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# Determinants of Tertiary Graduations

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**ECONOMICS DEPARTMENT**

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## Abstract/Résumé

### Determinants of Tertiary Graduations

This paper proposes and estimates a model of demand for and supply of graduations in tertiary education, which is then used to construct forward-looking scenarios for graduation rates by country. Consistent with evidence that economic returns to education have remained high in spite of rising educational attainment levels, the paper accords a great deal of attention to developments in gross earnings at various levels of the earnings distribution, though other factors are also accounted for. The analysis shows that demand for tertiary graduations increases in per capita incomes, wage differentials between high and medium earners, and PISA scores. Supply of graduations increases in tuitions and (to a lesser extent) government funding, but also in the share of students enrolled in private institutions and PISA scores. Based on the OECD 50-year scenarios for per capita incomes and earning inequalities (Braconier et al., 2014), the estimated model is used to generate future scenarios of demand for tertiary education, pointing to increases between 30 and 60 per cent across OECD countries over the coming 50 years. Such large increases in demand would put pressure on the supply, either requiring substantial additional government spending or a major shift towards tuition funding across OECD countries.

*JEL classification codes:* I2, H52, J24

*Keywords:* education, rate of return, models with panel data

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### Les déterminants des diplômes universitaires

Cette étude propose et estime un modèle de la demande et de l'offre de diplômes de l'enseignement supérieur, qui est ensuite utilisé pour établir des scénarios de long terme pour les taux d'obtention de diplômes pays par pays. Puisque l'évidence empirique suggère que les rendements de l'éducation universitaire sont restés élevés malgré l'augmentation du niveau moyen d'éducation obtenue, l'étude accorde une place importante à ces taux de rendement dans la détermination de l'offre et de la demande de diplômes, même si d'autres facteurs sont aussi inclus dans l'analyse. L'étude montre que la demande de diplômes universitaires augmente avec le revenu moyen, les écarts entre les hauts et les moyens salaires et les résultats des tests PISA. L'offre de diplômes augmente avec le niveau des frais d'inscription à l'université et (dans une moindre mesure) les financements publics ainsi qu'avec la part des étudiants inscrits dans des institutions universitaires privées et les résultats des tests PISA. Sur la base des scénarios de l'OCDE pour l'évolution des revenus moyens et des écarts de salaire au cours des prochains 50 ans (Braconier et al., 2014), le modèle estimé est utilisé pour engendrer des scénarios correspondants pour la demande de diplômes universitaires. Ces scénarios suggèrent que cette demande pourrait être en moyenne dans l'OCDE entre 30 et 50 pour cent plus élevée à terme que les niveaux actuels. Ces importantes augmentations de la demande mettraient une forte pression sur l'offre, qui ne pourrait augmenter de façon semblable qu'à condition d'accroître soit la dépense publique pour l'éducation supérieure soit les droits d'inscription à l'université.

*Classification JEL:* I2, H52, J24

*Mots clés:* éducation, taux de rendement, modèles à données de panel

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## DETERMINANTS OF TERTIARY GRADUATIONS

By Henrik Braconier<sup>1</sup>

### 1. Introduction

1. Levels of educational attainment have been rising rapidly both in OECD countries and emerging economies over the past decades: indeed, the 20<sup>th</sup> century has been described as the “human capital century” (Goldin and Katz, 2008). This rise has supported economic growth, and could continue to do so in coming decades. According to some estimates (Johansson et al., 2013; Braconier et al., 2014), rising stocks of human capital could account for 15-20% of expected increases in GDP per capita in most countries over the next fifty years. Rising educational attainment levels could also help reduce income inequality. For instance, Braconier and Ruiz-Valenzuela (2014) estimate that gross earning inequalities could be roughly 10% higher in the average OECD country by 2060 if the share of the population with tertiary education does not increase.

2. Persistence in skill-biased technological change will likely continue to increase demand for highly-educated workers over the next decades. In this context, a crucial issue is whether educational attainments will rise in line with demand. If investment in human capital does not keep up with increasing demand, the contribution of human capital to growth could be diminished and wage premia from skills and education would likely rise, with negative consequences for income equality. Resolving the tension between supply and demand requires an understanding of the factors driving investment in human capital and appropriate policies in education and other areas. Filling emerging gaps may also have implications for public budgets, as part of the required resources will likely have to come from government spending.

3. Tertiary education plays a key role, especially in OECD countries. Indeed, in emerging economies rising educational attainment levels going forward are likely to involve broad based expansion of the education system -- with rising participation and further years of schooling in all levels of education -- but for most OECD countries rising educational attainments will mainly be due to broadening participation in tertiary education as well as more graduates acquiring double or advanced degrees. Hence, exploring the drivers of future developments in demand for and supply of tertiary education is particularly important to analyse human capital formation in OECD countries. To this end, this paper proposes and estimates a model of graduations in tertiary education, which is then used to construct forward-looking scenarios for graduation rates by country.

4. There are multiple explanations for why tertiary graduation rates have increased fast during recent decades, including the extent of funding available and rising per capita incomes. One fundamental reason is, however, that the economic returns to education have remained high in spite of rising educational attainment levels. Without high private and social returns, it is hard to conceive such sustained investment in human capital. Thus the paper accords a great deal of attention to developments in gross earnings at various levels of the earnings distribution.

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1. At the time of writing, Henrik Braconier was a senior economist in the OECD Economics Department. The author would like to thank Giuseppe Nicoletti and Åsa Johansson and other colleagues at the OECD for valuable comments and suggestions. Giacomo Magistretti provided invaluable research assistance. Sarah Michelson and Ines Gomez Palacio provided excellent editorial assistance.

5. The analysis shows that demand for tertiary graduations (proxied by the number of graduations) increases in per capita incomes, wage differentials between high and medium earners, and PISA scores. Supply of graduations increases in tuitions and (to a lesser extent) government funding, but also in the share of students enrolled in private institutions and PISA scores.

6. Based on the OECD 50-year scenarios for per capita incomes and gross earning inequalities (Braconier et al., 2014), the tertiary education model developed in this paper is used to generate scenarios for demand for tertiary education, pointing to increases between 30 and 60 per cent across OECD countries over the coming 50 years. For most OECD countries these increases are substantially larger than those assumed in the OECD 50-year scenarios, which assume that levels of attainment will gradually flatten and converge across countries. Large increases in demand would put pressure on the supply, either requiring substantial additional government spending or a major shift towards tuition funding across OECD countries.

7. The rest of the paper is organised as follows. Section 2 describes the analytical framework, pointing to potential determinants of supply and demand for tertiary education. Section 3 presents the data and provides empirical estimates of the model. Section 4 provides the forward-looking scenarios.

## 2. The analytical framework

8. In comparison to earlier stages of education, tertiary education in the OECD has some specific characteristics. First, it is not compulsory or semi-compulsory as primary and secondary schooling. Hence, it has to provide students with some sort of intrinsic return in order for them to enrol and graduate. Second, it is much more reliant on private funding, especially tuition fees. These contribute less than 10 per cent of the available funds in primary and secondary schooling but roughly 30 per cent in tertiary education in the OECD area. Third, as early-stage and later-stage education are complements – and thus education begets education – participation and graduation is linked to previously acquired skills. Fourth, peer-effects are likely increasing with the complexity of issues dealt with and the maturity of peers, meaning that these effects are likely more important in tertiary education.<sup>2</sup> To analyse the determinants of graduations in tertiary education, this paper attempts to capture some of these features within a simple supply and demand framework, following similar approaches taken by, among others, Berger and Kostal (2002) and Oliveira Martins et al. (2009).

### 2.1 Demand for tertiary education

#### *Main demand drivers*

9. Demand for tertiary education entails both monetary and non-monetary returns. As discussed in Oliveira Martins et al. (2009), the monetary returns of tertiary education (compared with an upper secondary degree) can be summarized by the internal rate of return to investment in tertiary education. This return is a function of the expected benefits of graduating -- which include net wage increases, higher employment probabilities, higher statutory pension benefits and higher productivity levels due to delayed entry and exit into the labour market (given rising overall labour productivity) – and the expected costs of graduating – which include the direct and indirect costs of education (tuition fees, increased living costs etc.) and the opportunity costs, in terms of foregone labour market earnings, associated with participation in tertiary education. Oliveira Martins et al. (2009) show that higher internal rates of return – as estimated by Boarini and Strauss (2010) – lead to higher graduation rates in a panel of 20 OECD countries.

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2. In this paper, tertiary education, graduation and graduates are all defined as ISCED 5A+5B+6, following the International Standard Classification of Education.

10. While an “all-inclusive” internal rate of return measure is theoretically appealing, this paper adopts a simplified approach including only a few of the above-specified components. This is done for four reasons. First, direct costs of education may to some extent be endogenous, entering both demand for and supply of tertiary education. This does not apply to other components of the internal rate of return and, hence, an all-encompassing internal rate of return approach cannot be used to investigate the interplay between supply and demand. Second, the computation of an internal rate of return is very data intensive, which would limit the sample size. While Boarini and Strauss (2010) construct all-encompassing internal rates of return for 21 OECD countries, the data requirements and the complexity of the computations implied that estimates were only produced for a fairly limited sample of country-years, with the latest year for most countries being 2001. Thirdly, the simplified approach is more flexible in that it allows the impact of different demand components to deviate from the restrictions that an all-encompassing internal rate of return equation would impose. Finally, the lack of data on some of the variables needed to construct an all-encompassing internal rate of return would hinder the construction of forward-looking scenarios, which is a key purpose of this study. Therefore, in this study, incentives for investment in education are proxied by only three variables: wage premia, employment differentials and households’ direct costs of tertiary education.

#### *Discussion and other factors*

11. In terms of *specific cost and benefit elements*, many studies focus on the effects on enrolment. For instance, Berger and Kostal (2002) found that neither the graduate wage premium nor the graduate unemployment premium affect demand for enrolment, whereas demand for enrolment in US public universities decreases with tuition fees. McPherson and Schapiro (1991) found that higher net costs (tuition minus financial aid received) lower enrolment for low-income groups, but increase enrolment for medium- and high-income students in the United States, with the latter effect maybe reflecting a positive supply side push that their reduced-form estimate is unable to disentangle.<sup>3</sup> However, the effect of tuitions is likely to be less negative for graduations than for enrolment, because higher tuitions may disproportionately discourage enrolment of students with lower probabilities to graduate.

12. Participation in *higher education can also be seen as a consumption good* in itself. In this case, demand will depend on income, own price and the price of substitutes (Berger and Kostal, 2002). This perspective highlights the immediate benefits from participation. Conversely, Heckman et al. (2005) point to substantial psychic costs of participation in education for some individuals. Altogether, these analyses suggest two potential deviations from the investment perspective on education: on the one hand, some individuals with low expected future returns from graduation may enter into tertiary education but may not necessarily graduate. On the other hand, some individuals with high expected future returns may not enter tertiary education due to short term costs. The consumption perspective also points to a potential divergence in the determinants of enrolment and graduation: future net benefits may have a larger effect on graduations than on enrolment, while the opposite may be true for direct net benefits.

13. Besides the consumption perspective, *non-monetary returns to tertiary education* may also contribute to enrolment and graduation rates. Education provides status, which may be particularly accentuated in certain cultures and families. Furthermore, tertiary education can enhance future life quality by opening up opportunities for more interesting jobs, and may increase the value of future consumption of goods, services and leisure.

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3. Another interpretation of the positive relationship between demand and tuition fees could be that students pay for (unobserved) quality in terms of academic outcomes, status and higher quality study conditions.

14. These consumption and non-monetary factors are hard to measure. In this study, they are modelled as a function of country specific time-invariant effects (proxying for slow-changing cultural factors) and per capita incomes (capturing the income elasticity of the consumption component).

15. Capital market imperfections can limit students' abilities to borrow in order to invest in human capital and may therefore discourage demand. There are large uncertainties about ex post returns to tertiary education, holding back the willingness of risk-averse individuals and of financial institutions to invest. For financial institutions, further obstacles are the lack of collateral and risks of non-repayment, in combination with asymmetric information relating to students' abilities and efforts (Oliveira Martins et al., 2009). Access to up-front funding for tuition and living cost is difficult to measure however, as sources include government loans and grants, wage income, family funding and private loans. Oliveira Martins et al. (2009) develop an indicator of access to financing and found that OECD countries where students have better access to financing (in relation to costs) experience higher graduation rates. The results of McPherson and Schapiro (1991) implicitly suggest a similar relationship for students from low-income households, but the opposite for those from medium- or high-income households. Due to data limitations, in this study the direct measure of access to finance only includes government loans and grants per student, while access to funding from family sources is proxied by per capita income levels.

16. Graduation rates are likely to be influenced by students' abilities when they reach the age of entering tertiary education. These abilities - which in principle would entail both cognitive and non-cognitive skills - are a function of innate abilities, social conditions and the quality of previous schooling. Carneiro and Heckman (2003) find that the economic returns to college education are roughly twice as high for individuals in the top 5% of the ability distribution compared to those in the bottom 5%. Similarly, Chowdry et al. (2010) find that grades in secondary schooling in the United Kingdom are precise predictors for tertiary enrolment and graduation. There are several channels through which cognitive skills and grades can affect tertiary education performance, such as the probability of application, possibility of admission and the ability to complete tertiary education. It may therefore be expected that the impact of cognitive skills may be higher on graduations than on enrolment. Average scores from the OECD PISA surveys (various issues) - which measures reading abilities of 15 year olds - are used to proxy cognitive skills of potential entrants in tertiary education.

## 2.2 *Supply of tertiary education*

17. Supply of tertiary education is less well analysed than demand. Berger and Kostal (2002) investigate the role of a number of institutional and economic factors - including funding, organisation, unit costs and competition - on the enrolment in higher education in public universities across US states. Oliveira Martins et al. (2009) investigate the role of institutional arrangements on cross-country graduation rates in an OECD sample.

18. Supply conditions in tertiary education vary substantially across OECD countries, with Anglo-Saxon countries having a more market-based structure, whereas supply in many continental European countries is not very responsive to market signals (Oliveira Martins et al., 2009). Regardless of institutional settings, it is however likely that suppliers are driven by more complex objectives than profit-maximization, with James (1990) suggesting that "prestige maximization" may be a better approximation. The fact that universities may prioritize research, student excellence and impressive facilities rather than volumes of human capital production raises questions on how to best organize, regulate and fund them. It is likely, however, that supply responses may differ from those of profit-maximizing entities (Winston, 1999).

19. The most obvious candidate to include in a supply model is the overall level of available funds for the tertiary education sector. More resources per student should enable universities to hire more and

better lecturers and invest more in facilities, leaving room for higher levels of enrolment and graduations, but also higher quality of education. At the same time, the extent and efficiency of market clearing mechanisms may be limited in many tertiary education systems in the OECD. This means that the relationship between available inputs and output, in terms of graduations, cannot be expected to be overly strong. In addition, the number of graduations only measures the quantitative dimension of output. As it seems reasonable that extra resources put into tertiary education may partially be used to increase (unmeasured) quality of graduations, the link between inputs and graduations may be further weakened.

20. Different sources of funding may impact graduation rates differently, with funds received from tuition having a dissimilar impact from government block grants or donations. In principle, supply of graduations could be expected to be more sensitive to tuition fees than to public or other (e.g. corporate) funding. First, to the extent that universities are able to influence tuition fees and benefit financially from them, they could anticipate negative demand effects of higher direct costs for households, making supply more sensitive to household direct spending than other funding sources. It should be noted that this mechanism is not dependent on the aggregate price-elasticity of demand for graduations, but rather the elasticity that the individual university faces. While there is a large within-country variation among universities in many OECD countries in terms of organisation, the effects of funding on supply are likely to be stronger in more competitive markets like the United States (Epple et al., 2005) and stronger for graduations than for enrolment, as universities' target function likely incorporates low dropout rates.

21. Second, a higher proportion of funding via tuition may be associated with larger flexibility in spending. This flexibility may make supply more or less responsive to demand, depending on universities' objective function and their administrative freedom. Finally, it seems reasonable to assume that public and, in particular, corporate funding to a larger extent fund buildings, research and support staff, which have less direct implications for enrolment and graduation.<sup>4</sup>

22. The ownership structure of universities may also influence the supply of graduates. Depending on institutional arrangements, private universities may be more cost effective in delivering graduations. At the same time, private institutions may have larger possibilities to divert spending towards non-graduation related activities. Specific institutional settings for both public and private institutions are likely to be influential here, with Berger and Kostal (2002) finding that more academic and administrative flexibility lead to lower supply of tertiary education (potentially reflecting such a resource diversion), while Oliveira Martins et al. (2009) found that more flexible supply conditions tend to lead to higher graduation rates. There is limited scope for exploring the effects of institutional settings in this study. The functional share of graduations stemming from - and funding going to - private or public institutions are the two variables that are used in regressions.

23. As has been stressed by e.g. Winston (1999), universities have a special relationship with their "customers", providing students with education services where quality to a large extent is a function of students' (own and peer) quality and effort. This means that ability has an important role to play in the production of graduations (and to a lesser extent in enrolment). The average PISA score will therefore be included in the supply equation, as a proxy for (own and peer) ability in the student population.

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4. It should be noted however, that Berger and Kostal (2002) found no significant impact of tuitions on the supply of study places in US public universities, although this may reflect relatively small variations in tuitions in the sample.

### 3. Empirical analysis

#### 3.1 Empirical approach and data

24. The demand for and supply of tertiary graduations are estimated in two ways. First with ordinary least-squares and secondly with two-stage least squares to account for the potential endogeneity of graduation rates and tuition fees.<sup>5</sup> Time-invariant fixed-effects are used to capture country-specific factors. The estimated model comprises a demand and a supply equation:

$$\ln Grad_{igt}^D = \alpha_i + \beta_1 Tuition_{it} + x'_{igt} \gamma + \varepsilon_{igt} \quad (1)$$

$$\ln Grad_{igt}^S = \delta_i + \phi_1 Tuition_{it} + y'_{igt} \theta + \varepsilon_{igt} \quad (2)$$

where  $i$ ,  $g$  and  $t$  denote country, gender and time respectively. Demand for and supply of tertiary graduations ( $Grad$ ) are functions of a country-specific effect, household direct spending on tertiary education ( $Tuition$ ), a gender dummy ( $Female$ ) and the other variables ( $x, y$ ) described in the previous section, with  $(\gamma, \theta)$  being the corresponding vectors of parameters to be estimated. The analysis is based on a dataset initially comprising 25 OECD countries for the period 1998-2009. The variables are described in Table 1.

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5. This problem is akin to the standard problem of estimating supply and demand, with graduations playing the role of quantities and household direct spending (tuitions) representing the price.

**Table 1. Variables included in the empirical analysis**

Variable	Definition	In equation(s)	Sources	Data availability
<b>Dependent variable</b>				
ln(Grad)	Annual number of graduations from tertiary education in relation to population 20-29, by gender.	Demand and supply	OECD.stat	1998-2010 (a few missing observations)
<b>Endogenous explanatory variable</b>				
Tuition (Household direct expenditure per student)	Household average direct expenditure on tertiary education per enrolled student (in USD 2005 PPPs). <sup>6</sup>	Demand and supply	OECD Education at a Glance.	1997-2009
<b>Other explanatory variables</b>				
ln(Gross earning differentials, D9/D5)	Gross earnings of the upper bound of the 9 <sup>th</sup> decile of the earning distribution for full-time employees- to the upper bound of the 5 <sup>th</sup> decile.	Demand	The OECD earnings database.	1997-2010 (with several missing observations)
ln(Gross earning differentials, D5/D1)	Gross earnings of the upper bound of the 5 <sup>th</sup> decile of the earning distribution for full-time employees- to the upper bound of the 1 <sup>st</sup> decile.	Demand	The OECD earnings database.	1997-2010 (with several missing observations)
Employment by education	Employment ratio for individuals with tertiary education in relation to individuals with secondary education, age 25-64, by gender.	Demand	OECD Education at a Glance.	1997-2010
Government financial aid	Government financial aid to students in tertiary education in relation to total household expenditures on tertiary education.	Demand	OECD.stat	1997-2009
ln(GDP per capita)	GDP per capita (in USD 2005 PPPs).	Demand	OECD Economic Outlook database.	1997-2010
Unemployment gap	The difference between equilibrium and actual unemployment.	Demand	OECD Economic Outlook database.	1997-2010
Female	Dummy variable equal to 1 for females and 0 for men.	Demand		
Share part-time student	Part-time students as a share of total number of students.	Demand	OECD.stat	1997-2010 (a few missing observations)
Government direct expenditure per student	Annual direct expenditure per student by government (in USD 2005 PPPs).	Supply	OECD.stat, Education at a Glance	1997-2009
Private direct expenditure per student	Annual direct expenditure per student by non-household private sector (in USD 2005 PPPs).	Supply	OECD.stat, Education at a Glance	1997-2009 (a few missing observations)
Share of students in private institutions	Share of tertiary level students that are enrolled in private institutions	Supply	OECD.stat	1997-2009 (a few missing observations)
ln(PISA)	Average PISA score (reading), measured as a mean over the four waves 2000, 2003, 2006 and 2009. By gender.	Demand and supply	PISA manuals	Time invariant (average over 2000, 2003, 2006 and 2009)

6. Includes tuition fees, other fees (e.g. registration, laboratory, teaching material) and fees paid for other welfare services provided by educational institutions to students.

### 3.2 Results based on single equation estimates and 2SLS

25. Columns 1 and 2 of Table 2 report the results when demand and supply are estimated separately with fixed-effect estimators.

#### *Demand*

26. Consistent with the results of McPherson and Schapiro (1991), the demand equation shows that tuitions have a small, negative but insignificant impact on graduations. This contrasts with some previous studies, such as Berger and Kostal (2002), who found significantly negative effects of tuition. Possible explanations are:

- While cross-country differences in reliance on tuitions are large, the within-country variation is often small, with a few exceptions such as the United Kingdom, Australia, Ireland and Korea; this makes it more difficult to establish robust statistical relationships in a model with country fixed-effects.
- Reforms to increase direct funding from households are often accompanied by more generous loans and grants - as has been the case in *e.g.* the Australian HECS/HELP scheme and the recent UK tuition fee reform – which may blunt the impact of changes in direct costs on demand.<sup>7</sup>

27. In line with previous research, the earnings differential (D9/D5) has a positive and significant effect on graduation rates, while the impact of D5/D1 is negative and significant. While it is reasonable that investment in tertiary education is driven to a large extent by D9/D5 wage differentials, the negative result for D5/D1 is slightly surprising. It may be the case that higher D1 earnings (holding D5 constant) signals better opportunities for students' earnings when studying.<sup>8</sup>

28. Apart from relative earnings, the estimated coefficients for the “investment-related” determinants of demand are insignificant and/or often have the wrong sign. Thus, there is no evidence that relative probabilities of employment or access to financial aid affect graduation rates in the expected direction. In fact, the effects of the relative employment probability is negative and (weakly) significant. As the fixed-effect approach absorbs any country-specific drivers, within-country variation in data may be too small to accurately measure the effects of these variables.

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7. To investigate the robustness of this result, the sample was split into two, one with high and one with low dependence on direct funding from household as a share of total funding. Estimated demand-elasticities (from both OLS and 2SLS estimations) were negative, small and statistically insignificant for both groups, suggesting no major differences in impact across the two country groups.

8. Interestingly, when the sample is split into two equally-sized country groups based on the share of the workforce that has tertiary education, the D5/D1 becomes positive for the skill-intensive group (and having a bigger coefficient than the D9/D5-ratio), suggesting that for countries well-endowed with tertiary educated individuals, graduations may more play the role of escaping low incomes than gaining high incomes.

**Table 2. Estimates of demand and supply equations for graduation rates**

Results from single equation estimates and two-stage least squares, 1998-2009

VARIABLES	Single equation estimates		2SLS estimates	
	(1) DEM	(2) SUP	(3) DEM	(4) SUP
Household direct expenditure per student	-0.0087 (0.0119)	0.0564*** (0.0143)	-0.0151 (0.0250)	0.2594*** (0.0359)
ln(Gross earning differentials, D9/D5)	0.5092*** (0.1856)		0.5123*** (0.1836)	
ln(Gross earning differentials, D5/D1)	-0.4248** (0.1724)		-0.4256** (0.1702)	
Employment by education	-0.0041** (0.0019)		-0.0042** (0.0019)	
Government financial aid	-0.0001 (0.0001)		-0.0001 (0.0001)	
ln(GDP per capita)	1.8911*** (0.1325)		1.9129*** (0.1503)	
Unemployment gap	-0.0013 (0.0079)		-0.0022 (0.0083)	
Female	-0.3006*** (0.0824)		-0.3008*** (0.0814)	
Share part-time student	-0.0018 (0.0014)		-0.0019 (0.0014)	
Government direct expenditure per student		0.0389*** (0.0108)		0.0843*** (0.0150)
Private direct expenditure per student		0.0255* (0.0130)		0.0026 (0.0164)
Share of students in private institutions		0.0470*** (0.0047)		0.0444*** (0.0058)
ln(PISA)	9.6448*** (1.1248)	4.7594*** (0.2356)	9.6537*** (1.1111)	4.7594*** (0.2889)
Constant	-81.7110*** (6.9976)	-34.2489*** (1.4741)		
Observations	416	416	416	416
R-squared	0.7196	0.5855	0.7194	0.3686
Number of countries	25	25	25	25

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

29. The results in column 1 show a large and highly significant positive effect from average PISA scores on demand for graduations. Problem-solving cognitive skills of potential entrants in terms of generating demand for tertiary education thus seem important for graduations.<sup>9</sup>

9. The fact that the variation in average PISA scores only stems from differences in scores between male and female students in the fixed-effect model could suggest that results should be interpreted with caution. However, the impact remains positive, large and significant even when dropping the fixed effects.

30. There is fairly weak evidence that female and male graduations are driven by different factors. The negative gender dummy illustrates that females, for a given PISA score, are less likely to graduate. As females on average tend to perform better in terms of PISA, their unconditional graduation rates tend to be higher than for males.<sup>10</sup> Gender differences in graduations are further investigated by splitting the sample by gender (PISA scores then no longer can be included as they only vary along the gender dimension), but results remain largely the same.<sup>11</sup>

31. Demand for graduations is increasing in per capita incomes, with an estimated coefficient close to two. This could reflect that ‘non-economic’ factors have a large impact on demand, but also that high average per capita incomes can loosen credit constraints for individuals or families, and thus enable participation in tertiary education. There is no evidence that the share of students that pursue their studies on part time or the unemployment gap affects graduation rates.

### *Supply*

32. The results based on the single equation estimation for the supply equation are shown in column 2. Supply is responsive to tuitions and, to a lesser extent, to government grants, while other private (corporate) funding has a very small and weakly significant positive impact. A higher share of students that are enrolled in private universities is associated with higher supply. PISA scores have a positive and significant impact on supply of graduations, although the impact is smaller than on demand.

### *Two-stage estimations*

33. Columns (3) and (4) of Table 1 show the two-stage estimates of the demand and supply equations under the assumption that graduation rates and tuition are endogenous. Most of the results for the demand equation are stable, and the effect of tuitions on demand remains insignificant and negative. It may be argued that the impact of household’s direct spending on demand may only be discernible if the levels of spending are ‘significant’. However, splitting the sample into countries with low and high shares of direct funding did not reveal any significant impact on demand in either of the two groups.

34. Moving from single equation estimates to 2SLS has a stronger effect on supply than on demand estimates, although signs and levels of significance roughly remain similar in both equations. The estimated effects of household’s direct payments and government direct expenditure increase four-fold and two-fold respectively however compared to the single equation estimates, suggesting that addressing the endogeneity problem provides a bigger role for spending on the supply of graduates.

## **4. Projecting graduation rates until 2060**

### **4.1 The projection model**

35. For the purpose of enriching the OECD 50-year global scenarios, the estimated model of graduations needs to be adapted to generate projections up until 2060, based on assumptions about exogenous variables. As a first step, the 2SLS model is simplified, by sequentially deleting the variables with the lowest t-statistics from each of the two equations. The only exception is the endogenous variable

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10. Dropping the gender dummy also significantly lowers the estimated effect from PISA scores on graduation rates, although the effect continues to remain large, positive and highly significant.

11. There is some evidence that male graduation rates are more responsive to D9/D5 wage differentials and that per capita incomes have a larger impact on female graduation rates, but differences are not statistically significant.

(households' direct spending), which is retained through the simplification process even though it remains insignificant in the demand equation.

36. In a second step, a logit-transformation is applied to the graduation rate in order to construct a modified dependent variable for the scenario analysis that is bounded in out-of-sample predictions.<sup>12, 13</sup> The logit-transformation is also consistent with a decreasing marginal effect of explanatory variables on graduation rates: it is probably harder to achieve an increase in graduation rates of one per cent for a country where rates are already at 80 per cent compared to a country where rates are at 40 per cent.

37. Table 3 presents the results for the simplified model in the logit-form. The qualitative results are similar to those presented in Table 2, and the main difference between the single-equation estimate and the 2SLS continues to be the supply equation, where estimated coefficients for households' and governments' spending are much larger in the 2SLS specification. The analysis going forward is based on the 2SLS estimates, which correct for the possible endogeneity bias concerning the effect of spending on supply (Columns 3 and 4 of Table 3).

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12. For the purposes of the exercise, the boundary on the number of graduations is set to 20 per cent of the population aged 20-29, equivalent to roughly 2 degrees per 20-29 year old. Unfortunately while the left hand side variables are bounded, the exact boundary is hard to define in the available data. For example, if everyone in the cohort 20-29 participated in tertiary education continuously and the average time to earn a degree was 3 years, each individual would have 3.3 degrees and the graduation to population rate would be 30 percent. At the same time, foreign students and older graduates could in principle increase this ratio further.

13. The logit of  $p$  is constructed as  $\text{logit}(p) = \ln\left(\frac{p}{1-p}\right)$ .

**Table 3. Estimates of demand and supply equations for graduation rates****Results from single equation estimates and 2SLS using the transformed dependent variable, 1998-2009**

VARIABLES	Single equation estimates		2SLS estimates	
	(1) DEM	(2) SUP	(3) DEM	(4) SUP
Household direct expenditure per student	0.0171 (0.0163)	0.0976*** (0.0194)	-0.0029 (0.0403)	0.6111*** (0.0878)
ln(Gross earning differentials, D9/D5)	0.6133** (0.2519)		0.6227** (0.2508)	
ln(Gross earning differentials, D5/D1)	-0.5149** (0.2354)		-0.5120** (0.2339)	
Employment by education	-0.0054** (0.0026)		-0.0054** (0.0026)	
ln(GDP per capita)	2.2085*** (0.1500)		2.2440*** (0.1628)	
Female	-0.3907*** (0.1160)		-0.3908*** (0.1152)	
Government direct expenditure per student		0.0552*** (0.0142)		0.1662*** (0.0292)
Share of students in private institutions		0.0663*** (0.0066)		0.0586*** (0.0108)
ln(PISA)	13.3072*** (1.5932)	6.9718*** (0.3212)	13.3175*** (1.5828)	6.9718*** (0.5253)
Constant	-105.6651*** (9.8380)	-46.7803*** (2.0097)		
Observations	444	444	444	444
R-squared	0.7051	0.5965	0.7041	-0.0895
Number of countries	26	26	26	26

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

#### 4.2 Scenarios for demand for and supply of tertiary graduations

38. In order to generate tertiary graduation rates until 2060 consistent with the OECD 50-year global scenarios (Braconier et al., 2014), graduation projections based on the coefficient estimates of Table 3 (columns 3 and 4) are conditioned on projections for other variables in the central OECD scenario. These include the path of future GDP per capita -- based on the OECD Economic Outlook long-term growth scenarios (OECD, 2014; Braconier et al., 2014) -- and developments in earning differentials estimated by Braconier and Ruiz-Valenzuela (2014) (unless stated otherwise, all other exogenous variables are kept constant throughout the projection period). These variables are particularly important to assess possible future developments in tertiary graduations as they affect the private incentives to invest in this kind of human capital. Given the small and insignificant coefficients for households' direct expenditure (tuition) in the demand equation, this coefficient is set to zero.

39. Figure 1 shows the projected evolution of demand for tertiary graduations between 2009 and 2060 in two scenarios -- the central scenario assumed in the OECD 50-year global scenarios and a long-term scenario consistent with estimates in Table 3:

- In the central scenario the graduation rates are exogenous and mechanically driven by the assumption of gradual convergence in educational attainment across countries (see Johansson et al., 2012). This gradual convergence in attainments (expressed in terms of average years of education in the population) is converted into graduation rates by means of simple assumptions (Box 1).

- In the alternative long-term scenario the graduation rates are endogenous and consistent with the supply and demand estimates in Table 3, with increases mainly driven by a combination of rising D9/D5 earnings premia and rising per capita incomes.

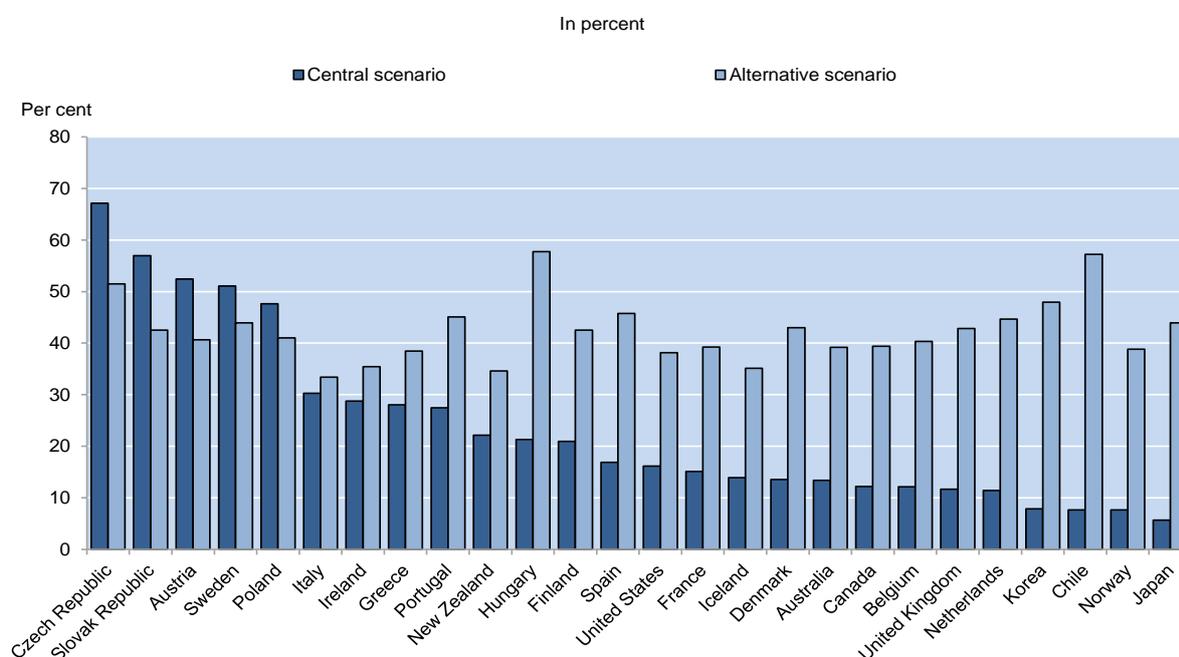
**Box 1. Transforming stocks of human capital from the central scenario of the OECD 50-year global scenario into graduation rates**

To compare the graduation rates from the model estimated in Table 3 to those assumed in the central scenario of the OECD 50-year global scenarios, the stock of tertiary educated workers in the central scenario is transformed into graduation rates. This is done in 4 steps:

1. As the stock of tertiary educated individuals (graduates) in the central scenario is available for 5-year periods (2000-2004 etc.), actual graduations are aggregated over the same periods.
2. For simplicity, all graduations during a five-year period are assigned to the cohort that is 25-29 years old at the end of the period to construct the stock of graduates. This means that graduations during the period 2000-2004 are assigned to the cohort born 1975-1979 and that graduates are assumed to be 25 year-old on average.
3. In order to correct for country-specific factors (e.g. the extent of double graduations and the share of foreign students) an adjustment factor is computed. The adjustment factor ( $a$ ) is computed as the ratio of graduates (aged 25-29) in relation to the number of graduations, both measured as averages over the period 2000-2009:  $a = \text{graduates}(25-29)_{2000-2009} / \text{graduations}_{2000-2009}$ . This relationship is assumed to stay constant over the projection period.
4. Project graduations for each 5-year period up until 2060, using the adjustment factor and the stock of tertiary educated 25-29 year-olds in the central scenario. For example, for the period 2010-2014,  $\text{graduations}_{2010-2014} = \text{stock of graduates}_{2010-2014}(\text{aged } 25-29) / a$ .

The projected increases in graduations are shown in Figure 1 below.

**Figure 1. Increase in demand for tertiary graduations 2009-2060 in central and alternative scenario**



Note: Central scenario refers to the implied increase in tertiary graduations between 2009 and 2060 needed to generate the share of tertiary graduates in the labour force assumed in the central scenario in the main paper. Alternative scenario refers to the projected demand based on Table 3.

Source: OECD calculations.

40. Figure 1 points to a tension embedded in the OECD 50-year central scenario: the quantity of tertiary graduates implied by the assumption of gradual convergence in educational attainments across countries is in most countries lower than the demand for tertiary graduates that would derive from the evolution of GDP per capita and earning differentials according to the demand model estimated in Table 3. To resolve this tension, supply of tertiary graduations (as modelled in Table 3) would have to adjust via an increase in government or private funding, an increase in household expenditure (tuitions), or a combination of the two. In other words, the projected increase in returns to higher education and other non-monetary returns captured by GDP per capita would call for much higher graduation rates in most countries.

41. Given already high graduation rates in many OECD countries, it could be argued that projected increases in demand by 30 to 60 per cent over the coming 50 years may seem excessive. This would lead to a mostly tertiary educated workforce across the OECD or a large increase in the share of workers that hold double degrees.<sup>14</sup> It should be stressed that the numerical estimates provided in Figure 1 are based on projections of per capita incomes and wage differentials which compound margins of uncertainty. At the same time, the logit-transformed model used for the predictions tends to dampen increases in countries that start off with high enrolment rates.

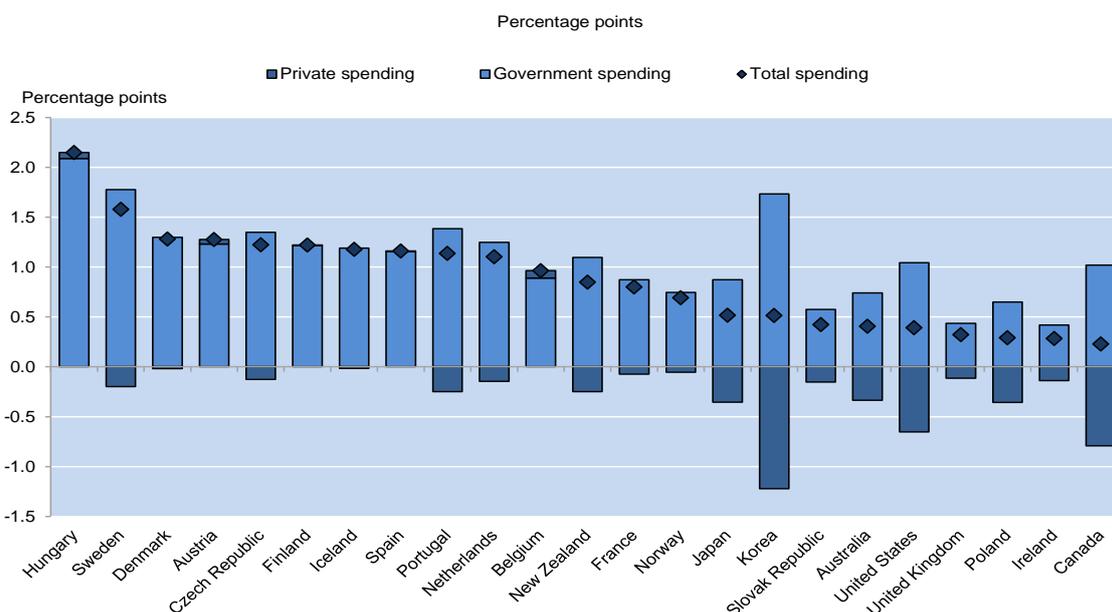
#### *Implications for the government budget*

42. To give an idea of the size of the challenge for the government budget if the alternative scenario would be realised, Figure 2 shows how public and private (corporate) financing of tertiary education as a share of GDP would need to increase over 2009-2060 to ensure that supply meets demand assuming that household spending per student remains constant in real terms (i.e. that tuitions evolve in line with inflation). Such financing would have to rise in all countries, partly reflecting increasing volumes, but also diseconomies of scale.<sup>15</sup> These increases would tend to be larger for countries that are expected to see large increases in demand, such as Hungary and the Czech Republic.

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14. For example, in Korea today already more than 60 per cent of youth enter tertiary education.

15. While this can be deducted from the supply equations in Table 2 and 3, the economic rationales could be that higher enrolment will lead to a lower average level of skills among students which has to be compensated through increasing other types of inputs disproportionately.

**Figure 2. Increase in spending on tertiary education as a share of GDP, 2009-2060**

Source: OECD calculations.

43. Given that the estimated elasticity of supply with respect to government spending is fairly low compared to the one for households' spending, significant increases in government spending will often be needed. These effects are more pronounced in countries with initially low shares of household financing, where (more inefficient) government funding will have to cover a larger share of the expansion. Thus countries with low levels of tuitions, such as the Nordic countries, will experience large increases in total spending, while countries with high levels of household spending (e.g. Korea) will experience smaller increases in total spending in relation to GDP. In this scenario, government funding would rise from 76% of total funding in 2009 to 89% in 2060 for the average OECD country.

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