Should higher education be subsidized more?

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Abstract

Fiscal externalities arise if subsidies to higher education raise future net fiscal revenues. We investigate in which countries fiscal externalities provide a justification for increasing subsidies to higher education. First, we show that the marginal fiscal recovery rate, i.e., the ratio of the change in total net fiscal revenues and the change in total subsidy costs caused by a small change in tuition subsidies, is the key statistic: if larger than one, then a small increase in subsidies is unambiguously desirable. We also show that the marginal fiscal recovery rate depends on three sufficient statistics: the elasticity of participation with respect to subsidies, the success probability of the marginal student, and the ratio of the net fiscal revenue gain and the subsidy cost of a degree in tertiary education. Second, we use the sufficient statistics formula to approximate the marginal fiscal recovery rate in twenty OECD countries. The average marginal fiscal recovery rate is equal to 0.89, meaning that, on average, 0.89 euro is recovered of an increase in subsidies with one euro. This average hides substantial heterogeneity between countries. In six countries (Australia, Israel, the Netherlands, Ireland, the United Kingdom, and the United States), the marginal fiscal recovery rate is larger than one, implying that an increase in subsidies to higher education is unambiguously desirable in these countries. Third, to check the quality of our approximation, we also simulate the marginal fiscal recovery rate for one country (Belgium) on the basis of a more detailed model that allows for heterogeneity between students. Reassuringly, this simulation provides a roughly similar result than the approximation for this country. Moreover, the more detailed model allows for additional simulations (e.g., to compute a maximal tuition level) that are not feasible with the sufficient statistics formula.

Keywords: higher education, tuition subsidies, fiscal externalities, marginal fiscal recovery rate, maximal tuition

JEL-codes: H23, I22, I23, I26

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1 Introduction

There is clear empirical evidence that subsidizing higher education increases both participation and graduation (see, e.g., Dynarski, 2003 and Falch and Oosterbeek, 2011). This increase in graduation increases in turn wages and employment (see, e.g., Card, 1999 and Harmon et al., 2003). As a consequence, tax revenues increase and welfare expenditures decrease, and thus, in the end, the net fiscal revenues increase. The effect of higher education subsidies on net fiscal revenues is called a fiscal externality.

In this paper we investigate, in theory and in practice, whether fiscal externalities can provide a justification for increasing subsidies to higher education. This is possible if the fiscal externality outweighs the subsidy cost. So, we define the marginal fiscal recovery rate of subsidies to higher education as the ratio of the change in total net fiscal revenues and the change in total subsidy costs caused by a small change in tuition subsidies to higher education.

As a first contribution, this paper adds to the theoretical literature on fiscal externalities. We show that if the marginal fiscal recovery rate is larger than one, then a small increase in subsidies is unambiguously desirable. Unambiguous means that increasing subsidies increases both welfare and net fiscal revenues, irrespective of the degree of inequality aversion, general equilibrium effects on wages, externalities, and credit constraints. We also show that the marginal fiscal recovery rate depends on three sufficient statistics: the elasticity of participation with respect to subsidies, the success probability of the marginal student, and the ratio of the net fiscal revenue gain and the subsidy cost of a degree in tertiary education.

Although the marginal fiscal recovery rate may provide a clear and simple justification for increasing subsidies to higher education, surprisingly little is known about its magnitude.

In their *Education at a Glance* series, the OECD reports the net fiscal revenue gain (OECD, 2019, Tables A5.2a and A5.2b, columns 2 and 6) and the subsidy cost of a degree in tertiary education across OECD countries (OECD, 2019, Tables A5.2a and A5.2b, column 1). The ratio of both—one of the three key factors underlying the marginal fiscal recovery rate—is on average equal to 4.09 for men and 2.61 for women across the OECD. As shown later on, these gain-cost ratios turn out to be an upper bound for the marginal fiscal recovery rate because the other two factors—based on the participation elasticity and the marginal success probability—are smaller than one.

To the best of our knowledge, only two studies, one for Europe and one for the United States, compute marginal fiscal recovery rates.[1] de la Fuente and Jimeno (2009) focus on a selection of 14 European countries. Their marginal fiscal recovery rates range between -0.25 for Sweden and 2.40 for Ireland, with an average rate of 0.97 across countries. Colas, Findeisen, and Sachs (2021) find an overall marginal fiscal recovery rate of 0.76 for the United States, implying that a small uniform increase in financial aid is not desirable.[2] They also show that the marginal fiscal recovery rate is larger than one for students from poor families and that it

[1] There is a related empirical (US-based) literature that, in contrast to our paper, focuses on the effect of *non-marginal* policy changes in higher education, including its impact on fiscal revenues; see, e.g., Caucutt and Kumar (2003), Johnson (2013), Krueger and Ludwig (2013, 2016), Lawson (2017), and Abbott et al. (2019).

[2] The reported number was kindly provided by one of the authors on request.

decreases with family income. So, a small increase in subsidies targeted at all students with a parental income below the 59th percentile would still break even.

As a second contribution, this paper adds to the empirical literature by using the sufficient statistics formula to approximate the marginal fiscal recovery rate for twenty OECD countries. The average marginal fiscal recovery rate is equal to 0.89, so, 0.89 euro is recovered of an increase in subsidies with one euro. This average marginal fiscal recovery rate hides substantial heterogeneity between countries. The marginal fiscal recovery rate ranges from 0.14 in Estonia to 2.19 in the United States. Moreover, the marginal fiscal recovery rate is larger than one in at least six countries (Australia, Israel, the Netherlands, Ireland, the United Kingdom, and the United States), implying that an increase in subsidies to higher education is unambiguously desirable in these countries. In the other fourteen countries (Portugal, New Zealand, Belgium, Austria, Germany, Slovenia, Korea, Spain, Chile, Finland, Slovak Republic, Norway, Latvia, and Estonia) the marginal fiscal recovery rate is smaller than one. Yet, this does not imply that one should decrease subsidies in these countries because, e.g., positive non-fiscal externalities may justify the current subsidy levels.

Our results can also be compared to the findings of de la Fuente and Jimeno (2009) and of Colas, Findeisen, and Sachs (2021). First, if we only focus on the nine European countries that our study has in common with de la Fuente and Jimeno (2009), then the average marginal fiscal recovery rate is equal to 1.22 in de la Fuente and Jimeno (2009) and 1.03 in our study. Our lower average rate is not surprising. de la Fuente and Jimeno (2009) analyze the impact of a marginal increase in average educational attainment, but do not consider how this marginal increase comes about. We focus instead on a marginal change in tuition fees and therefore take the response of students, through the participation elasticity, into account. Moreover, de la Fuente and Jimeno (2009) focus on the period 1995-2002 when tuition fees, and thus recovery rates, were much lower in many countries compared to now. Second, our marginal fiscal recovery rate of 2.19 for the United States is much higher than the 0.76 of Colas, Findeisen, and Sachs (2021). The third key factor—the gain-cost ratio—mainly causes the difference.[3] Our approximation for the United States is, qualitatively speaking, closer to Lawson's (2017, p. 340) observation for the United States that "fiscal externalities on their own justify increased government support for students."[4]

As a third contribution, we carefully check the quality of the previous approximation for one country. We model enrollment, study choice and duration, dropout, degree completion, employment, earnings, taxes, and welfare benefits and estimate the parameters of the model on the basis of administrative and survey data for Flanders (the Dutch-speaking region in Belgium). All elements of the model together allow to simulate how a small change in tuition would lead to changes in future net fiscal revenues and changes in the subsidy costs of higher education (whose ratio is the marginal fiscal recovery rate). A major advantage of this more

[3]The participation elasticity (1.69pp per 1000 dollar) and the success rate (27.7/38.4) in Colas, Findeisen, and Sachs (2021, figure 4 and online appendix) are similar to our study, implying that indeed the third key factor (not reported in their study) must cause the difference.

[4]Lawson (2017) does not compute marginal fiscal recovery rates, but analyzes optimal subsidies to higher education in the United States.

detailed model is that heterogeneity between students is taken into account. On the one hand, students at the margin of participating—those who are most likely to be affected by a small change in tuition fees—turn out to be more likely to choose programs with lower earnings (professional instead of academic bachelor programs) than the average student in higher education. They also have a higher chance of drop-out and are less likely to complete their degree within the theoretical duration of the program. On the other hand, students on the margin of participating turn out to be more sensitive to tuition changes. Consequently, ignoring heterogeneity between students leads to a downward bias of the first sufficient statistic (the participation elasticity) and an upward bias of the other two sufficient statistics (the success probability of the marginal student and the gain-cost ratio of a degree in tertiary education). Because the different biases counteract each other, it is not clear how heterogeneity between students will affect the marginal fiscal recovery rate for Flanders. According to the sufficient statistics approximation, the marginal fiscal recovery rate is equal to 0.89 for Belgium, while according to the simulation for Flanders it is equal to 0.74.[5] Roughly speaking, the aforementioned upward and downward biases seem to offset each other and the approximation is therefore very reasonable for Flanders. This, of course, does not mean that the same conclusion can be made for other countries, but we do think that similar counteracting biases are probably at work in other OECD countries too.

While the sufficient statistics approach offers a good approximation of the marginal fiscal recovery rate, it is less useful to analyze some further extensions. First, we use the more detailed model to simulate the impact of tuition subsidies specifically targeted towards students from low-income families. We find that the marginal fiscal recovery rate rises from 0.74 to 0.86. Second, as the marginal fiscal recovery rate turns out to increase with tuition, we can also use the more detailed model to compute the level of tuition where it becomes exactly equal to one. This tuition level maximizes "net fiscal revenues minus subsidy costs" and can be interpreted as the maximal tuition level. Indeed, at higher tuition levels the marginal fiscal recovery rate would become larger than one, which is not desirable. In our benchmark simulation, the maximal tuition fee is about 2500 euro for a regular student in Flanders. Compared to the current tuition fee of 950 euro, it suggests that there is room for, e.g., tuition increases, but that this room is limited to roughly tripling tuition.[6]

The remainder of this paper is organized as follows. Section 2 introduces the sufficient statistics approach to approximate the marginal fiscal recovery rate. Section 3 expounds the more detailed model to simulate the marginal fiscal recovery rate for Flanders. Section 4 concludes.

2 A sufficient statistics approach

The marginal fiscal recovery rate tells us to what extent a small increase in tuition subsidies to higher education can be recovered through the fiscal system. In this theoretical section we

[5] We use the approximation for Belgium as an approximation for Flanders.

[6] An increase in the private cost of higher education should not necessarily be implemented via tuition increases; see, e.g., Diris and Ooghe (2018) for a discussion of income-contingent loans and graduate taxes.

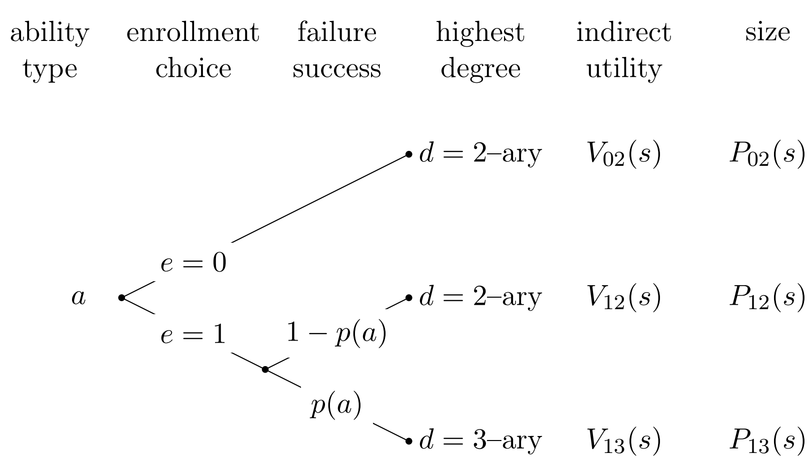
highlight the policy importance of the marginal fiscal recovery rate. We also provide a decomposition based on three empirically observable sufficient statistics and use it to approximate the marginal fiscal recovery rate for twenty OECD countries.

2.1 The model

The positive part of our model is based on Hanushek, Lueng, and Yilmaz (2003). We use their basic version that includes general equilibrium effects, but no externalities and credit constraints. This is not only for ease of exposition, but also without loss of generality as we will argue later on why introducing externalities and credit constraints will not change the main theoretical result.

The basic model features two sequential choices: the choice to enroll or not in tertiary education and the choice of labour hours in the labour market. Figure 1 summarizes the model.

Figure 1: Type, enrollment, failure/success, degree, utility, and size



In a nutshell, high school graduates differ in educational ability a. They choose to enroll or not in tertiary education, and, depending on their success probability $p(a)$, they do or do not get a degree in tertiary education. This leaves us with three groups, denoted by $ed \in \{02, 12, 13\}$, depending on enrollment choice ($e \in \{0, 1\}$) and highest degree ($d \in \{2, 3\}$), with $e = 1$ if an individual chooses to enrol and $e = 0$ otherwise and $d = 3$ if the highest degree is a tertiary degree and $d = 2$ otherwise (i.e., if the highest degree is a secondary degree). The size of each group ed is denoted by P_{ed}, which add up to one. Depending on their highest degree, they face a different (general equilibrium) wage rate in the labour market. Based on this wage rate and the current tax-benefit scheme, they choose labour hours, a choice that is hidden in the indirect utilities of Figure 1.

In the remainder of this subsection, we discuss both sequential choices in more detail. As the subsidy level s is the policy parameter of interest, we make this dependency explicit and suppress all other dependencies for ease of exposition.

Enrollment High school graduates differ in educational ability $a \in \mathbb{R}$. They choose to enroll or not in tertiary education depending on their probability of success and on the utilities in the different states.

The probability of success depends on the ability of a high school graduate and is given by

$$p : \mathbb{R} \to (0,1) : a \mapsto p(a),$$

with $p' > 0$, $p(-\infty) \to 0$, and $p(+\infty) \to 1$. Because one can only obtain a tertiary degree upon enrolment in tertiary education, we are left with three possible states, i.e., $ed \in \{02, 12, 13\}$.

A high school graduate with ability level a chooses to enroll if the expected utility of enrolling is larger than the utility of not enrolling, i.e.,

$$EV_1(s|a) \equiv p(a)V_{13}(s) + (1 - p(a))V_{12}(s) \geq V_{02}(s), \tag{1}$$

where $V_{ed}(s)$ are the indirect utilities of the different states $ed \in \{02, 12, 13\}$ (to be explained in more detail later on). This condition can be rewritten as

$$p(a) \geq \frac{V_{02}(s) - V_{12}(s)}{V_{13}(s) - V_{12}(s)},$$

leading to a cut-off ability level[7]

$$a^*(s) = p^{-1}\left(\frac{V_{02}(s) - V_{12}(s)}{V_{13}(s) - V_{12}(s)}\right).$$

For later use, high school graduates at the margin are, by definition, indifferent, i.e.,

$$EV_1(s|a^*(s)) = V_{02}(s). \tag{2}$$

Moreover, using the ability density function f, the proportions of individuals in each of the three states are

$$\begin{aligned} P_{02}(s) &= \int_{-\infty}^{a^*(s)} f(a)da = F(a^*(s)), \\ P_{12}(s) &= \int_{a^*(s)}^{+\infty} (1 - p(a))f(a)da, \\ P_{13}(s) &= \int_{a^*(s)}^{+\infty} p(a)f(a)da, \end{aligned}$$

which, by definition, add up to one. Sometimes, we want to split up the population in different subgroups depending on either enrollment status e or highest degree d. The proportion of individuals that do not and do enroll are defined as $P_0(s) = P_{02}(s)$ and $P_1(s) = P_{12}(s) + P_{13}(s)$, respectively, with $P_0(s) + P_1(s) = 1$. Similarly, the proportions of individuals with a highest degree in secondary and tertiary education are defined as $P_2(s) = P_{02}(s) + P_{12}(s)$ and $P_3(s) =$

[7] The cut-off ability level is well-defined because, as we will see later on, general equilibrium wages adjust such that $V_{13}(s) > V_{02}(s) > V_{12}(s)$.

$P_{13}(s)$, respectively, with $P_2(s) + P_3(s) = 1$.

Labour hours Workers in the labour market differ in wages, depending on their highest educational degree $d \in \{2, 3\}$.[8] They choose labour hours depending on their preferences and budget constraint. As there is only one working period, labour hours can best be interpreted as lifetime labour hours (and the same holds for the resulting earnings and taxes).

Preferences over consumption c and labour hours ℓ are represented by a quasi-linear utility function

$$U(c, \ell) = c - \frac{1}{\delta} \frac{\varepsilon}{1+\varepsilon} \ell^{\frac{1+\varepsilon}{\varepsilon}},$$

with δ the (common) taste for working and ε the elasticity of labour supply.

The budget constraint is

$$c \leq b - (k - s)\mathbf{1}[e = 1] + (1 - t)w_d(s)\ell,$$

with b the demogrant and t the tax rate of a linear tax scheme, $k - s$ the net private cost of a degree in higher education (with k the full cost and s the subsidy),[9] $\mathbf{1}[\cdot]$ an indicator function that returns one if the statement between brackets ($e = 1$, meaning that the individual was enrolled) is true and zero otherwise, and $w_d(s)$ the (general equilibrium) wage rate that depends on the highest degree obtained ($d = 2$ or $d = 3$) and on the subsidy level. Indeed, as we will see later on, subsidies have an impact on the labour supply of workers with different degrees and thus, in general equilibrium, on the corresponding wage rates.

A worker with highest degree d optimally chooses labour hours to be equal to

$$\ell_d(s) = (\delta(1 - t)w_d(s))^{\varepsilon}, \tag{3}$$

and the resulting indirect utilities (for $ed = 02, 12, 13$) can now be specified as

$$\begin{aligned} V_{ed}(s) &= b - (k - s)\mathbf{1}[e = 1] + \frac{1}{1+\varepsilon}\delta^{\varepsilon}((1 - t)w_d(s))^{1+\varepsilon}, \\ &= b - (k - s)\mathbf{1}[e = 1] + \frac{1}{1+\varepsilon}(1 - t)w_d(s)\ell_d(s). \end{aligned} \tag{4}$$

Finally, we assume a constant-returns-to-scale production technology, i.e., production is given by $Q(L_2, L_3)$, with L_d the amount of labour from workers with a highest degree in secondary ($d = 2$) or tertiary education ($d = 3$).[10] In a competitive environment, wages are

[8] As in Hanushek, Lueng, and Yilmaz (2003), (expected) wages indirectly depend on ability through success, but not directly.

[9] As in Hanushek, Lueng, and Yilmaz (2003), the implicit assumption is perfect credit markets, i.e., the net private cost of education is borrowed during tertiary education and paid back afterwards (without interest, for ease of exposition and without loss of generality). As we discuss later on, introducing credit constraints does not alter our main theoretical result. Yet, we will relax this assumption (absence of credit constraints) in the more detailed empirical model of section 3 (albeit in a reduced form way). Contrary to Hanushek, Lueng, and Yilmaz (2003) we assume for simplicity that the full cost of higher education k is exogenous (it will not depend on the endogenous wage rate of teachers).

[10] We assume that $Q(0, L_3) = Q(L_2, 0) = 0$, i.e., both types of labour are necessary to produce. This ensures that strictly positive fractions of both labour types will be used in in equilibrium.

equal to marginal productivities, i.e.,

$$w_d = \frac{\partial Q(L_2, L_3)}{\partial L_d} > 0, \tag{5}$$

for each degree $d = 2, 3$. The supply of labour is defined as

$$S_d(s) = P_d(s)\ell_d(s). \tag{6}$$

With constant returns to scale and competition, there are no profits, so we must have

$$Q(S_2(s), S_3(s)) - (w_2(s)S_2(s) + w_3(s)S_3(s)) = 0.$$

Taking the derivative with respect to s, and using equations (5) and (6), the change in equilibrium wage rates must be zero-sum at the margin, i.e.,

$$w_2'(s)P_2(s)\ell_2(s) + w_3'(s)P_3(s)\ell_3(s) = 0,$$

which implies

$$w_3'(s) = -\frac{P_2(s)\ell_2(s)}{P_3(s)\ell_3(s)} w_2'(s). \tag{7}$$

The change in wage rates must have opposite signs in our model. In particular, empirical evidence shows that workers with a highest degree in secondary and tertiary education are substitutes; see, e.g., Katz and Murphy (1992), Angrist (1995), Johnson (1997), Krusell et al. (2000), and Ottaviano and Peri (2012). It implies that increasing subsidies increases the relative supply of workers with a tertiary degree and, as a consequence, the wage rate of workers with a secondary degree increases and the wage rate of the workers with a tertiary degree decreases.

2.2 Policy evaluation

A marginal increase in tuition subsidies to higher education will have a welfare effect and a revenue effect. We first look at both effects separately and discuss the policy consequences afterwards. Our welfare framework allows for different degrees of inequality aversion, including utilitarianism as a special case.

The marginal welfare effect Ex ante welfare is given by

$$W(s) \quad = \quad \int_{-\infty}^{a^*(s)} \phi(V_{02}(s))f(a)da + \int_{a^*(s)}^{+\infty} \phi(EV_1(s|a))f(a)da,$$

with ϕ a differentiable transformation function satisfying $\phi' > 0$ and $\phi'' \leq 0$. Proposition 1 summarizes the welfare impact of a marginal increase in subsidies to higher education.[11]

[11] All proofs can be found in the appendix.

Proposition 1. The marginal welfare impact of subsidies to higher education is equal to

$$\begin{aligned} W'(s) &= P_{12}(s)\bar{g}_{12}(s) + P_{13}(s))\bar{g}_{13}(s) \\ &\quad + [P_{02}(s)(\bar{g}_{02}(s) - \bar{g}_{13}(s)) + P_{12}(s)(\bar{g}_{12}(s) - \bar{g}_{13}(s))](1-t)w_2'(s)\ell_2(s), \end{aligned}$$

where $\bar{g}_{02}(s)$, $\bar{g}_{12}(s)$, and $\bar{g}_{13}(s)$ are the average marginal social welfare weights of the different groups, satisfying $\bar{g}_{02}(s) \geq \bar{g}_{12}(s) \geq \bar{g}_{13}(s) > 0$.

Proposition 1 tells us that marginally increasing subsidies has a direct and an indirect welfare effect. First, the direct effect is equal to $P_{12}(s)\bar{g}_{12}(s) + P_{13}(s))\bar{g}_{13}(s)$ and measures the welfare effect of increasing subsidies for those who do enroll in tertiary education. As they simply receive more money, this direct effect is strictly positive. Second, the remaining indirect effect is caused by the general equilibrium effect of subsidies on wages. If workers with a highest degree in secondary and tertiary education are substitutes—a reasonable assumption as mentioned before—then increasing subsidies increases the wage rate of workers with a secondary degree ($w_2'(s) > 0$) and decreases the wage rate of the workers with a tertiary degree. Because the workers with a tertiary degree have a lower average marginal social welfare weight, the total indirect effect is non-negative. To sum up, if we look at the direct and indirect effect together, then marginally increasing subsidies has a strictly positive effect on welfare.

The marginal revenue effect The (expected average) net government revenues are equal to the net fiscal revenues minus the subsidies to tertiary education, i.e.,

$$R(s) = P_2(s)t_2(s) + P_3(s)t_3(s) - P_1(s)s,$$

with $t_d(s) = tw_d(s)\ell_d(s) - b$ the net fiscal revenue of a worker with degree $d \in \{2, 3\}$. Proposition 2 summarizes the revenue impact of a marginal increase in subsidies to higher education.

Proposition 2. The marginal revenue impact of subsidies to higher education is equal to

$$R'(s) = P_3'(s)(t_3(s) - t_2(s)) - (P_1'(s)s + P_1(s)), \tag{8}$$

which can also be rewritten as

$$R'(s) = (P_1'(s)s + P_1(s))(MFRR(s) - 1), \tag{9}$$

with

$$MFRR(s) = \frac{\eta(s)}{1+\eta(s)} \cdot p(a^*(s)) \cdot \frac{t_3(s) - t_2(s)}{s}, \tag{10}$$

the marginal fiscal recovery rate, based on the elasticity of enrollment with respect to subsidies $\eta(s) = \frac{P_1'(s)}{P_1(s)}s$, the success probability of the marginal student $p(a^*(s))$, and the ratio of the net fiscal revenue gain $t_3(s) - t_2(s)$ and the subsidy cost s of a degree in tertiary education.

First, equation (8) of Proposition 2 tells us that marginally increasing subsidies has a revenue effect that is equal to the difference between the marginal fiscal externality and the marginal subsidy cost. The marginal fiscal externality is equal to the increase in degrees $P_3'(s) > 0$ multiplied with the net fiscal revenue gain of a degree in tertiary education $t_3(s) - t_2(s)$, which can be expected to be positive. The marginal subsidy cost is equal to the full subsidy for the newly enrolled (marginal) students, i.e., $P_1'(s)s > 0$, augmented with the extra subsidy for the already enrolled (inframarginal) students, i.e., $P_1(s) > 0$. The sign of the marginal revenue effect is not defined a priori.

Second, equation (9) rewrites the marginal revenue effect in terms of the marginal fiscal recovery rate. As $P_1'(s)s + P_1(s) > 0$, it clearly shows that if the marginal fiscal recovery rate is larger than one, then the marginal revenue effect is strictly positive.

Third, equation (10) of Proposition 2 tells us that the marginal fiscal recovery rate depends on three statistics, the elasticity of enrollment with respect to subsidies, the success probability of the marginal student, and the ratio of the net fiscal revenue gain and the subsidy cost of a tertiary degree. Because the first two factors in equation (10) are bounded from above by one, the last statistic is an upper bound for the marginal fiscal recovery rate.

Discussion Proposition 1 and 2 together tell us that, if the marginal fiscal recovery rate is larger than one, then both the marginal welfare effect and the marginal revenue effect are strictly positive such that a small increase in tuition subsidies is unambiguously desirable. We now argue that externalities and credit constraints will not change this marginal result.

Externalities can be modelled in the utility function or in the production function. First, they can be modelled as a direct effect on utility, because, e.g., a more educated society increases everyone's utility directly. For example, following the literature on public goods, we could simply add an externality term to everyone's utility that depends on the proportion of graduates, say, $x(P_3(s))$, satisfying $x' > 0$. This extra term does not influence the decision to enroll in tertiary education. So, it will only augment the marginal welfare impact with a term $x'(P_3(s))P_3'(s) > 0$, ceteris paribus. As a consequence, a marginal fiscal recovery rate larger than one remains a sufficient condition for a small increase in subsidies to be unambiguously desirable. Second, externalities can also be modelled as an indirect effect on utility through spill-over effects on wages because, e.g., a more educated workforce increases the productivity of all workers. For example, following Lucas (1988), total production $Q(L_2, L_3)$ could be multiplied with a total factor productivity that depends on the proportion of graduates, say, $A(P_3(s))$, with $A' > 0$. Such an externality will increase everyone's wage rate. As a consequence, both the marginal welfare effect and the marginal revenue effect increase and, again, a marginal fiscal recovery rate larger than one remains a sufficient condition.

Introducing credit constraints can also be done in different ways. First, following Colas, Findeisen, and Sachs (2021), one could add heterogeneity in parental income to the heterogeneity in ability. A lower parental income increases the prevalence of borrowing constraints because of lower parental transfers. Second, following Lawson (2017), one could introduce a maximum on accumulated debt. Introducing credit constraints implies that either the elasticities tend to be larger (as in Colas, Findeisen, and Sachs, 2021) or the welfare gains are larger (as in Lawson, 2017). In both cases, introducing credit constraints will not change our main finding that a marginal fiscal recovery rate larger than one is a sufficient condition.

2.3 An approximation of the marginal fiscal recovery rate

We use equation (10) to approximate the marginal fiscal recovery rate for twenty OECD countries. We deliberately write 'approximate' here because this approach does not take into account heterogeneity between students, an issue to which we return later on. Our approximation is based on publicly available indicators reported by the OECD in their Education at a Glance report of 2019.[12] Table (C1) in appendix C presents the different indicators on costs, enrollment, success and net fiscal revenues. Table (C2) in appendix C reports the three sufficient statistics and the marginal fiscal recovery rate for each country. To explain the computation, we apply it to Belgium as an example.

The first key statistic in equation (10) is the elasticity of participation with respect to subsidies. Previous studies show that a 1000 euro tuition increase lowers enrollment by 1-4 percentage points; see, e.g., Abraham and Clark (2006), Dynarski (2002, 2003), Nielsen et al. (2010), and Steiner and Wrolich (2012). To compute the participation elasticity, we therefore assume in our baseline model that a 1000 euro tuition increase lowers enrollment by 2.5 percentage points. Taking into account the average subsidy cost per student per year of 11848 US$ (OECD, 2019, Table C1.2, column 8) and an average participation in higher education of 69% (OECD, 2019, Table B4.3, column 14), the average participation elasticity with respect to subsidies is equal to $\eta(s) = \frac{0.025}{1000} \cdot \frac{11848}{0.69} = 0.43$ in Belgium.

The second key statistic is the success probability of the marginal student. Ignoring heterogeneity between students, we assume that the success probability of the marginal student is equal to the success probability of the average student in our approximation. According to the OECD (OECD, 2019, Table B4.3, column 5), 61% of all entrants in bachelor programs complete a degree within the theoretical duration of the program plus 3 years in Belgium.[13]

The third and last key statistic is the gain-cost ratio, i.e., the ratio of the net fiscal revenue gain and the subsidy cost of a tertiary degree. Expressed in PPP US$ of 2016, the average net fiscal revenues in Belgium—based on income taxes, social security contributions, welfare transfers, and unemployment benefits—are equal to 273200 US$ for a man and 256600 US$ for a woman (OECD, 2019, Tables A5.2a and A5.2b, column 7), and the average subsidy costs—including the direct costs—are equal to 54000 US$ for both men and women (OECD, Tables A5.2a and A5.2b, column 1). The average gain-cost ratio—the ratio of the net fiscal revenue gain and the subsidy cost of a tertiary degree—is thus equal to $\frac{1}{2}(273200 + 256600)/54000 = 4.91$ in our approximation.

Based on these three statistics, we can approximate the marginal fiscal recovery rate in Belgium as

[12] We consider only the set of countries for which the required indicators are available in OECD (2019).

[13] This completion rate is computed as the average of the completion rate in Flanders (67%) and Wallonia (54%).

$$MFRR(s) \quad = \quad \frac{0.43}{1+0.43} \cdot 0.61 \cdot 4.91 = 0.89. \tag{11}$$

The marginal fiscal recovery rate is equal to 0.89, i.e., 0.89 euro is recovered in net fiscal revenues of an extra euro of subsidies to higher education in Belgium. As the marginal fiscal recovery rate is below one, the cost of additional tuition subsidies is not fully recovered by higher future tax revenues.

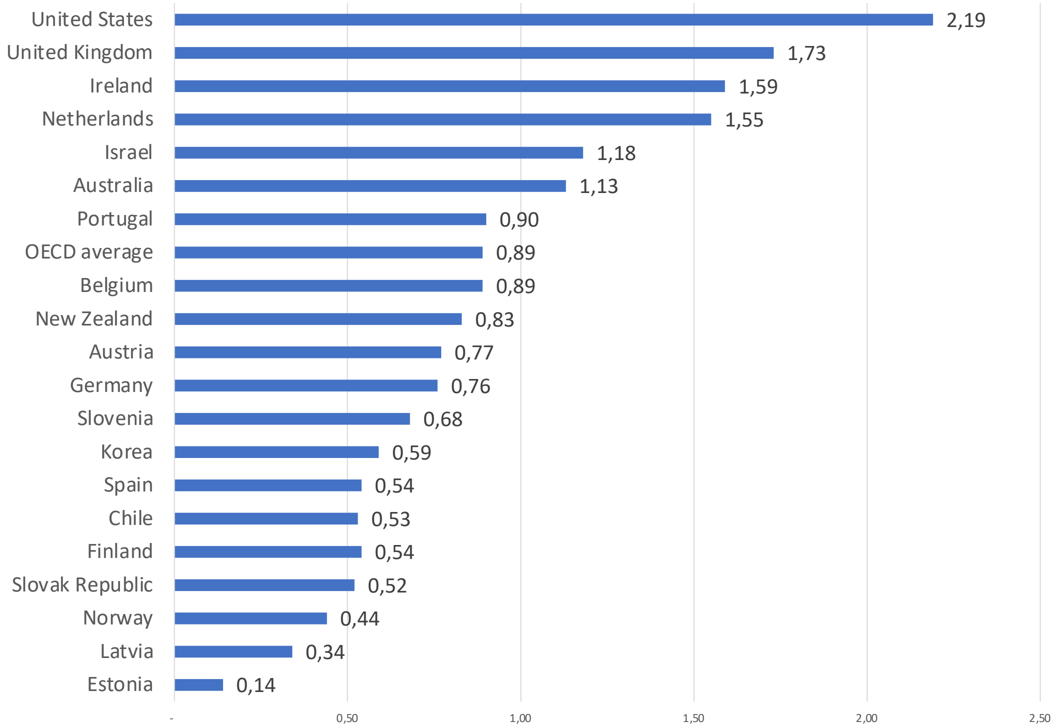
In our approximation of the marginal fiscal recovery rate, we use average statistics that might be different from the true marginal statistics. This will bias our results, but the direction of the bias is a priori not clear. The first key statistic is based on the participation elasticity, which is likely to be larger for students at the participation margin. The reason is that these marginal students are more likely to live in poorer families who are more sensitive to tuition changes. The second and third key statistic, the success rate and the gain-cost ratio, are probably lower for students at the participation margin. The reason is that their academic background is likely to be weaker and that they choose more often educational programs (such as professional rather than academic bachelor programs) with lower earnings. As these biases go in opposite directions, the net effect is not clear a priori. We will quantify some of these biases in our more detailed model of Section 3.

Figure (2) shows the marginal fiscal recovery rate for a selection of OECD countries. The average marginal fiscal recovery rate for our selection of OECD countries is 0.89 and identical to the marginal fiscal recovery rate computed for Belgium. The marginal fiscal recovery rate ranges from 0.14 in Estonia to 2.19 in the United States. Moreover, the marginal fiscal recovery rate is larger than one in at least six countries (Australia, Israel, the Netherlands, Ireland, the United Kingdom, and the United States), implying that an increase in subsidies to higher education is unambiguously desirable in these countries. For the other fourteen countries (Portugal, New Zealand, Belgium, Austria, Germany, Slovenia, Korea, Spain, Chile, Finland, Slovak Republic, Norway, Latvia, and Estonia) the marginal fiscal recovery rate is smaller than one. Yet, this does not imply that one should decrease subsidies in these countries because, e.g., positive non-fiscal externalities may justify the current subsidy levels.

3 A more detailed model

A second way to compute the marginal fiscal recovery rate is to use a more detailed model to simulate the impact of a limited change in tuition subsidies on the change in the total costs of tuition subsidies and the change in fiscal revenues. We allow for heterogeneity between students in enrollment, study choice and duration, dropout, degree completion, employment, earnings, taxes, and welfare benefits. We start by discussing the different components of the model. Afterwards, we use the model to simulate the impact of a small increase in tuition subsidies to compute the marginal fiscal recovery rate.

Figure 2: The marginal fiscal recovery rate in OECD countries



3.1 Model and estimation

Utility of studying The model is similar to Declercq and Verboven (2015). After graduating from high school, students can choose to continue education or to start working. A student i chooses an option $j \in J$, with J the set of choice alternatives to maximize the utility of studying. The utility of studying U_{ij} depends on student' characteristics (captured by X_i), and the cost of studying for students CS_{ij} and is specified as

$$\begin{aligned} U_{ij}(X_i, CS_{ij}) &= \beta_{0j}^u + \beta_{1j}^u X_i + \beta_2^u (CS_{ij}) + \beta_3^u X_i (CS_{ij}) + \varepsilon_{ij}^u \\ &= V_{ij}(X_i, CS_{ij}) + \varepsilon_{ij}^u, \end{aligned}$$

where $V_{ij}(X_i, CS_{ij})$ represents the deterministic part of utility and ε_{ij} represents the unobserved factors affecting the utility of studying. Students are heterogeneous in their sensitivity to costs captured by an interaction effect between student' characteristics and the cost variable.

Cost of studying The monetary cost of being enrolled for one year in option j for student i is specified as

$$CS_{ij} = f_i + tc(td_{ij}, tt_{ij}, r_{ij}) - g_i,$$

where f_i is the tuition fee, tc the travel cost function, and g_i the study grant received in higher education.

First, tuition fees and study grants depend on household income. The lower the household income, the higher the amount of the study grant and the lower the tuition fee.[14] To compute the study grant we face two problems. We observe only whether a student obtains a study grant, but not the exact amount. Moreover, we only observe this grant dummy for students who start in higher education, but not for students who do not participate. This implies that we need some additional assumptions to compute the amount of the study grant for both participants and non-participants. We assume that students, who get a grant, obtain the average amount of the grants assigned in higher education, being 1573 euro in academic year 2008-2009 (the year of our analysis).[15] To predict the expected grant for non-participants, we assume that pupils who choose not to participate would have received a grant in higher education if they already obtained a grant in high school, which is also based on family income.[16] Again, we assume that they would have received the average grant in higher education.

Second, travel costs consist of two components: transportation costs and the opportunity costs of time. As in Kelchtermans and Verboven (2010) we assume that the transportation costs depend on the travel distance td_{ij} (in km) and the travel time tt_{ij} (in hours) between the home municipality of student i and college or university campus j, and on the costs of going on residence, denoted r_{ij} (in euro per year). The annual travel cost for students who do not go on residence is $n(p \cdot td_{ij} + w \cdot tt_{ij})$, with $n = 300$ the number of trips per year (10 trips during 30 weeks), $p = 0.25$ the transportation cost (in euro/km), and $w = 8.36$ the opportunity cost of time (in euro/hour).[17] Students who go on residence, save a fraction $\pi = 0.8$ of the trips—residential students go home every week—but pay an extra annual cost on rent equal to r_{ij} (which is again lower for students who obtain a study grant).[18] As we do not observe whether students decide to commute or go on residence, we assume that students go on residence if the costs of commuting exceed the costs of going on residence. To sum up, we have

$$tc(td_{ij}, tt_{ij}, r_{ij}) = \min\{n(p \cdot td_{ij} + w \cdot tt_{ij}), r_{ij} + (1 - \pi)n(p \cdot td_{ij} + w \cdot tt_{ij})\}.$$

Estimation We estimate a nested logit model of enrollment in the first year in higher education. This model allows for correlation of the unobserved factors ϵ_{ij}^{u} within each nest. We specify a model with two nests: a no-study nest and a study nest. The study nest includes 45 study options in higher education. Students can choose a professional or academic bachelor program at each of the several college or university campuses. Academic programs consist of two cycles, a three-year bachelor program, usually followed by a one- or two-year master

[14] In Flanders, tuition fees are already low (approximately 562 euro in 2008 (the year that we model the enrollment decision) and currently around 950 euro). Students who receive a scholarship have to pay a tuition fee of only 112 euro.

[15] https://www.studietoelagen.be/algemene-cijfergegevens-per-school-en-academiejaar

[16] From the sample of participants, we find that obtaining a study grant in high school is a strong predictor of obtaining a study grant in higher education. The correlation between both is 72%.

[17] This corresponds to the typical wage for student jobs (Jobdienst KU Leuven).

[18] Estimates of the annual cost of going on residence are available for the university of Ghent (Sociale dienst, UGent). Students without a study grant pay an annual rent of 3096 euro, while students with a study grant pay an annual rent of only 1764 euro for a room offered by the university. We assume that rental prices are similar in other cities.

program and are offered at colleges but mainly at universities. Professional programs only consist of a three-year bachelor program and are only offered at colleges. We do not model the choice between the several majors. The no-study nest includes the drop-out option. As in Train (2009), the probability that student i chooses option j in nest B_n can be estimated by the following equation:

$$p_{ijn} = \frac{e^{V_{ij}(X_i, k_{ij} - s_{ij})/\lambda} \left(\sum_{j' \in B_n} e^{V_{ij'}(X_i, k_{ij} - s_{ij})/\lambda} \right)^{\lambda - 1}}{\sum_{n=1}^{2} \left(\sum_{j' \in B_n} e^{V_{ij'}(X_i, k_{ij} - s_{ij})/\lambda} \right)^{\lambda}}$$

The parameter λ measures the degree of independence in unobserved utility among the alternatives in the study nest. There is perfect correlation if $\lambda = 0$, and there is no correlation as in the conditional logit model if $\lambda = 1$.

Empirical results We combine two rich datasets provided by the Flemish Ministry of Education and Training. The first dataset contains detailed information on all 56672 pupils who graduated from high school in academic year 2007-2008. We observe gender, age, high school background, and socio-economic status. We also observe detailed information on the residence of students. The second dataset contains information of all students who first registered for a program in higher education in 2008 or 2009. We observe the type of program (university, academic college, or professional college) and the study result at the end of the first year. On the basis of a unique identification number, we can combine both datasets as in Declercq and Verboven (2015). From the 56672 high school graduates, 38571 students start in higher education in academic year 2008-2009, while another 1121 students do not immediately start in higher education after graduating from high school, but enter higher education with one year of delay. Table C3 in Appendix C shows enrollment in the first year at university, academic college and professional college according to the gender, age, high school background and socio-economic status of the students.

Table C4 in Appendix C shows the estimates of the nested logit model for enrollment in the first year of higher education. Gender, age, high school background, and socio-economic status are interacted with indicators for the different choice options (no study option, university, academic college) and effects have to be interpreted relative to the reference category, a professional bachelor program at college.[19] Gender, age, high school background and socio-economic status have a statistically significant effect on study decisions. Students are sensitive to the costs of higher education and students from disadvantaged backgrounds are more sensitive to the costs of education.

Success in the first year We use the same dataset to estimate the probability of success at the end of the first year in higher education. Success in the first year in study program j is given by $\beta^s_{0j} + \beta^s_{0j} X_i + \epsilon^s_{ij}$, where we also interact student background X_i with program dummies to allow for a different effect of student characteristics on success in the different type

[19]We do not include interaction effects between programs in technical secondary education and university level programs, because only few students from technical, artistic, or vocational programs start at university.

of programs. We divide the outcome variable in three categories—success for at most half of the courses (0-49%), for at least half of the courses, but not for all courses (50-99%), and for all courses (100%)—and use an ordered logit model to estimate success. Table C5 in Appendix C shows success at te end of the first year at university, academic college and professional college according to the gender, age, high school background and socio-economic status of the students. Table C6 in Appendix C presents the results of the ordered logit regression. Student' characteristics have a statistically significant effect on success.

Study duration, degree completion, and dropout Conditional upon the study program and success in the first year, students can continue the same program, switch to another program, or drop out of higher education. To predict drop-out and degree completion, we use a separate dataset of all students who started higher education in 2005.[20]

Table C7 in Appendix C shows the probability of obtaining a bachelor degree at university, academic college, and professional college for all entrants in higher education and the time they need to complete this degree (3, 4, 5 or 6 years). Many students drop out or switch to other programs during their studies. Students graduating from professional bachelor programs are assumed to start working. Students graduating from academic bachelor programs are assumed to enroll in the corresponding master program and to successfully complete one or two years of studying if they graduated from an academic bachelor at college or university, respectively. Students can thus be enrolled for a maximum of eight years in higher education if they complete their bachelor degree at university after six years of studying.

Subsidies to higher education Higher education in Flanders is highly subsidized and students pay only a small part of the total costs. The total expected discounted subsidy to student i who chooses study option j is equal to

$$s_{ij} = \sum_{t=1}^{8} 0.98^{t-1} \sum_{j=1}^{J} p_{ijt}(vc + g_i),$$

where the discount factor equals 98%.[21] As costs and benefits are expressed in real terms, this implies that the discount rate is 2 percentage points above the inflation rate. p_{ijt} is the estimated probability that student i is enrolled in program j in period t. vc is the variable cost of higher education per student and is equal to the sum of the variable subsidies to higher education institutions (4190 euro per student in 2008) and child benefits (1637 euro in 2008).[22] As we focus on marginal changes in subsidy levels, it is safe to assume that the

[20]In contrast to the 2008 cohort of students used in Table C3 in Appendix C, we can follow this 2005 cohort during six years in higher education. Yet, we will use the 2008 cohort in our estimations of enrollment and success in the first year, as we observe more student characteristics and the location of the students, which will allow us to compute their travel costs.

[21]The discount rate is used by the OECD to compute the public return to higher education. This is the same discount rate used in the approximation of the marginal fiscal recovery rate in section 2. To check robustness, we will look at other values later on.

[22]Based a regression using budgetary administrative data of all colleges and universities in Flanders, we computed that the variable cost was equal to 4940 euro per student in 2016 (or 4190 euro in 2008 euros). In Belgium, parents are still eligble for child benefits for children enrolled in higher education. In 2020, parents

resulting changes in enrollment do not affect the supply of study programs such that we can ignore the fixed costs of higher education. Finally, as discussed in section 3.1.1. subsidies to higher education also consist of study grants g_i for low-income students.

Earnings, taxes, and labor market participation After graduating from secondary or tertiary education, or after dropping out of higher education, individuals enter the labor market. To compute expected discounted earnings, tax contributions, and welfare benefits, we allow individuals to work (full-time or less), to be unemployed, or to be inactive during the different parts of their career. The earnings and activity level differ according to the obtained degree and gender.

Earnings and activity level on the labor market for individual i with a degree in program j with t years of work experience are estimated via

$$y_{ijt} = \beta^l_{0j} + \beta^l_{1j} m_i + \beta^l_{2j} exp_{it} + \beta^l_{3j} (exp_{it})^2 + \epsilon^l_{ijt}.$$

Depending on the estimation, the dependent variable is $y_{ijt} = w_{ijt}$ for the yearly full-time net earnings of workers, $y_{ijt} = tax_{ijt}$ for the yearly tax contributions of full-time workers, $y_{ijt} = h_{ijt}$ for hours worked (as a fraction of full-time), and $y_{ijt} = p_{ijt}(emp)$, $p_{ijt}(unemp)$, $p_{ijt}(inactive)$ for the probability of being employed, unemployed, or inactive.[23] The indicator variable m_i is equal to one for male workers and exp_{it} stands for work experience. The intercept and the effect of gender and work experience can differ according to the obtained degree of the worker, denoted by j.

To estimate these regressions, we use two datasets. First, a large survey dataset, 'Vacature salarisenquête', contains earnings and tax information for workers in Flanders in 2006 who graduated from secondary education and academic or professional programs at college and university. Second, the EU-SILC data for Flanders, contains additional information on labour market participation of different groups but only allows to distinguish between high school graduates and graduates from higher education.

We estimate the probability that someone is employed, unemployed, or inactive based on a multinomial fractional logit model (to guarantee that these probabilities add up to one for each individual in each period). We estimate earnings and tax contributions by OLS and the number of hours worked as a fraction of a full-time equivalent by a fractional logit model. Table C8 in Appendix C shows the output of the fractional multinomial logit model for the probability of being employed, unemployed, or inactive. Table C9 in Appendix C shows the OLS estimates of the yearly net earnings of full-time workers, yearly tax contributions, and the estimates of the fractional logit model for the number of hours worked as a fraction of a full-time equivalent.

Altough we use data from students starting tertiary education in 2005 or 2008 and data

receive 1958 euro per year for each child (or 1637 euro in 2008 euros). Source: https://www.vlaanderen.be/het-groeipakket-nieuwe-kinderbijslag.

[23]Because a substantial fraction of workers with more than 30 years of working experience is retired, we consider these individuals as inactive.

from labor market participants in 2006, we use the most recent policy paramters to predict tax contributions, unemployment and retirement benefits. The reason is that we want to compute the marginal fiscal recovery rate later on as closely as possible for the current generation/cohort of graduates in high school. We assume that people participate in the labor market for at most 45 years (or until the age of 67). If unemployed, then one receives benefits equal to 62% of the net wage they could have earned when working full-time.[24] If inactive, then one does not obtain a wage or welfare benefits and does not pay taxes. In addition to the income tax contributions, workers pay, on average, a consumption tax of 10.2% on their net earnings, and employers pay an employer social security contribution of 25% on gross earnings.[25]

All indviduals retire 45 years after graduation from secondary or higher education or, at the latest, at the age of 67. Their net pension is equal to 66.2% of their average yearly net income during their career.[26] This net income includes net earnings and unemployment benefits. We assume that all individuals live during 82 years.[27]

To compute expected discounted tax revenues of each individual in our sample we use a discount factor of 0.98.

3.2 A policy simulation to compute the marginal fiscal recovery rate

Additional tuition subsidies will increase enrollment because students are responsive to costs. A higher enrollment will in turn lead to more graduates. Given that graduates from higher education pay more taxes, additional tuition subsidies will lead to higher future net tax revenues.

To illustrate the trade-off between the increase in net tax revenues and the higher costs of subsidizing higher education, we use our model to simulate the impact of a change in tuition subsidies on enrollment in higher education. Subsequently, we predict how the change in enrollment affects degree completion and drop-out. Based on the predicted final degree, we can compute total discounted tax contributions of each individual.

First, we consider a uniform change in tuition subsidies. Afterwards, we simulate the impact of a discriminatory change in tuition subsidies limited to students from disadvantaged backgrounds.

Uniform changes in tuition subsidies Figure 3.2 shows the impact of changing the level of tuition subsidies on enrollment (solid line), degree completion without study delay (dashed line) and total degree completion (dotted line). On the horizontal axis, we present the change

[24] In principle, 62% applies to the earnings over previous work episodes, but current and last earnings are very similar. Source: https://stats.oecd.org/Index.aspx?DataSetCode=NRR

[25] The (average) consumption (i.e., value-added and excise) tax in Belgium as a percentage of disposable income is computed using EUROMOD. The employer contribution rate of 25% is the current employer contribution for the private for-profit sector.

[26] OECD (2019b, Table 5.5)

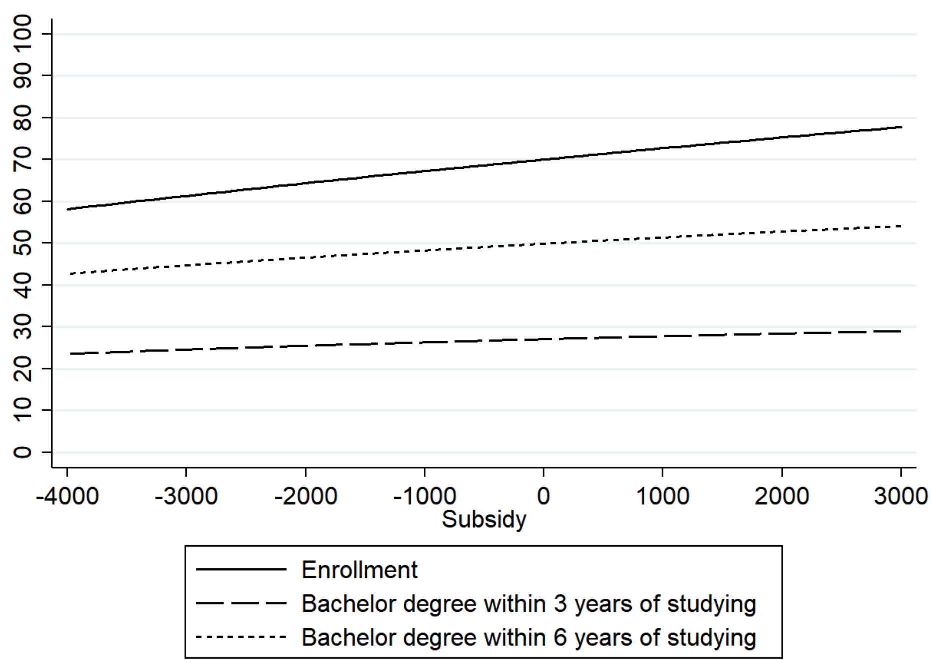
[27] Source: https://statbel.fgov.be/sites/default/files/files/documents/bevolking/5.4%20Sterfte%2C%20levens verwachting%20en%20doodsoorzaken/5.4.3%20Sterftetafels%20en%20levensverwachting/sterftetafelsAE.xls. We find that results are similar when we do not include pensions. This robustness check implies that results are not sensitive to alternative assumptions on life expectancy.

in the level of subsidies: 0 corresponds to the status quo, positive values imply an increase in tuition subsidies, and vice-versa for negative values.

At the current tuition level, 70.04% of high school graduates are predicted to enroll in higher education, 27.07% obtains a degree without study delay, and 49.90% of high school graduates eventually graduate from higher education. An increase in tuition subsidies increases enrollment and, to a lesser extent, also degree completion. For example, a marginal increase in tuition subsidies by 100 euro would increase enrollment by 0.27 percentage points (from 70.04% to 70.31%). Degree completion within 3 and 6 years would increase by respectively 0.07 and 0.15 percentage points. Table 1 provides more detail as it shows how this change in tuition subsidies affects enrollment and degree completion at university and college programs. Changes in enrollment caused by changes in tuition subsidies are largest in professional college programs and smallest in university programs. An increase in tuition subsidies of 100 euro leads to an increase in enrollment at university by only 0.03 percentage points while enrollment in professional bachelor programs would increase by 0.22 percentage points. As graduates from university programs have the highest earnings and are most likely to work (full-time), additional tuition subsidies mainly increase enrollment in programs with relatively lower labour market returns.

Changes in tuition subsidies have a proportionally smaller effect on degree completion than on enrollment because they mainly encourage participation of students of, on average, lower ability. Table C10 in Appendix C shows the increase in enrollment caused by a uniform tuition subsidy of 100 euro for students graduating from the different programs in high school. Enrollment of students from general secondary education (the track that prepares students for academic higher education) would increase by 0.10 percentage points (from 95.76% to 96.86%), while participation of students from vocational secondary education would increase by a larger amount of 0.32 percentage points (from 13.40% to 13.72%). Subsidies have a larger impact on participation of students from disadvantaged backgrounds because they are more responsive to costs.

Figure 3: Uniform change in tuition subsidies: Enrollment and degree completion



Note: Enrollment and degree completion are expressed as a percentage of high school graduates of 2008.

Table 1: Uniform change in subsidies

	Status quo	Counterfactual subsidy (+100 euro)
Enrollment	70.04	+0.27
University	23.65	+0.03
Academic college	8.29	+0.02
Professional college	38.10	+0.22
Degree within 3 years	27.07	+0.07
University	9.56	+0.01
Academic college	2.93	+0.00
Professional college	14.58	+0.06
Degree within 6 years	49.90	+0.15
University	15.46	+0.02
Academic college	5.58	+0.01
Professional college	28.86	+0.12
Discounted government expenditures and tax income		
Subsidy costs	16914	+317
Net tax revenues	488398	+236
Net government revenues	471484	-81
Marginal fiscal recovery rate		0.74
Net tax revenue maximizing subsidy		-1900

Note: Enrollment and degree completion in the status quo are expressed as a percentage of high school graduates. Results of the counterfactual are expressed as percentage point changes relative to the status quo. Subsidy costs, net tax and net government revenues are expressed in euro per high school graduate.

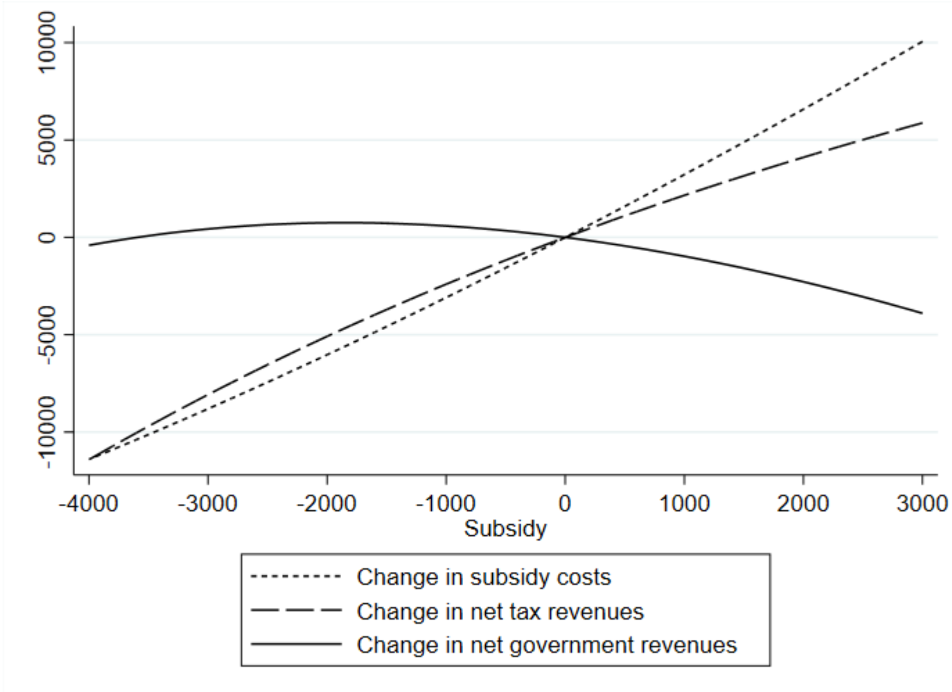
Figure 4 shows the impact of a change in the level of subsidies on the net tax revenues (dashed line) defined as tax contributions minus unemployment benefits and pension expenditures, the costs of subsidizing higher education (dotted line), and on the net government revenues (solid line), defined as the difference between the net tax revenues and the costs. All these outcomes are normalized to the level at the status quo. Subsidizing higher education increases the costs but, also leads to fiscal externalities. The solid line shows that the increase in net tax revenues does not cover the increase in the additional costs of subsidies. The bottom rows of Table 1 provide more detail on the fiscal returns to higher education. Marginally increasing the yearly subsidy level by 100 euro for each participating student increases the discounted cost for the government per high school graduate by 317 euro, but increases net tax revenues by only 236 euro. From the change in costs and tax revenues, we can compute the marginal fiscal recovery rate, i.e., the ratio of the change in total net fiscal revenues and the change in total subsidy costs caused by a small change in subsidies. When considering the increase in the level of subsidies by 100 euro, we find that this rate is equal to 0.74, meaning that increasing subsidies with one euro raises the net fiscal revenues with only 0.74 euro. The simulated marginal fiscal recovery rate for Flanders is therefore roughly similar to its approximation (0.89) based on OECD indicators for Belgium in Figure 2.

From Figure 4, the net government revenues follow an inverted U-shaped curve. So, a limited increase in tuition fees would increase the net government revenues. We can use our model to compute the tuition fee that maximizes the net government revenues. While this tuition level is not necessarily optimal, it is maximal, in the sense that higher tuition levels are Pareto inferior. We compute that an increase in tuition fees by 1900 euro would be maximal. This corresponds to a yearly tuition fee of approximately 2500 euro (to be compared with tuition of 600 euro at the time of our analysis and 950 euro now).

Changes in tuition subsidies targeted at disadvantaged students While a uniform change in tuition subsidies does not allow for Pareto improvements, we investigate whether a change in tuition subsidies targeted at disadvantaged students could be more succesful. On the one hand, an increase in subsidies limited to students from disadvantaged backgrounds may be more beneficial, because these students are more responsive to changes in tuition (See Table C4 in Appendix C). On the other hand, Table C6 in Appendix C shows that students from disadvantaged backgrounds are, on average, less successful in higher education. This makes the posssibility of a Pareto improvement less likely.

We repeat the counterfactual simulations of the previous subsection on the sample of disadvantaged high school graduates. We consider high school graduates from low-income families, i.e., students who received a study grant during their secondary education. The results are shown in Figures C1 and C2 and Table C11 in Appendix C. For the group of students from disadvantaged backgrounds, we compute a larger marginal fiscal recovery rate of 0.86. As this rate is still below one, a further increase in scholarships for disadvantaged students cannot be justified from a fiscal perspective. We find that tuition fees could be raised by at most 600 euro for this group of students (to be compared with a tuition fee of about 110

Figure 4: Uniform change in subsidies: Fiscal externalities



Note: Changes in subsidies, net tax and net government revenues are expressed in euro per high school graduate of 2008.

euro currently).

3.3 Robustness checks

In this section we check the robustness of our results with respect to a number of assumptions. We start with a broad discussion of general equilibrium effects, externalities, and credit constraints. Afterwards, we look at more fine-grained changes in pensions, subsidy costs, and the discount factor.

First, in the theoretical discussion, we mentioned that general equilibrium effects, externalities, and credit constraints will not change the theoretical insight that a marginal fiscal recovery rate larger than one is a sufficient condition for a Pareto improvement. The reason was that general equilibrium effects do not affect the marginal fiscal recovery rate, while externalities and credit constraints are likely to increase the marginal fiscal recovery rate. However, as our empirical results indicate that the marginal fiscal recovery rate is smaller than one, we cannot be sure that it remains smaller than one if we would also take externalities and credit constraints into account.

The empirical literature on externalities show that, if anything, externalities are likely to be small.[28] For example, Acemoglu and Angrist (2001) and Ciccone and Peri (2006) find that wages increase with about two percent if the average years of education increase with one year. So, in case of a marginal increase in tuition subsidies of, say, 100 euro, the increase in average

[28]Admittedly, identification of externalities is difficult and therefore the precise magnitude remains debatable.

years of education and thus also the resulting wage increase can be safely ignored. The impact of credit constraints is less clear. We can only hope that the estimated elasticities do a good job in capturing that, e.g., low-income students are more sensitive to tuition subsidies (which could be reflecting the presence of credit constraints among other things). Our estimates suggest that this is indeed the case: for example, the elasticities in case of an increase in subsidies targeted to low-income students are much higher than in case of a uniform increase. All in all, we expect our estimates to be fairly robust, but only further analysis can confirm our expectation.

Second, table 3.3 assesses how some of the assumptions of the model affect the results. The first panel repeats the results of the uniform change in subsidies computed from our baseline model.

Because there is much uncertainty about the design of pension systems in the future, Panel B assesses how the inclusion of pensions affects our results. On the one hand, pension expenses will be higher for graduates from higher education because they are calculated as a percentage of net earnings. On the other hand, graduates from higher education retire when they are older which reduces the period that these people will receive pension benefits. The results in Panel B are very similar when we exclude pension benefits from the calculation of the net tax revenues. The marginal tax return is slightly more negative and the maximal tuition fee slightly higher.[29]

Panel C shows the sensitivity of our results to the definition of variable costs of higher education. In our baseline model, variable costs are the sum of variable subsidies to higher education (4190 euro per student), child benefits (1637 euro per student) and study grants. In panel C we repeat the analysis with variable costs that are 1000 euro lower. As expected, we find a slightly higher marginal fiscal recovery rate of 0.77.

The final two panels assess the robustness of our results to the choice of the discount rate. In our baseline model, net tax revenues are discounted at a rate that is 2 percentage points above the inflation rate. The results in panel D show that discounting the future more (3 percentage points above the inflation rate) further decreases the marginal returns to subsidies and increases the maximal tuition fee. In contrast, setting a lower discount rate in panel E (1 percentage point above inflation) implies that marginal tax returns become positive and increasing subsidies by 100 euro would be beneficial for both students and the government. This sensitivity analysis shows that the discount rate is an important parameter in the policy decision about the level of tuition fees or subsidies to higher education. Notice that our benchmark factor of 0.98 is high compared to the discount rates used in national cost-benefit analysis, ranging between 0.93 and 0.97 for a selection of OECD countries (OECD, 2018, Table A5.a).

[29]It is observed that highly educated individuals live on average longer than lower educated individuals. Because we assume that all individuals live until their 82th birthday, our model underestimates the total discounted expenditures for pensions for the group of higher educated individuals. Consequently, the fiscal returns to higher education are overestimated. However, given that we discount future expenditures at a yearly discount factor of 0.98 and that we find that ignoring pension expenditures hardly affects our results, we believe that ignoring the difference in life expectancy between individuals will not affect our main results.

Table 2: Robustness checks

	Status quo	Counterfactual subsidy (+100 euro)
Panel A: Baseline model		
Discounted government expenditures and tax income		
Subsidy costs	16914	+317
Net tax revenues	488398	+236
Net government revenues	471484	-81
Marginal fiscal recovery rate		0.74
Net tax revenue maximizing subsidy		-1900
Panel B: No pensions		
Discounted government expenditures and tax income		
Subsidy costs	16914	+317
Net tax revenues	548877	+226
Net government revenues	531963	-91
Marginal fiscal recovery rate		0.71
Net tax revenue maximizing subsidy		-2100
Panel C: Subsidy costs (- 1000 euro)		
Discounted government expenditures and tax income		
Subsidy costs	14323	+308
Net tax revenues	488398	+236
Net government revenues	471484	-81
Marginal fiscal recovery rate		0.77
Net tax revenue maximizing subsidy		-1700
Panel D: Discount factor = 0.97		
Discounted government expenditures and tax income		
Subsidy costs	16624	+312
Net tax revenues	442861	+152
Net government revenues	391561	-153
Marginal fiscal recovery rate		0.51
Net tax revenue maximizing subsidy		-3900
Panel E: Discount factor =0.99		
Discounted government expenditures and tax income		
Subsidy costs	17210	+322
Net tax revenues	541553	+328
Net government revenues	524343	+19
Marginal fiscal recovery rate		1.06
Net tax revenue maximizing subsidy		+400

Note: Subsidy costs, net tax reveneus and net government revenues are expressed in euro per high school graduate.

4 Conclusion

We have studied fiscal externalities of subsidizing higher education. By increasing enrollment and degree completion, tuition subsidies will lead to higher future net fiscal revenues because graduates from higher education earn higher wages and receive less benefits. In this paper we investigated whether such fiscal externalities provide a justification for increasing subsidies to higher education.

As a first contribution, we showed that if the marginal fiscal recovery rate—the ratio of the change in total net fiscal revenues and the change in total subsidy costs caused by a small change in tuition subsidies—is larger than one, then a small increase in subsidies is unambiguously desirable. Unambiguous means that increasing subsidies increases both welfare and net fiscal revenues, irrespective of the degree of inequality aversion, general equilibrium effects on wages, externalities, and credit constraints. We also showed that the marginal fiscal recovery rate depends on three sufficient statistics: the elasticity of participation with respect to subsidies, the success probability of the marginal student, and the ratio of the net fiscal revenue gain and the subsidy cost of a degree in tertiary education.

As a second contribution, we used the sufficient statistics formula to approximate the marginal fiscal recovery rate for 20 OECD countries. The average marginal fiscal recovery rate is equal to 0.89. This means that on average 0.89 euro is recovered of an increase in subsidies with one euro. The average marginal fiscal recovery rate hides substantial heterogeneity between countries. It turns out to be larger than one in six countries (Australia, Israel, the Netherlands, Ireland, the United Kingdom, and the United States), implying that an increase in subsidies to higher education is unambiguously desirable in these countries.

As a third contribution, we carefully checked the quality of the previous approximation for one country. We modelled and estimated enrollment, study choice and duration, dropout, degree completion, employment, earnings, taxes, and welfare benefits for Flanders. All elements of the model together allow to simulate the marginal fiscal recovery rate in Flanders, taking heterogeneity between students into account. According to the simulation, the marginal fiscal recovery rate is equal to 0.74, which is a roughly similar to the approximation based on the sufficient statistics (being equal to 0.89). This obviously does not imply that the same is true in other countries, but we do think that similar counteracting biases are probably at work in other OECD countries too, suggesting that the approximate figures can be used for policy purposes. The more detailed model also allows to simulate other figures of interest (e.g., the marginal fiscal recovery rate for low-income students or the maximal tuition level in Flanders), figures that are hard to approximate using the sufficient statistics approach.

5 References

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A Proof of proposition 1

Ex ante welfare is given by

$$\begin{aligned} W(s) &= \int_{-\infty}^{a^*(s)} \phi(V_{02}(s)) f(a) da + \int_{a^*(s)}^{+\infty} \phi(EV_1(s|a)) f(a) da, \\ &= \phi(V_{02}(s)) + \int_{a^*(s)}^{+\infty} [\phi(EV_1(s|a)) - \phi(V_{02}(s))] f(a) da, \end{aligned}$$

with ϕ differentiable and satisfying $\phi' > 0$ and $\phi'' \leq 0$. The marginal welfare impact is

$$\begin{aligned} W'(s) &= \phi'(V_{02}(s))V'_{02}(s) - \underbrace{\{\phi(EV_1(s|a^*(s))) - \phi(V_{02}(s))\}}_{=0,\text{ from eq. (2)}} f(a^*(s)) \frac{\partial a^*(s)}{\partial s} \\ &\quad + \int_{a^*(s)}^{+\infty} [\phi'(EV_1(s|a))EV'_1(s|a) - \phi'(V_{02}(s))V'_{02}(s)] f(a) da, \end{aligned}$$

which can be rewritten as

$$W'(s) = P_{02}(s)\phi'(V_{02}(s))V'_{02}(s) + \int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a))EV'_1(s|a) f(a) da.$$

Using equation (4), we have

$$\begin{aligned} V'_{ed}(s) &= \mathbf{1}[e=1] + \delta^{\varepsilon}((1-t)w_d(s))^{\varepsilon}(1-t)w'_d(s), \\ &= \mathbf{1}[e=1] + (1-t)w'_d(s)\ell_d(s), \end{aligned}$$

which can be used to further rewrite the marginal welfare effect as

$$\begin{aligned} W'(s) &= P_{02}(s)\phi'(V_{02}(s))V'_{02}(s) + V'_{13}(s) \int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a)) p(a) f(a) da \\ &\quad + V'_{12}(s) \int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a))(1-p(a)) f(a) da, \\ &= \underbrace{P_{02}(s)}_{=P_0(s)} \underbrace{\phi'(V_{02}(s))}_{\equiv \bar{g}_0(s)} (1-t)w'_2(s)\ell_2(s) + \\ &\quad \underbrace{P_{13}(s)}_{=P_3(s)} \underbrace{\frac{\int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a)) p(a) f(a) da}{P_{13}(s)}}_{\equiv \bar{g}_{13}(s)} [1 + (1-t)w'_3(s)\ell_3(s)] + \\ &\quad P_{12}(s) \underbrace{\frac{\int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a))(1-p(a)) f(a) da}{P_{12}(s)}}_{\equiv \bar{g}_{12}(s)} [1 + (1-t)w'_2(s)\ell_2(s)], \end{aligned}$$

or

$$\begin{aligned} W'(s) &= P_{12}(s)\bar{g}_{12}(s) + P_{13}(s))\bar{g}_{13}(s) \\ &+ [P_{02}(s)\bar{g}_{02}(s) + P_{12}(s)\bar{g}_{12}(s)](1-t)w_2'(s)\ell_2(s) \\ &+ P_3(s)\bar{g}_{13}(s)(1-t)w_3'(s)\ell_3(s). \end{aligned}$$

Finally, using equation (7) we can further simplify the marginal welfare impact as

$$\begin{aligned} W'(s) &= P_{12}(s)\bar{g}_{12}(s) + P_{13}(s))\bar{g}_{13}(s) \\ &+ [P_{02}(s)\bar{g}_{02}(s) + P_{12}(s)\bar{g}_{12}(s)](1-t)w_2'(s)\ell_2(s) \\ &- \underbrace{P_2(s)}_{=P_{02}(s)+P_{12}(s)} \bar{g}_{13}(s)(1-t)w_2'(s)\ell_2(s), \end{aligned}$$

which leads to

$$\begin{aligned} W'(s) &= P_{12}(s)\bar{g}_{12}(s) + P_{13}(s))\bar{g}_{13}(s) \\ &\quad + [P_{02}(s)(\bar{g}_{02}(s) - \bar{g}_{13}(s)) + P_{12}(s)(\bar{g}_{12}(s) - \bar{g}_{13}(s))](1-t)w_2'(s)\ell_2(s), \end{aligned}$$

as required. Finally, we show that $\bar{g}_{02}(s) \geq \bar{g}_{12}(s) \geq \bar{g}_{13}(s) > 0$ must hold. First, all weights are strictly positive (as $\phi' > 0$). Second, as the inequality (1) holds for those who enroll (satisfying $a \geq a^*(s)$) and as $\phi'' \leq 0$, we must have $\bar{g}_{02}(s) \geq \bar{g}_{12}(s)$ and $\bar{g}_{02}(s) \geq \bar{g}_{13}(s)$. Third, we also have $\bar{g}_{12}(s) \geq \bar{g}_{13}(s)$ because successful students are more likely to have a higher ability and thus also a lower welfare weight. To see this formally, define the conditional covariances and

$$\begin{aligned} COV[\phi'(EV_1(s|a))(1-p(a))|a \geq a^*(s)] &= E[\phi'(EV_1(s|a))(1-p(a))|a \geq a^*(s)] \\ &\quad - E[\phi'(EV_1(s|a))|a \geq a^*(s)]E[1-p(a)|a \geq a^*(s)] \geq 0, \end{aligned}$$

and

$$\begin{aligned} COV[\phi'(EV_1(s|a))p(a)|a \geq a^*(s)] &= E[\phi'(EV_1(s|a))p(a)|a \geq a^*(s)] \\ &\quad - E[\phi'(EV_1(s|a))|a \geq a^*(s)]E[p(a)|a \geq a^*(s)] \leq 0, \end{aligned}$$

where the signs of the covariances follow from $\phi'(EV_1(s|a))$ being decreasing in ability and p being strictly increasing (and thus $1-p$ strictly decreasing) in ability. We have

$$\begin{aligned} \bar{g}_{12}(s) &= \frac{\int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a))(1-p(a))f(a)da}{\int_{a^*(s)}^{+\infty}(1-p(a))f(a)da}, \\ &= \frac{E[\phi'(EV_1(s|a))(1-p(a))|a \geq a^*(s)]}{E[1-p(a)|a \geq a^*(s)]}, \\ &= \frac{COV[\phi'(EV_1(s|a))(1-p(a))|a \geq a^*(s)]}{E[1-p(a)|a \geq a^*(s)]} + E[\phi'(EV_1(s|a))|a \geq a^*(s)], \end{aligned}$$

and

$$\begin{aligned}
\bar{g}_{13}(s) &= \frac{\int_{a^*(s)}^{+\infty} \phi'(EV_1(s|a))p(a)f(a)da}{\int_{a^*(s)}^{+\infty} p(a)f(a)da}, \\
&= \frac{E[\phi'(EV_1(s|a))p(a)|a \geq a^*(s)]}{E[p(a)|a \geq a^*(s)]}, \\
&= \frac{COV[\phi'(EV_1(s|a))p(a)|a \geq a^*(s)]}{E[p(a)|a \geq a^*(s)]} + E[\phi'(EV_1(s|a))|a \geq a^*(s)],
\end{aligned}$$

so that the result $\bar{g}_{12}(s) \geq \bar{g}_{13}(s)$ follows directly from the signs of the covariances.

B Proof of Proposition 2

The net fiscal revenues minus the subsidy costs are equal to

$$R(s) = P_2(s)t_2(s) + P_3(s)t_3(s) - P_1(s)s,$$

with $t_d(s) = tw_d(s)\ell_d(s) - b$ the net fiscal revenue of a worker with degree $d \in \{2, 3\}$. Using the fact that $P_2'(s) = -P_3'(s)$ holds (as $P_2(s) + P_3(s) = 1$), the marginal revenue effect is

$$R'(s) = P_3'(s)(t_3(s) - t_2(s)) + P_2(s)t_2'(s) + P_3(s)t_3'(s) - (P_1'(s)s + P_1(s)).$$

Using equation (3), we have

$$\begin{aligned}
t_d(s) &= tw_d(s)\ell_d(s) - b, \\
&= t\delta^\varepsilon(1-t)^\varepsilon w_d(s)^{1+\varepsilon} - b,
\end{aligned}$$

and thus

$$\begin{aligned}
t_d'(s) &= t\delta^\varepsilon(1-t)^\varepsilon(1+\varepsilon)w_d(s)^\varepsilon w_d'(s), \\
&= (1+\varepsilon)tw_d'(s)\ell_d(s),
\end{aligned}$$

for each degree $d \in \{2, 3\}$, where the last step follows again from equation (3). Filled in in the marginal revenue effect, we get

$$\begin{aligned}
R'(s) &= P_3'(s)(t_3(s) - t_2(s)) \\
&\quad + P_2(s)(1+\varepsilon)tw_2'(s)\ell_2(s) + P_3(s)(1+\varepsilon)tw_3'(s)\ell_3(s) - (P_1'(s)s + P_1(s)),
\end{aligned}$$

which, using equation (7), becomes

$$R'(s) = P_3'(s)(t_3(s) - t_2(s)) - (P_1'(s)s + P_1(s)).$$

This is equation (8), as required. It can be easily rewritten to get equation (9), being

$$R'(s) = ((P_1'(s)s + P_1(s)))(MFRR(s) - 1),$$

with

$$MFRR(s) = \frac{P_3'(s)(t_3(s) - t_2(s))}{P_1'(s)s + P_1(s)},$$

the marginal fiscal recovery rate, being the ratio of change in net fiscal revenue gains in the numerator and the change in subsidy costs in the denominator caused by a small change in subsidies. Finally, to get equation (10), it is easy to verify that $P_3'(s) = P_1'(s)p(a^*(s))$ holds by definition, i.e., the marginal increase in graduates is equal to the marginal increase in enrollment multiplied with the marginal success probability. This allows to rewrite the marginal fiscal recovery rate as

$$\begin{aligned} MFRR(s) &= \frac{P_3'(s)s}{P_1'(s)s + P_1(s)} \cdot \frac{t_3(s) - t_2(s)}{s}, \\ &= \frac{P_1'(s)p(a^*(s))s}{P_1'(s)s + P_1(s)} \cdot \frac{t_3(s) - t_2(s)}{s}, \\ &= \frac{\eta(s)}{1 + \eta(s)} \cdot p(a^*(s)) \cdot \frac{t_3(s) - t_2(s)}{s}, \end{aligned}$$

where $\eta(s) = \frac{P_1'(s)}{P_1(s)}s$ is the elasticity of enrollment with respect to subsidies, as required.

C Additional tables and figures

Table C1: The cost of studying, participation, degree completion and fiscal returns of higher education in OECD countries

Countries	Yearly cost	Participation	Degree completion	Direct costs	Net fiscal returns
Australia	10791	77%	70%	24100	150450
Austria	13596	54%	58%	68300	233850
Belgium	11848	69%	61%	54000	264900
Chile	9271	85%	54%	8800	40950
Estonia	9237	60%	59%	48900	41600
Finland	10314	52%	73%	74600	168100
Germany	9863	53%	80%	71100	212600
Ireland	9102	69%	81%	37000	295750
Israel	7050	52%	83%	23700	133700
Korea	8385	57%	94%	20100	46900
Latvia	6110	70%	48%	19800	78300
Netherlands	12517	54%	69%	59100	359300
New Zealand	11910	61%	77%	31000	103000
Norway	14050	68%	72%	82500	147800
Portugal	8380	59%	65%	32100	169700
Slovak Republic	8816	49%	62%	35700	95850
Slovenia	8974	70%	53%	38300	203550
Spain	9416	74%	80%	35200	98750
United Kingdom	18405	66%	85%	26500	130550
United States	26550	47%	69%	47900	260250
OECD average	11229	62%	70%	41935	161793

Note: The yearly cost is the average cost per student per year in US$ (OECD, 2019, Table C1.2, column 8). Participation is the first time tertiary entry rate (OECD, 2019, Table B4.3, column 14). As this statistic is not reported for Australia, Estonia, Ireland, Israel, Korea and Latvia, we report the enrollment in bachelor programs for these countries (OECD, 2019, Table B4.3, column 5). Degree completion is measured by the completion rate in bachelor programs within the theoretical duration of the program plus 3 years (OECD, 2019, Table B5.1, column 12). For Belgium, we take the average of degree completion in Flanders and Wallonia. Direct costs are the average of the total costs of subsidizing higher education for men and women (OECD, 2019, Table A5.2a and A5.2b, column 1). Net fiscal returns are the total benefits for men and women expressed in US$ (OECD, 2019, Table A5.2a and A5.2b, column 6). The OECD average is an unweighted average of the corresponding statistics of the 20 OECD countries reported in this table.

Table C2: Sufficient statistics and the marginal fiscal recovery rate

Countries	$\frac{\eta(s)}{1+\eta(s)}$	$p(a^*(s))$	$\frac{t_3(s)-t_2(s)}{s}$	MFRR
Australia	0.26	0.70	6.24	1.13
Austria	0.39	0.58	3.42	0.77
Belgium	0.30	0.61	4.91	0.89
Chile	0.21	0.54	4.65	0.53
Estonia	0.28	0.59	0.85	0.14
Finland	0.33	0.73	2.25	0.54
Germany	0.32	0.80	2.99	0.76
Ireland	0.25	0.81	7.99	1.59
Israel	0.25	0.83	5.62	1.18
Korea	0.27	0.94	2.22	0.59
Latvia	0.18	0.48	3.62	0.34
Netherlands	0.37	0.69	5.83	1.55
New Zealand	0.33	0.77	3.13	0.83
Norway	0.34	0.72	1.62	0.44
Portugal	0.26	0.65	5.16	0.90
Slovak Republic	0.31	0.62	2.53	0.52
Slovenia	0.24	0.53	4.92	0.68
Spain	0.24	0.80	2.77	0.54
United Kingdom	0.41	0.85	4.67	1.73
United States	0.58	0.69	5.28	2.19
OECD average	0.31	0.70	3.86	0.89

Note: The participation elasticity with respect to subsidies for the OECD average is equal to $\eta(s) = \frac{0.025}{1000} \cdot \frac{11056}{0.58} = 0.48$. The success probability of the marginal student $p(a^*(s))$ is approximated by the average success rate in higher education as reported in Table C1. The third component $\frac{t_3(s)-t_2(s)}{s}$ is calculated as the difference between column 6 and 5 Table C1. The MFRR is the product of the three components. The OECD average is an unweighted average of the three components and MFRR of the 20 OECD countries reported in this table.

Table C3: Enrollment in the first year of higher education

Characteristics	University	Academic college	Professional college	Total
All pupils	23.61	8.30	38.13	70.04
Gender and study delay				
Male	21.29	10.19	34.07	65.55
Female	25.79	6.52	41.94	74.25
Study delay	7.84	5.64	38.40	51.88
No study delay	30.72	9.49	38.01	78.22
High school background				
General high school	52.88	12.81	30.06	95.76
latin + math	83.95	7.12	5.68	96.75
latin + languages	69.97	10.74	14.89	95.60
sci + math	65.87	16.60	13.98	96.46
math + languages	48.11	15.60	31.15	94.86
econ + math	53.33	19.47	24.27	97.07
econ + languages	28.38	15.74	51.25	95.37
human	29.26	6.54	58.67	94.48
Technical high school	3.47	5.74	63.21	72.43
business	4.96	4.86	76.98	86.80
sci + tech	9.50	22.45	59.46	91.41
social + tech	2.24	2.37	81.85	86.46
technics	0.58	3.82	46.68	51.09
other tech	2.85	2.95	57.39	63.19
Artistic high school	9.46	37.04	39.83	86.33
Vocational high school	0.24	0.53	12.62	13.40
Socio-economic status				
Mother no high school degree	9.68	4.52	36.06	50.26
Mother high school degree	16.85	7.30	41.85	66.00
Mother higher education degree	39.80	11.75	35.30	86.85
Dutch at home	23.71	8.36	38.45	70.52
No Dutch at home	21.87	7.24	32.50	61.60
High income	25.59	8.64	37.55	71.79
Low income	16.13	6.98	40.31	63.42
Total	13,382	4,701	21,609	39,692

Note: Enrollment rates in 2008 or 2009 are expressed as a percentage of 56,672 students graduating from high school in 2008.

Table C4: Enrollment in the first year of higher education (nested logit model)

	No study option[a]		Study options			
			University[a]		Academic college[a]	
Variables	Coef.	St. error	Coef.	St. error	Coef.	St. error
Constant	0.922***	(0.044)	-0.338***	(0.022)	-0.648***	(0.050)
Gender and high school background						
Male	0.263***	(0.030)	0.038***	(0.008)	0.167***	(0.013)
Study delay	0.606***	(0.028)	-0.080***	(0.011)	-0.047***	(0.012)
General high school[b]						
latin + math	-4.069***	(0.109)	1.381***	(0.080)	0.801***	(0.060)
latin + languages	-4.029***	(0.109)	1.101***	(0.064)	0.686***	(0.054)
sci + math	-4.329***	(0.083)	1.096***	(0.063)	0.778***	(0.056)
math + languages	-4.160***	(0.106)	0.810***	(0.048)	0.588***	(0.049)
econ + math	-4.734***	(0.163)	0.920***	(0.055)	0.701***	(0.055)
econ + languages	-4.502***	(0.075)	0.541***	(0.033)	0.457***	(0.042)
human	-4.331***	(0.075)	0.530***	(0.032)	0.238***	(0.038)
Technical high school[b]						
business	-3.693***	(0.054)	-	-	0.070*	(0.037)
sci + tech	-4.160***	(0.081)	-	-	0.441***	(0.043)
social + tech	-3.558***	(0.061)	-	-	-0.072	(0.044)
technics	-2.026***	(0.044)	-	-	0.085**	(0.038)
other tech	-2.369***	(0.040)	-	-	0.046	(0.038)
Artistic high school	-3.447***	(0.089)	-	-	0.729***	(0.054)
Socio-economic status						
Mother no high school degree[c]	0.446***	(0.040)	-0.125***	(0.014)	-0.109***	(0.015)
Mother high school degree[c]	0.300***	(0.035)	-0.101***	(0.010)	-0.072***	(0.010)
No Dutch at home	0.275***	(0.062)	0.148***	(0.019)	0.095***	(0.022)
Low income	0.338***	(0.045)	0.004	(0.010)	0.012	(0.012)
Cost sensitivity	-0.223***	(0.013)				
Cost sensitivity and socio-economic status						
Mother no high school degree[c]	-0.047***	(0.004)				
Mother high school degree[c]	-0.033***	(0.003)				
No Dutch at home	-0.019***	(0.006)				
Low income	-0.065***	(0.005)				
Nesting parameter	0.248***	(0.014)				
Log likelihood	-122519					
Observations	56672					

Note: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[a]Base category = professional college program.

[b]Base category = technical + artistic + vocational secondary education for university, vocational secondary education for college.

[c]Base category = mother has a degree in higher education.

Table C5: Study success in the first year of higher education

Characteristics	University	Academic college	Professional college	Total
All pupils	67.00	66.03	65.89	66.28
Gender and study delay				
Male	62.95	63.46	60.34	61.67
Female	70.14	69.78	70.11	70.09
Study delay	37.94	47.07	52.15	49.45
No study delay	70.34	71.10	72.14	71.31
High school background				
General high school	69.63	71.32	81.11	73.46
latin + math	80.39	82.54	86.09	80.88
latin + languages	69.65	74.85	82.05	72.17
sci + math	74.22	79.48	86.58	76.91
math + languages	63.17	69.03	86.13	71.68
econ + math	74.48	75.04	90.89	78.70
econ + languages	50.08	58.32	80.16	67.60
human	53.34	65.15	76.97	68.83
Technical high school	28.52	52.34	61.49	59.18
business	24.55	37.19	63.15	59.49
sci + tech	40.51	64.90	68.81	64.91
social + tech	19.63	39.49	61.49	59.80
technics	27.13	46.67	64.39	62.64
other tech	21.50	43.72	54.92	52.89
Artistic high school	26.09	68.96	59.08	59.70
Vocational high school	6.48	35.19	32.49	32.13
Socio-economic status				
Mother no high school degree	52.88	55.38	56.47	55.68
Mother high school degree	62.33	63.29	65.67	64.55
Mother higher education degree	71.34	70.47	72.18	71.56
Dutch at home	68.11	67.25	66.98	67.39
No Dutch at home	46.10	41.26	43.35	44.08
High income	68.34	67.12	67.37	67.69
Low income	59.00	60.91	60.64	60.25
Total	13,382	4,701	21,609	39,692

Note: First-year success rates of students graduating from high school in 2008 and starting higher education in 2008 or 2009 expressed as a fraction of the courses for which a student has succeeded.

Table C6: Ordered logit regression of first year success

	University		Academic college		Professional college	
Variables	Coef.	St. error	Coef.	St. error	Coef.	St. error
Constant	-0.453***	(0.109)	0.538*	(0.279)	-	-
Gender and high school background						
Male	-0.416***	(0.034)	-0.486***	(0.063)	-0.639***	(0.171)
Study delay	-0.849***	(0.063)	-0.837***	(0.076)	-0.589***	(0.030)
General high school[a]						
latin + math	2.279***	(0.092)	1.585***	(0.297)	2.570***	(0.171)
latin + languages	1.660***	(0.096)	0.870***	(0.292)	2.176***	(0.127)
sci + math	1.998***	(0.090)	1.576***	(0.276)	2.600***	(0.099)
math + languages	1.372***	(0.102)	0.839***	(0.286)	2.547***	(0.104)
econ + math	2.009***	(0.108)	1.124***	(0.289)	2.894***	(0.141)
econ + languages	0.840***	(0.098)	0.284	(0.274)	2.078***	(0.070)
human	1.005***	(0.100)	0.703**	(0.289)	1.779***	(0.070)
Technical high school[a]						
business	-	-	-0.472	(0.303)	1.312***	(0.065)
sci + tech	-	-	0.943***	(0.279)	1.802***	(0.078)
social + tech	-	-	-0.363	(0.358)	0.943***	(0.068)
technics	-	-	0.189	(0.308)	1.765***	(0.073)
other tech	-	-	-0.113	(0.306)	0.875***	(0.066)
Artistic high school	-	-	1.048***	(0.278)	1.018***	(0.102)
Socio-economic status						
Mother no high school degree[b]	-0.421***	(0.062)	-0.417***	(0.092)	-0.365***	(0.038)
Mother high school degree[b]	-0.264***	(0.038)	-0.235***	(0.062)	-0.187***	(0.031)
No Dutch at home	-0.522***	(0.083)	-0.575***	(0.149)	-0.622***	(0.068)
Low income	-0.038	(0.050)	-0.011	(0.077)	-0.054*	(0.033)
Constant 1	-0.057	(0.064)				
Constant 2	1.173***	(0.064)				
Log likelihood	-39211					
Observations	39692					

Note: standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

[a]Base category = technical + artistic + vocational secondary education for university, vocational secondary education for college.

[b]Base category = mother has a degree in higher education.

Table C7: Degree completion and dropout in higher education

Study outcomes	Enrollment in the first year		
	University	Academic college	Professional college
Panel A: Study success in the first year 0-49%			
Degree completion within 3 years			
University	0.08	0.00	0.00
Academic college	0.03	0.00	0.00
Professional college	0.03	0.00	0.06
Degree completion within 6 years			
University	16.35	2.40	0.34
Academic college	7.61	11.20	0.38
Professional college	36.38	36.06	18.92
Dropout	36.66	50.34	80.36
Observations	3694	1456	7084
Panel B: Study success in the first year 50-99%			
Degree completion within 3 years			
University	17.20	0.00	0.00
Academic college	0.00	13.76	0.00
Professional college	0.04	0.00	14.93
Degree completion within 6 years			
University	70.51	3.36	0.18
Academic college	4.10	56.38	0.41
Professional college	11.40	16.00	66.51
Dropout	14.00	24.27	32.90
Observations	2465	894	4407
Panel C: Study success in the first year 100%			
Degree completion within 3 years			
University	85.47	0.15	0.00
Academic college	0.02	77.18	0.00
Professional college	0.02	0.00	81.96
Degree completion within 6 years			
University	96.80	1.18	0.29
Academic college	0.23	91.33	0.12
Professional college	0.47	2.01	94.51
Dropout	2.50	5.48	5.07
Observations	6408	2042	8827

Note: Dropout and degree completion are expressed as a percentage of starters in higher education in 2005 conditional upon the chosen option in the first year (university, academic bachelor, professional bachelor and success (0-49% of credits 50-99% of credits and 100% of credits) in the first year.

Table C8: Unemployment and inactivity

	Unemployment		Inactivity	
Variables	Coef.	St. error	Coef.	St. error
Constant	-1.045***	(0.251)	-2.137***	(0.326)
Male	-0.944***	(0.175)	-1.401***	(0.163)
Experience	-0.193***	(0.030)	-0.033	(0.031)
Experience^2	0.005***	(0.001)	0.002***	(0.001)
Higher education	-1.441***	(0.414)	-0.239	(0.444)
Male	0.220	(0.308)	0.211	(0.260)
Experience	0.003	(0.049)	-0.112**	(0.045)
Experience^2	0.001	(0.001)	0.003***	(0.001)
Observations	3,375			

Note: The probability of being employed, unemployed or inactive is estimated by a fractional logit model with being employed as the reference category. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table C9: Full-time earnings, taxes, and percentage of time worked

	Net earnings		Tax contributions		% of time worked	
Variables	Coef.	St. error	Coef.	St. error	Coef.	St. error
Constant	11,975***	(164.4)	10,914***	(323.6)	2.559***	(0.0934)
Male	2,266***	(117.5)	5,603***	(231.4)	2.302***	(0.0955)
Experience	326.5***	(21.91)	742.2***	(43.13)	-0.00225	(0.0128)
Experience^2	-2.621***	(0.625)	-8.174***	(1.230)	-0.000629*	(0.000352)
University	993.5***	(218.3)	3,025***	(429.7)	1.295***	(0.156)
Male	390.6**	(175.5)	378.7	(345.5)	-0.392**	(0.161)
Experience	756.4***	(33.29)	1,843***	(65.54)	-0.0798***	(0.0260)
Experience^2	-13.91***	(1.063)	-35.02***	(2.094)	0.00169**	(0.000819)
Academic college	623.4**	(260.2)	2,681***	(512.2)	1.582***	(0.210)
Male	-380.9*	(216.7)	-891.9**	(426.6)	-0.0334	(0.207)
Experience	581.9***	(36.97)	1,394***	(72.78)	-0.107***	(0.0363)
Experience^2	-10.40***	(1.176)	-26.84***	(2.315)	0.00222*	(0.00118)
Professional college	391.4*	(203.8)	1,947***	(401.2)	1.305***	(0.133)
Male	-272.3*	(154.1)	-622.2**	(303.4)	-0.0113	(0.134)
Experience	245.8***	(28.50)	521.0***	(56.11)	-0.120***	(0.0184)
Experience^2	-5.033***	(0.846)	-10.93***	(1.665)	0.00253***	(0.000516)
R-squared	38,872		38,872		38,872	
Observations	0.347		0.411			

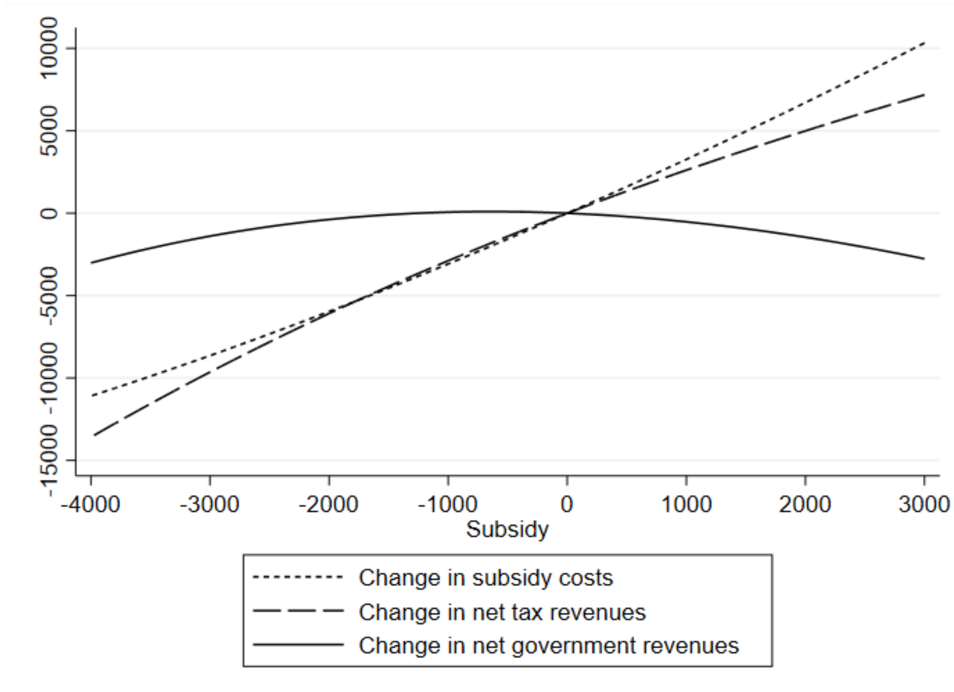
Note: All regressions are estimated on the sample of workers with at most 41 years of working experience, older than 18 and younger than 65. Full-time yearly net earnings and taxes are estimated by OLS. The fraction of hours worked is estimated by a fractional logit model. Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table C10: Predicted effects of subsidizing higher education

Characteristics	Status quo	Counterfactual subsidy of 100 euro
All pupils	70.04	+0.27
University	23.65	+0.03
Academic college	8.29	+0.02
Professional college	38.10	+0.22
Gender and study delay		
Male	65.55	+0.30
Female	74.25	+0.24
Study delay	51.88	+0.38
No study delay	78.22	+0.22
High school background		
General high school	95.76	+0.10
latin + math	96.75	+0.08
latin + languages	95.60	+0.10
sci + math	96.46	+0.08
math + languages	94.86	+0.12
econ + math	97.07	+0.07
econ + languages	95.37	+0.11
human	94.48	+0.13
Technical high school	72.43	+0.44
business	86.80	+0.30
sci + tech	91.41	+0.20
social + tech	86.46	+0.30
technics	51.09	+0.63
other tech	63.19	+0.59
Artistic high school	86.33	+0.30
Vocational high school	13.40	+0.32
Socio-economic status		
Mother no high school degree	50.26	+0.37
Mother high school degree	66.00	+0.32
Mother higher education degree	86.85	+0.16
Dutch at home	70.52	+0.27
No Dutch at home	61.60	+0.32
High income	71.79	+0.24
Low income	63.42	+0.38

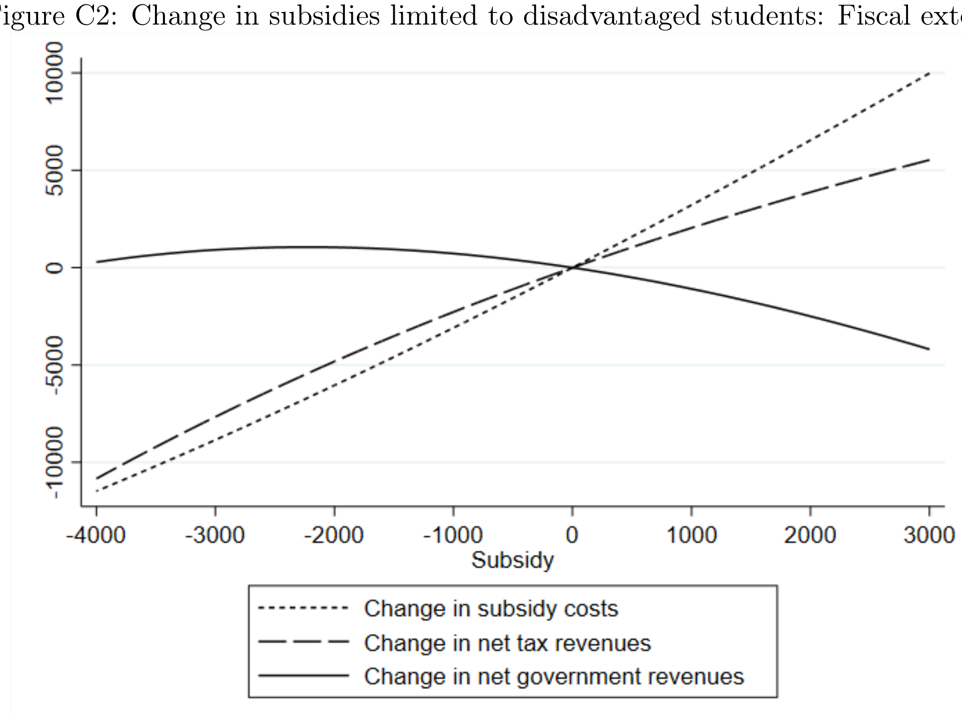
Note: Predicted enrollment rates are expressed as a percentage of 56,672 students graduating from high school in 2008. Results of the counterfactual are expressed as percentage point changes relative to the status quo.

Figure C1: Change in subsidies limited to disadvantaged students: Enrollment and degree completion



Note: Enrollment and degree completion are expressed as a percentage of high school graduates with disadvantaged background of 2008.

Figure C2: Change in subsidies limited to disadvantaged students: Fiscal externalities



Note: Changes in subsidies, net tax revenues and net government revenues are expressed in euro per high school graduate with disadvantaged background of 2008.

Table C11: Change in subsidies limited to disadvantaged students

	Status quo	Counterfactual subsidy (+100 euro)
Enrollment	63.43	+0.36
University	16.12	+0.03
Academic college	6.99	+0.02
Professional college	40.32	+0.31
Degree within 3 years	21.53	+0.10
University	5.61	+0.01
Academic college	2.20	+0.01
Professional college	13.71	+0.08
Degree within 6 years	42.00	+0.20
University	9.73	+0.02
Academic college	4.40	+0.01
Professional college	27.87	+0.17
Discounted government expenditures and tax income		
Subsidy costs	18944	+318
Net tax revenues	456066	+272
Net government revenues	437122	-33
Marginal fiscal recovery rate		0.86
Net tax revenue maximizing subsidy		-600

Note: The status quo is expressed as a percentage of low SES high school graduates of 2008. Results of the counterfactual are expressed as percentage point changes relative to the status quo. Results of the counterfactuals are expressed as changes in euro per high school graduate.