap	4.7890 **	2.2068	0.1091
for dTFR	0.8007	0.4476	0.1161

(a): not over identified;’*’: statistically significant at 10 percent;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

As to the results, the fertility variables contribute to increase of R-square of the Unconstrained and Middle-class countries. Even for the Constrained countries, the L1.TFR is about to be statistically significant. The signs of the fertility variables are also noteworthy, so this study discusses them intensively in the next section. In turn, the L1.EXP bolsters R-square of just the Constrained countries. Yet, the variable does not nullify the negative sign of L1.LE. The negative coefficient of L1.LE would come from other sources than its possible crowding out of educational expenditures. This study also discusses the negative value of L1.LE in the next section. Next, increase of the cohort size for tertiary education has statistically significant negative correlation with the enrollment ratio in the Constrained countries while it is not significant in the Unconstrained countries.

The result was expected but an unexpected result accompanies: its negative coefficient with statistical significance in the Middle-class countries. Although the coefficient of the Middle-class countries is much smaller than that of the Constrained countries, existence of some degree of the supply constraint is suggested even for the Middle-class countries. Or the negative coefficient might come from positive impact of the cohort ´decrease´ to dEnroll rather than the supply constraint—educational institutions may lower income or quality cutoff when the cohort for tertiary education decreases from the previous period in order to maintain the absolute number of the students. Detailed investigation of behavior of educational institutions in the cohort decrease is preferred. When it comes to the other non-demographic variables, significance of dGDPcap has completely disappeared by the introduction of the AR terms. The significance does not recover even when L1.GDPcap and insignificant lags of the level variables are excluded. The same thing, insignificance even in the exclusion of those level variables, is the case for dLE. In fact, exclusion of all the level variables worsens fit of the models while that of all the differenced terms except the previous dEnrolls does not. It is likely that previous level of variables rather than change of them determines dEnroll. Genuine drivers of the change of the enrollment ratio seem to be the AR terms, COHORT and previous lags of the level variables. Differenced variables must work indirectly on dEnroll though changing the level variables.

This study discusses connotation of the results much more in detail in the next section together with description of results of Granger causality tests. It concludes this section with abstract of results of addition of other variables to the final models above. This study does not discuss them in detail here because the other variables necessitate further cut of observation and generally do not improve the R-squared very much. The variables that improve the final models above are unemployment variables, especially unemployment rate of youth (See Table A.5 and A.6 of Appendix for the result of the estimation). Unemployment variables generally hold the signs indicating that increase of unemployment stimulates participation into education. The significance and expected role of the unemployment variables suggest that consideration of returns to education is needed in the models. On the other hand, the Gini index variable does not enter the model with statistical significance. The insignificance may however be due to the fact that the Gini index variable contains various concepts of income. In turn, whereas endogeneity of the other variables, the private expenditures to education per GDP, government expenditures to family and children per GDP, and the number of teachers for tertiary education are suspected, this study does not detect valid instruments for them even by making use of other indicators of WDI (World Bank 2012). While this study tried to put those variables outside of the instruments by examining their exogeneity, lack of proper instruments inhibits the examination because the Hausman test for exogeneity requires strong instruments (Hahna et al. 2011). This study gives up examination of those variables and leaves it and examination of dEXP to future researches.

6 Discussion

In this section, this study discusses the results of the estimation of relationship between enrollment ratio in tertiary education and its determinants. It particularly ponders implications of the demographic variables in the final model with educational expenditures and fertility. The final model will give clear story of dynamics of change of the enrollment ratio for the Constrained and Middle-class countries. Validity of the story line will be examined by the Granger causality tests with vector autoregressive models.

6.1 Temporary shocks and permanent determinants of change of enrollment ratio in tertiary education

The results overall let this study classify important temporary shocks to and permanent determinants of enrollment ratio in tertiary education according to each category of the countries. Particularly, the result of the Middle-class countries indicates the shocks that accord quite well with endogenous fertility models described in Section 2.2. First, decrease of fertility as well as that of cohort size there generate positive shock to the difference of enrollment ratio in the tertiary education. Then, while the positive shocks persist owing to the AR terms, the lower level fertility brings about higher stead increase of the enrollment ratio than the previous. The fertility decline can further support the increase of the enrollment ratio through decrease of the cohort size. In all, fertility decline has multiplier positive contribution to change of the enrollment ratio. Second, elevation of economic wealth heightens increase of the enrollment ratio of the countries, but the level of the economic wealth rather than the change is important for the increase. Yet, since the coefficient of the previous level of the enrollment ratio is negative, downward pressure is imposed on those positive factors above as the enrollment ratio becomes high. Other factors including unobserved factors seem unimportant very much considering no statistical significance in the time trend and constant terms. Overall, decline of fertility and cohort size, and accumulation of economic wealth would be main drivers of their educational participation in the Middle-class countries. However, it should be noted that the upward pressure of the economic wealth and downward pressure of the high enrollment ratio might be false as those variables are I(1).

Meanwhile, in the Constrained countries, decline of cohort size for the tertiary education works as positive shock to the enrollment ratio. However, decline of the cohort size connotes fertility decline in the past, which can give rise to downward pressure to the enrollment ratio. High level fertility on the other hand can arouse both positive impact on the enrollment ratio by itself and negative influence on the enrollment ratio through causing higher increase of the cohort size than that in low fertility. Thus, change of fertility and change of the cohort size should anyway not have big impact on change of the enrollment ratio. High rise of the enrollment ratio cannot be expected with change of fertility and the cohort size. In turn, high level of expenditures to education permanently contributes to increase of the enrollment ratio. Yet, the interpretation might be wrong due to the possible spurious correlation of the variable. Furthermore, those possible positive contributions will be offset by downward pressures of high level of the enrollment ratio as the enrollment ratio increases. High life expectancy may additionally decelerate the enrollment ratio permanently. Although the statistical significance should be doubted because life expectancy is I(1), the negative sign just itself is notable. The negative impact, if exist, seems to be genuine direct effect of life expectancy since this study controls for many factors that can change according to increase of life expectancy such as expenditures to education. Finally, there are some unobserved factors that are hidden in the time trend and accelerate dEnroll. The positive effect of the time trend is in fact larger than that of the Middle-class countries. While the Constrained countries have more negative factors for change of the enrollment ratio than the Middle-class countries, their enrollment ratio may increase faster than the other with help from the time trend.

Next, this study discusses validity of the positive coefficient of L1.TFR of the Constrained countries, which is about to be statistically significant. According to Björklund and Salvanes (2010) described in Section 2.2, increase of family size likely should not lead to improvement of quality of children. Yet, Bonke and Browning (2011) demonstrate that, for Danish family, per child expenditures to non-durable and semi-durable goods specifically for the children increase as the number of children rises. Denmark is actually included in the Constrained countries and the other Constrained countries might have the same tendency. Or, high fertility can imply family friendly policies, and the policies may eventually lead to increase of enrollment ratio in tertiary education through heightening quality and/or income situation of children. Further examination would be needed to confirm causes of the positive coefficient of L1.TFR.

Finally, this study infers determinants of enrollment ratio in tertiary education in the Advanced countries by comparison of the results between the Unconstrained and Middle-class countries. Most of their coefficients and statistical significance have the same tendencies; however, the same tendencies do not tell that both the countries have the same factors of the enrollment ratio. It is entirely possible that statistical significance of a variable in the Unconstrained countries is caused just by the Middle-class countries, not by the Advanced countries. On the contrary, their difference surely gives important or unimportant factors of the enrollment ratio for the Advanced countries. While the previous level of the enrollment ratio and fertility have statistically significance in the Middle-class countries, they are not statistically significant in the Unconstrained countries. Thus, the two factors are likely unimportant for the Advanced countries. When it comes to important factors for the Advanced counties, difference of the signs of L1.GDPcap between the Unconstrained countries and Advanced countries indicates the important factors: high level of economic wealth puts downward pressures to the enrollment ratio. The result accords with the original intention of this study to put the variable argued in Section 3.2. Although the variable requires care for the interpretation because of the nonstationarity, decreasing impact of income increase to the enrollment ratio is indicated.

6.2 Granger causality tests and reexamination of the temporary shocks and permanent determinants

Whereas this study delineates possible story of temporary shocks and permanent determinants for dEnroll for each category of the countries, the story may be wrong because direction of the causality is not confirmed. Therefore, this study conducts Granger causality tests of the differenced terms with vector autoregressive (VAR) models (Sims et al. 1990). To be specific, this study uses dEnroll, dLE, dGDPcap, dTFR and dEXP for the endogenous variables for the Granger causality tests. If the causality inferences done in the previous section is wrong, the Granger causality test will signify the wrongness.

In the VAR models, this study includes time trend, constant and COHORT as the exogenous variables. Then, it chooses number of lags of vector of the endogenous variables and that of the COHORT so that the VAR models do not incur autocorrelation of the residuals. Yet, the Granger causality test is not applied to the Unconstrained countries because this study does not delineate clear storyline of the development of the enrollment ratio for the countries.

The results of the Granger causality tests for the Constrained countries are depicted in Table 6.1. None of the differenced terms Granger causes the dEnroll as evident from no statistical significance of the variables in the equation with dependent variable of dEnroll. Change of enrollment in tertiary education in those countries would be driven by just the COHORT, the AR terms and time trend.

Table 6.1. Results of the Granger causality test for the Constrained countries

obs: 206			
Exogenous variables: Constant, year, COHORT			
Number of lags of the vector: 13			
Number of lags of COHORT: 0			
Dependent variable: dEnroll		Chi-squared	Significance
Excluded	dTFR	3,565	
	dLE	8,985	
	dGDPcap	11,138	
	dEXP	17,582	
	All	44,905	
Dependent variable: dLE		Chi-squared	
Excluded	dEnroll	21,166	*
	dTFR	25,390	**
	dGDPcap	25,439	**
	dEXP	8,402	
	All	86,467	***
Dependent variable: dGDPcap		Chi-squared	
Excluded	dEnroll	14,221	
	dTFR	18,500	
	dLE	8,039	
	dEXP	9,070	
	All	69,064	*
Dependent variable: dTFR		Chi-squared	
Excluded	dEnroll	11,551	
	dLE	10,564	
	dGDPcap	23,016	**
	dEXP	3,917	
	All	50,218	
Dependent variable: dEXP		Chi-squared	
Excluded	dEnroll	6,598	
	dTFR	14,928	
	dLE	13,156	
	dGDPcap	18,285	
	All	53,921	

'*': statistically significant at 10 percent;
': statistically significant at 5 percent; '*': statistically significant at 1 percent

While the other equations than one of dEnroll does not provide valuable insights for the Constrained countries, very insightful indications can be obtained by looking into all the equations of the Granger causality test for the Middle-class countries (Table 6.2). The equation of dEnroll shows that dEnroll is Granger caused by dEXP. Both dTFR and dGDPcap do not Granger cause dEnroll contrarily to the inference in the previous section. dTFR instead Granger causes dEXP, so indirect effect of dTFR to dEnroll through dEXP is suggested. The statistical significance of the dTFR and L1.TFR may have described their indirect contribution to dEnroll through dEXP, rather than their direct effect. In fact, the VAR model underlying the Granger causality test has negative coefficient for the fertility rate (See Table A.7 of Appendix); therefore, decrease of fertility seems to increase expenditures to education per GDP. The indication accords with the finding of Lee and Mason (2010) described in Section 2.2. It can also be taken as reflection of change of focus of parents from quantity of children to their quality as demonstrated by endogenous fertility models (Grimm 2003)—parents have fewer children while investing in children more because of their focus on the quality. In turn, dGDPcap does not Granger cause any of the differenced terms. The fact is surprising since its significant effect to all of the other variables can be expected. Another remarkable fact is that dLE Granger causes dTFR. The causality matches existing findings for example in Bryant (2007). In addition, as dTFR indirectly contributes to dEnroll, indirect contribution of dLE to dEnroll is eventually suggested. However, sum of the coefficient of the dEXP in the equation of dEnroll is negative, meaning that decrease of expenditures to education per GDP increase dEnroll. While causal link of life expectancy and fertility with enrollment was established, a puzzle is left by the Granger causality test. The results of the estimation in Section 5.4 may be more reliable.

Table 6.2. Results of the Granger causality test for the Middle-class countries

obs: 148			
Exogenous variables: Constant, year, COHORT			
Number of lags of COHORT: 4			
Number of lags of the vector: 2			
Dependent variable: dEnroll		Chi-squared	Significance
Excluded	dTFR	0,042	
	dLE	0,770	
	dGDPcap	0,035	
	dEXP	6,947	**
	All	8,456	
Dependent variable: dLE		Chi-squared	
Excluded	dEnroll	3,267	
	dTFR	3,620	
	dGDPcap	4,137	
	dEXP	0,069	
	All	11,680	
Dependent variable: dGDPcap		Chi-squared	
Excluded	dEnroll	11,793	***
	dTFR	0,488	
	dLE	0,091	
	dEXP	4,239	
	All	16,871	**
Dependent variable: dTFR		Chi-squared	
Excluded	dEnroll	3,585	

	dLE	10,403	***
	dGDPcap	2,024	
	dEXP	1,005	
	All	22,617	***
Dependent variable: dEXP		Chi-squared	
Excluded	dEnroll	4,862	*
	dTFR	9,484	***
	dLE	3,078	
	dGDPcap	0,511	
	All	15,836	**

’*’: statistically significant at 10 percent;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

7 Human capital accumulation and population aging

7.1 Potential of the theoretical framework

At last, this study turns to examination of its main contribution and of the research questions. One of main contributions of this study is integration of various factors of educational enrollment ratio into an equation of an enrollment ratio, where many variables are related mainly to the educational constraints. The integration and equation in fact led to hypotheses related to previous lags of the level variables. For instance, this study has come up with the hypothesis that improvement of quality situation surrounding the candidates might be decreasing in level of the enrollment ratio. The hypothesis had not been tested in existing studies. Although the observed decreasing improvement of quality situation in previous enrollment ratio in the results can be doubted because the variable suggesting it is I(1), the hypothesis might be worth testing in future researches as well. Furthermore, while this study abandoned discussion of strengths of each of the educational constraints with the equation, control of appropriate variables may make the discussion feasible. Seeds of new findings lie in the equation that this study engenders.

One crucial limitation of the equation, however, would be that it is difficult to discuss long-term determinants of level, not change, of the enrollment ratio with the equation. Whereas the limitation is not crucial for the objective of this study because the equation anyway enables discussion of whether population aging stimulates human capital accumulation or not, this study needs to acknowledge the limitation. In addition, several important variables have not been tested owing to difficulty to detect strong instruments for them. Tests of those variables as well as consideration of long-term factors of the enrollment ratio in light of the equation of this study are left to future researches.

7.2 Causes of enrollment ratio in tertiary education of OECD countries

The next main contribution of this study is the finding of probable causes of enrollment ratio in tertiary education of OECD countries. For countries with educational supply constraint, change of the cohort size seems the most significant determinant of the enrollment ratio. The change of the cohort size even would have positive impact in average considering their mean value, -0.354 (Table 5.3), though the contribution seems not big: -0.354*-0.329= 0.12% increase of the enrollment ratio.

When it comes to other determinants of change of the enrollment ratio in the Constrained countries, level of expenditures of education as well as level of life expectancy come out. While the former puts upward pressure to the enrollment ratio, the latter presses it down. However, further verifications should be needed for them because those variables are I(1) and their indications may be spurious.

For less developed OECD countries without educational supply constraint, expenditures into education may be a sheer cause of the enrollment ratio according to the Granger causality test. However, the Granger causality test produced a very contradicting result with intuition. The result may not be trustable. Instead, positive contribution of fertility decline to the enrollment ratio very likely exists. The multivariate regression demonstrates the positive contribution, and Granger causality test verifies the causal link. In addition, the positive contribution accords with indications of endogenous fertility models described in Grimm (2003). All the facts above suggest that fertility is an important cause of the enrollment ratio in the developed OECD countries.

Other factors positively affecting the enrollment ratio are high GDP per capita and decrease of cohort size. The positive influence of the latter is especially plausible because of the stationarity. Yet, the positive contribution of the fertility decline to the enrollment ratio seems much more outstanding. According to the Table 5.8, 0.1 point decrease of the fertility leads to -0.1*(-5.829-0.775)=0.66% increase of the enrollment ratio in the Middle-class countries. In addition, the lowered fertility level permanently puts upward pressure to the enrollment ratio. Fertility decline seems crucial for elevation of the enrollment ratio in those countries.

Finally, this study would refer to the two hypotheses for the econometric study posed in Section 3.3. The first hypothesis for the econometric study, positive effect of life expectancy just in the Constrained countries, is thoroughly rejected by the results. The life expectancy variables hold negative or statistically insignificant correlation with change of enrollment ratio in tertiary education, even under control of the expenditure variable. Yet, this study identifies difference of effect of life expectancy according to existence of the supply constraint. Life expectancy might have negative impact in the Constrained countries while it does not in the Unconstrained and Middle-class countries. The result might hint that the supply constraint play a role to emphasize negative effect of life expectancy on the enrollment ratio. In addition, the Unconstrained countries in fact exhibit positive coefficients of the life expectancy variables. Further inquiry into the Unconstrained and Advanced countries would be favored as a future research as it may lead to identification of positive impact of life expectancy on the enrollment ratio. Meanwhile, the second hypothesis developed in Section 3.3 is supported by the result. Change of the cohort size is not significant in the Unconstrained countries while it is in the Constrained countries. Moreover, whereas the Unconstrained countries also develop negative value with statistical significance for change of the cohort size, the value is much smaller than that of the Constrained countries. Consideration of educational supply constraint in this study seems to work well.

7.3 Relationship between population aging and human capital accumulation, and its implications

Lastly, this study discusses the results in light of the research questions. The two determinants of population aging, increase of life expectancy and decrease of fertility, produced different results according to countries. Thus, this study examines relationship between population aging and human capital accumulation by the two types of countries: the Middle-class OECD countries without educational supply constraint and the OECD countries with the supply constraint.

First, as described above, fertility decline likely has significant positive impact on enrollment ratio in tertiary education in the Middle-class OECD countries. In turn, the Granger causality test also identifies causal link from life expectancy to the enrollment ratio. However, since the causal link is far from the enrollment ratio, this study suspects that life expectancy has negligible effect to the enrollment ratio. The insignificance is supported by the multivariate regressions, where the variables do not develop statistical insignificance. Thus, in relatively developed countries, population aging would heighten the enrollment ratio in tertiary education through fertility decline, not through increase of life expectancy.

Second, the discussion of the results of the multivariate regressions in Section 6.1 detects likely small impact of fertility decline to enrollment ratio in tertiary education in the OECD countries with educational supply constraints. Impact of population aging by low fertility on the enrollment ratio should be negligible. In turn, increase of life expectancy at most has no effect to and might have negative impact on educational participation. Population aging likely does not stimulate enrollment ratio in tertiary educations in the OECD countries with educational supply constraint.

The discussion above actually warns modelers of population aging. On the contrary to the assumption of recent economic simulations of population aging, positive relationship between population aging and human capital for developed countries is not confirmed in this study. Economic simulations of population aging could abandon the assumption of positive relationship between population aging and human capital for right assessment of effect of the aging on the economy.

In turn, policy makers in developed countries could not expect possibility of the stimulation of human capital accumulation by population aging. They could instead increase educational supply in order to avoid possible educational constraints, which have already been seen in some developed countries. Effective measures for prevention of educational constraints would be different according to countries. For instance, when a country forecasts stagnation of educational participation by both educational supply constraint and income cutoff by educational institutions, policy makers there could prioritize expenditures to community college or equivalent institutions because expansion of those educational institutions must lead to both mitigation of the supply constraint and income cutoff, as discussed in Section 3.1. Direct subsidy to children and family must work as another way to prevent educational constraints there. Meanwhile, a country that suffers from both educational supply constraint and public finance constraint could conduct deregulation in favor of private colleges and/or encourage establishment of new private colleges. Policy makers in developed countries could choose proper measures to prevent educational constraints according to situation of the countries. The attempts to increase educational supply are highly recommended also from the viewpoint of preventing the possible negative influence of life expectancy to enrollment ratios in tertiary education.

8 Conclusion

Doubting the assumption of population aging simulations that there exists positive relationship between population aging and human capital accumulation, this study has conducted panel data analysis of enrollment ratio in tertiary education of 32 OECD countries from 1970 onward. Simulations of effect of population aging to economic growth have recently taken the positive relationship into account. Whereas those simulations produce optimistic results against possible threat by population aging, the positive contribution of population aging may not be feasible in reality because some countries may suffer from educational supply constraint or provide education to just wealthy students. This study has examined existence of the positive relationship between of human capital accumulation and population aging by using life expectancy and fertility variables.

Through review of existing studies in determinants of educational attainment or enrollment ratios, this study identifies three factors of enrollment ratios: demand factors, supply factors and educational constraints. The three factors are then integrated into an equation, where the variables reflect interaction among the three types of factors. This study applies the equation to enrollment ratio in tertiary education of 32 OECD countries from 1970 onward. The countries are classified into three categories according to existence of educational supply constraint and their level of economic development.

The results of the panel data analysis together with the Granger causality test indicate that population aging in OECD countries with educational supply constraint would not lead to increase of enrollment ratio in tertiary education. Rather, high life expectancy through population aging might pose downward pressure to the enrollment ratio in the countries. On the contrary, population aging in Middle-class OECD countries with little educational supply constraint can stimulate the enrollment through decline of the fertility. Increase of life expectancy there may increase the enrollment ratio through decreasing the fertility, but the rise of the enrollment ratio would be negligible.

The results of this study leads to conclusion that the assumption of population aging simulations that population aging stimulates human capital accumulation would be invalid at least for developed countries with educational supply constraint. Economic models for those countries could abandon the assumption while policy makers in those countries could attempt to increase educational supply in order to prevent the possible negative effect of population aging to enrollment ratio in the tertiary education.

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Appendix

Table A.1. Observations deleted because of the doubtful values

Variables deleted	Country	Period	Reason
Unemployment rate with tertiary education	United Kingdom	1992	Exceptional value
Unemployment rate with tertiary education	United States	Whole	Unreliable values because the rate is always worse than that with secondary education
Expenditures to education from WDI	Estonia	1987*~1991	Does not change at all just in this period
Expenditures to family and children	Sweden	1995*~2000	Considerable difference from the values after the period
Expenditures to family and children	Turkey	1996*~1998	Considerable difference from the values after the period

*The beginning of the observations for the country

Table A.2. Mean, Median and Standard Deviation (SD) of enrollment ratios in tertiary education (Enroll) for observations according to possible educational supply constraint and change of the cohort size for the tertiary education

Enroll	Countries with the supply constraint in the cohort increase	Countries with the supply constraint in decrease or no change of the cohort size	Countries without the supply constraint in the cohort increase	Countries without the supply constraint in decrease or no change of the cohort size
Obs	202	238	365	232
Mean	0.644	2.142	1.3	1.838
Median	0.585	1.782	0.915	1.456
SD*	1.746	1.957	2.057	2.078

SD: Standard Deviation

Table A.3. Test statistics and statistical significance of the panel unit root tests of Im et al. (2003) for main variables of this study

Trend	with intercept	with intercept and trend	with intercept	with intercept and trend	with intercept	with intercept and trend
Countries	Constrained		Unconstrained		Middle-class	
Enrollment ratio in tertiary education (Enroll)	7,09	2,09	9,50	3,53	6,15	3,79
dEnroll	-9,36 ***	-7,71 ***	-8,29 ***	-6,85 ***	-2,26 **	-4,54 ***
Life expectancy at birth (LE)	8,26	-1,07	7,35	1,67	3,45	4,34
dLE	-23,64 ***	-25,18 ***	-25,82	-27,23	-9,84 ***	-11,77 ***
Logarithm of GDP per capita in PPP (GDPcap)	-0,68	0,73	-0,64	0,96	0,95	0,35
dGDPcap	-12,28 ***	-11,81 ***	-12,52 ***	-11,48 ***	-8,20 ***	-6,91 ***
Change of schooling age population for tertiary education (COHORT)	-5,85 ***	-4,05 ***	-4,49 ***	-3,59 ***	-1,82 **	0,72
Total fertility rate (TFR)	-3,64 ***	4,74	-3,76 ***	2,19	-6,01 ***	-4,99 ***
Expenditures to education per GDP (EXP)	-0,41	-1,45 *	-1,44 *	-1,78 **	-1,17	-1,86 **
dEXP	-18,11 ***	-15,58 ***	-22,67 ***	-19,60 ***	-12,00 ***	-9,03 ***

’*’: statistically significant at 10 percent;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

Table A.4. Test statistics and statistical significance of the panel unit root tests of Im et al. (2003) for the other variables than those in Table A.3

Trend	with intercept	with intercept and trend	with intercept	with intercept and trend	with intercept	with intercept and trend
Countries	Constrained		Unconstrained		Middle-class	
Unemployment rate in total (UNEMT)	-4,11 ***	-2,64 ***	-2,81 ***	-0,44	-2,31 **	-0,32
Unemployment rate of youth (UNEMY)	-2,70 ***	-2,34 ***	-3,00 ***	-0,52	-2,16 **	-0,58
Longterm unemployment rate (LUNEM)	-1,33 *	-2,73 ***	-1,97 **	-1,23	-1,83 **	-0,45
dLUNEM	-9,98 ***	-7,74 ***				
Returns to tertiary education in unemployment (ROIUNEM)	-2,72 ***	0,24	0,32	1,68	0,55	1,58
dROIUNEM			-9,27 ***	-9,24 ***	-5,80 ***	-5,47 ***
Number of teacher in tertiary education (TEACHER)	-6,22 ***	-3,91 ***	-14,02 ***	-9,91 ***	-11,19 ***	-8,22 ***
Private expenditures to education per GDP (PEXP)	-0,38	-0,66	4,25	2,32	0,47	1,53
dPEXP	-10,66 ***	-6,44 ***	-5,47 ***	-3,16 ***	-3,22 ***	-1,97 **
Gini index (Gini)	-2,34 ***	-0,42	-0,10	-1,26	-1,10	-3,27 ***
dGini			-7,23 ***	-2,51 ***	-7,30 ***	-3,72 ***
Government expenditures to family and children per GDP (FCEXP)	-2,69 ***	-1,67 **	-0,60	-0,61	-0,92	1,01
dFCEXP			-7,82 ***	-3,77 ***	-4,89 ***	-1,94 **

’*’: statistically significant at 10 percent;
’: statistically significant at 5 percent; ‘*’: statistically significant at 1 percent

Table A.5.Results of estimation of the equations where unemployment rate for youth (UNEMY) is added to the final models

Dependent variable			dEnroll			
Countries	Constrained		Unconstrained		Developing	
_cons	-230.964		-11.999		112.205	
	(51.543)	***	(37.894)		(99.944)	
year	0.118		0.009		-0.065	
	(0.026)	***	(0.019)		(0.052)	
dLE	0.087		-0.237		-0.708	
	(0.359)		(0.536)		(0.662)	
L1.LE	-0.162		0.034		0.057	
	(0.045)	***	(0.064)		(0.077)	
dGDPcap	21.152		9.339		8.184	
	(19.566)		(4.715)	**	(6.147)	
L1.GDPcap	0.806		-0.678		1.805	
	(0.916)		(0.490)		(1.033)	*
L1.Enroll	-0.050		-0.008		-0.028	
	(0.012)	***	(0.010)		(0.013)	**
L1.dEnroll	0.277		0.189		0.250	
	(0.068)	***	(0.089)	**	(0.105)	**
L2.dEnroll	0.043		0.080		0.182	
	(0.068)		(0.074)		(0.087)	**
COHORT	-0.349		-0.019		-0.135	
	(0.083)	***	(0.089)		(0.125)	
dTFR	-1.715		1.648		-7.286	
	(2.541)		(2.901)		(4.492)	
L1.TFR	0.686		-0.717		-0.758	
	(0.512)		(0.316)	**	(0.374)	**
L1.EXP	0.302		0.161		-0.104	
	(0.127)	**	(0.126)		(0.187)	
dUNEMY	0.216		0.146		0.113	
	(0.162)		(0.041)	***	(0.057)	**
L1.UNEMY	0.041		-0.005		0.012	
	(0.022)	*	(0.015)		(0.020)	
Variables instrumented	dGDPcap					
Obs	281		354		126	
Wald Statistics	199.640	***	61.120	***	86.440	***
R-squared	0.441		0.132 (a)		0.365	(a)
Root MSE	1.630		2.109		1.652	

Standard errors in parentheses; ’*’: statistically significant at 10 percent; **’: statistically significant at 5 percent; ‘***’: statistically significant at 1 percent;

(a): Although the R-squared is not improved compared with the final models of Table 5.8, the worsened result is caused by the change of the observations. The unemployment variables in fact increase the R-squared.

Table A.6. Results of tests for the instrumental variable estimation in Table A.5

Countries	Constrained	Unconstrained	Middle-class
	First stage regressions		
Instruments added	L2.GDPcap L1+L2.IMP(a) L3.CAPF(b)		
F-statistics	7.057***		
Minimum eigenvalue statistic	7.277		
Correspondent size of 5% Wald test	25%~		
	Over identifying restriction test		
Woodridge´s Score	5.402		
	Exogeneity test		
Countries	Constrained for dGDPcap+ dUNEMY	Unconstrained for dUNEMY	Middle-class for dUNEMY
Instruments Added	L2.GDPcap L2.UNEMY	L2.UNEMY	L2.UNEMY L3+L4.IMP(a)
Wu-Hausman Statistics			
forUNEMY	0.2000		
for dGDPcap	3.0894*		
Woodridge´s score		0.1649	1.5493

(a): Import of goods and services per GDP from WDI (World Bank 2012);
(b): Gross fixed capital formation per GDP from WDI (Ibid)
’*’: statistically significant at 10 percent; ‘***’: statistically significant at 1 percent

Table A.7. The underlying VAR model for the Granger causality test of the Middle-class countries (N=148)

Equation of	dEnroll	dTFR	dLE	dGDPcap	dEXP
Constant	-14.56	-3.342	29.799	0.442	0.271
	[-0.212]	[-2.486]	[3.438]	[0.295]	[0.018]
Year	0.00771	0.00167	-0.0147	-0.000220	-7.20E-05
	[0.225]	[2.491]	[-3.404]	[-0.294]	[-0.009]
L1.dEnroll	0.349	0.000712	-0.00899	0.00514	0.0110
	[4.733]	[0.493]	[-0.965]	[3.193]	[0.672]
L2.dEnroll	0.228	0.00242	-0.0114	0.000344	-0.0383
	[2.921]	[1.582]	[-1.150]	[0.202]	[-2.203]
L1.dTFR	0.626	0.283	0.931	-0.0138	-2.910
	[0.145]	[3.357]	[1.712]	[-0.146]	[-3.041]
L2.dTFR	0.221	0.281	-0.0700	-0.0480	1.820
	[0.052]	[3.393]	[-0.131]	[-0.520]	[1.934]
L1.dLE	-0.278	-0.0367	0.119	0.000220	-0.0326
	[-0.452]	[-3.052]	[1.529]	[0.016]	[-0.239]
L2.dLE	-0.357	-0.00143	-0.0520	0.00375	-0.215
	[-0.590]	[-0.120]	[-0.680]	[0.284]	[-1.596]
L1.dGDPcap	0.827	0.0851	-1.055	0.325	0.697
	[0.177]	[0.930]	[-1.790]	[3.186]	[0.672]
L2.dGDPcap	-0.482	0.0779	0.830	-0.0498	0.0844
	[-0.100]	[0.825]	[1.364]	[-0.473]	[0.079]
L1.dEXP	0.246	0.00498	0.000852	-0.0176	0.0545
	[0.627]	[0.648]	[0.017]	[-2.054]	[0.631]
L2.dEXP	-1.017	-0.00604	-0.0131	-0.000713	-0.107
	[-2.576]	[-0.782]	[-0.262]	[-0.083]	[-1.223]
COHORT	-0.347	0.000464	0.0281	0.00129	-0.121
	[-1.080]	[0.074]	[0.694]	[0.184]	[-1.698]
L1.COHORT	0.203	0.00398	-0.0916	-0.00548	0.0917
	[0.383]	[0.384]	[-1.370]	[-0.474]	[0.779]
L2.COHORT	-0.287	-0.0200	0.120	-0.00936	0.101
	[-0.549]	[-1.954]	[1.815]	[-0.820]	[0.867]
L3.COHORT	0.361	0.0267	-0.0453	0.0222	-0.0574
	[0.668]	[2.526]	[-0.663]	[1.884]	[-0.478]
L4.COHORT	0.119	-0.0140	-0.00614	-0.00937	-0.0628
	[0.368]	[-2.226]	[-0.151]	[-1.333]	[-0.877]
Adj. R-squared	0.3386	0.7814	0.2228	0.1665	0.04485
Sum of squared residuals	376.12	0.1442	5.9926	0.1791	18.570
F-statistic	5.7039	33.838	3.6338	2.8353	1.4314

t-statistics in bracket