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Abstract

Fiscal externalities arise when subsidies to higher education raise future net fiscal revenues. We quantify the marginal fiscal recovery rate, i.e., the ratio of the change in net fiscal revenues and the change in subsidy costs caused by a small change in tuition subsidies. We find that this ratio is equal to 0.73 in Flanders (Belgium), meaning that 0.73 euro is recovered of a one euro increase in subsidies. We also compute the maximal tuition level as the tuition level where the marginal fiscal recovery rate is exactly equal to one. This tuition level is maximal in the sense that higher tuition levels are not only bad for students, but will also generate lower tax revenues. The maximal tuition level is around 2600 euro, which is almost three times as high as the current tuition level of 930 euro.

Keywords: higher education, 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. To that end, 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 provide a decomposition of the marginal fiscal recovery rate based on three 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. We will use this decomposition to approximate the marginal fiscal recovery rate based on these three key statistics.

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 and the subsidy cost of a degree in tertiary education across OECD countries. The ratio of both—which is one of the three key factors underlying the marginal fiscal recovery rate—is on average equal to 3.88 for men and 2.61 for women across the OECD.[1] While these ratios vary considerably over countries—between 0.88 and 19.37 for men and between 0.82 and 32.83 for women (respectively in Estonia and Greece in both cases)—they are larger than one in most countries.[2] For later use, the ratio is 5.13 for both men and women in Belgium (which includes Flanders, the region that we study in this paper); and the ratio is 6.32 for men and 3.35 for women in the United States, whose average (4.84) is fairly similar to Belgium.

Such gain-cost ratios turn out to be an upper bound for the marginal fiscal recovery rate because the two 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,

[1] On average across the OECD and expressed in PPP US$ of 2015, the net fiscal revenues—based on income taxes, social security contributions, welfare transfers, and unemployment benefits—are equal to 188100 US$ for a man and 116800 US$ for a woman (OECD, Tables A5.2a and A5.2b, column 8) and (ii) the average subsidy costs—including the direct costs and the foregone taxes on earnings over an average study period—are equal to 48500 US$ for a man and 44700 US$ for a woman (OECD, Tables A5.2a and A5.2b, column 3).

[2] Exceptions are Estonia (for both men and women) and Switzerland (for women only).

one for Europe and one for the United States, compute marginal fiscal recovery rates.[3] de la Fuente and Jimeno (2009) focus on a selection of 14 European countries. Their marginal recovery rates range from -0.25 for Sweden and 2.40 for Ireland, with an average rate of 0.97 across countries. For later use, note that for Belgium the marginal recovery rate is equal to 1.33. Colas, Findeisen, and Sachs (2019) find an overall marginal recovery rate of 0.76 for the United States, but show that it decreases with parental income. In particular, the marginal fiscal recovery rate is larger than one for students below the 32nd percentile of the parental income distribution.[4] So, while a small uniform increase in financial aid does not seem desirable, a small targeted increase in subsidies to students from poor families can be self-financing in the United States.[5]

As a second contribution, this paper adds to the empirical literature on fiscal externalities by quantifying the marginal fiscal recovery rate in Flanders. In Flanders, most high school graduates can start higher education without admission requirements. This allows us to observe the preferred study option of students that is not restricted by admission requirements. Tuition fees are low (currently around 930 euro per year for regular students). As a consequence, enrollment is high, but success rates are relatively low, especially in the first year, and study delay is common. Many students also reorient towards other programs during higher education or even drop out without obtaining a degree. Because of the low tuition fees and absence of admission standards we expect lower returns for students at the margin of participation compared to countries that have higher tuition fees and select students before entry. In the U.S., for example, the gain in earnings to college admission for academically marginal students is 22% of expected earnings just below the admission threshold (Zimmerman, 2014).

To model the key ingredients of higher education—enrollment, reorientation, drop-out, study delay, and graduation—we use administrative data.[6] We estimate a nested logit model to predict the initial program choice (professional bachelors, academic college bachelors, and academic university bachelors at several campuses in Flanders) conditional on background variables (gender, type of high school degree, and socio-economic background). Variation in the private costs of higher education mainly arises from travel costs, besides grants and reduced tuition fees. We estimate an ordered logit model to predict success in the first year of higher education, conditional again on background variables. And, conditional on initial program choice and on first-year success, we predict the likelihood of obtaining a bachelor degree in

[3]There is a related empirical (US-based) literature that focuses on non-marginal policy changes in higher education; see, e.g., Caucutt and Kumar (2003), Johnson (2013), Krueger and Ludwig (2013, 2016), Lawson (2017), and Abbott et al. (2019). We will come back to some of these papers later on.

[4]The exact number was kindly provided by the authors on request.

[5]Lawson (2017) does not compute marginal fiscal recovery rates, but analyzes optimal subsidies to higher education in the United States. His results indicate that, in contrast to Colas, Findeisen and Sachs (2019), "fiscal externalities on their own justify increased government support for students. (Lawson, 2017, p340)"

[6]As there is no unique panel dataset available that would allow us to estimate the different models from the same data source, we combine (i) a dataset of all high school graduates of 2008 that were eligible to enter higher education in Flanders, (ii) a (linked) dataset of all students that registered for a program in higher education in 2008 or 2009, and (iii) a (separate) panel dataset in which we observe all entrants in higher education in 2005 over a period of six years. A limitation of our study is that we cannot control for persistent unobserved heterogeneity between individuals.

each program within 3, 4, 5, or 6 years.[7]

To model the key ingredients of the labour market—wages, employment, direct and indirect taxes, and welfare benefits—we use survey data to estimate net wages, labour market status (employed, unemployed, inactive), percentages of time worked, and earnings taxes over the lifetime for the different programs in higher education. Approximate policy parameters, such as the average indirect tax rate and the average replacement rate (for unemployment and retirement), are used to predict consumption taxes and welfare benefits.

The combination of both empirical models allows to compute the marginal fiscal recovery rate of subsidies to higher education in Flanders. In our benchmark simulations, the marginal fiscal recovery rate is equal to 0.73, i.e., 0.73 euro is recovered in net fiscal revenues of an extra euro of subsidies to higher education. The Flemish marginal fiscal recovery rate is therefore similar to the 0.76 figure reported by Colas, Findeisen, and Sachs (2019) for the United States. The similarity between Flanders and the United States, with very different higher education systems, might be surprising at first sight. Yet, recall that the third statistic underlying the marginal fiscal recovery rate (the ratio of the net fiscal revenue gain and the subsidy cost of a degree in tertiary education) is very similar for both countries according to the OECD (2018). de la Fuente and Jimeno find a larger marginal fiscal recovery rate of 1.33 for Flanders. The difference between our estimate for Flanders and de la Fuente and Jimeno (2009) for Belgium mainly arises because we use detailed administrative data, rather than raw indicators, to model the key ingredients of higher education. The fact that we can take into account that marginal students have lower success probabilities than the average student also explains why we find a lower marginal fiscal recovery rate.

If subsidies are targeted towards students from low-income families in Flanders, then the marginal fiscal recovery rate rises from 0.73 to 0.88. Targeted subsidies give rise to two counteracting forces in Flanders. On the one hand these students turn out to be more sensitive to subsidies and are therefore more likely to participate. On the other hand, they are also more likely to enrol in (or switch to) professional bachelor programs—with lower labour market returns than academic bachelor programs—and they are also less likely to graduate. The first force dominates the second force such that the marginal fiscal recovery rate turns out to be larger for low-income students. Yet, the marginal fiscal recovery rate remains below one. For comparison with Colas, Findeisen, and Sachs (2019) note that a low-income family is a categorical variable in our data that corresponds with parental incomes below the 21st percentile. So, our findings are different from Colas, Findeisen and Sachs (2019) who report a marginal fiscal recovery rate larger than one for students below the 32nd percentile of the parental income distribution. As borrowing constraints are much stronger in the United States, talented, but poor students are less likely to enroll. This leads to higher enrollment elasticities and probably also higher success probabilities of low-income students in the United States compared to Flanders, resulting in a higher marginal fiscal recovery rate of targeted subsidies.

While the marginal fiscal recovery rates are sizeable in Flanders, they remain below one and thus increasing tuition subsidies to higher education in a uniform or targeted way is not

[7] The graduation program can be different from the initial program to allow for switching behaviour.

unambiguously desirable. Yet, we do like to stress that this finding does not imply that we should decrease subsidies—e.g., by increasing tuition—because other positive externalities may justify the current subsidy levels. As the marginal fiscal recovery rate turns out to increase with tuition, we compute the level of tuition where it becomes exactly equal to one. This tuition level maximizes the net future fiscal revenues minus the 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 cannot be desirable. In our benchmark simulation, the maximal tuition fee is about 2600 euro for a regular student in Flanders. Currently at about 930 euro, it suggests that there is room for, e.g., tuition increases, but that this room is limited to roughly tripling tuition.[8]

Robustness checks show that our results are fairly robust, except for the choice of the discount factor. In our baseline specification, we follow the OECD (2018) and use a discount factor of 0.98 (a discount rate of roughly 2%) per year. Using a lower discount factor of 0.97 puts relatively less weight on the future and lowers therefore the marginal fiscal recovery rate from 0.73 to 0.50. In contrast, a higher discount factor of 0.99 increases the marginal fiscal recovery rate to 1.02. While the sensitivity of our results for the discount factor is thus high, we would like to stress that the 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).

The remainder of this paper is organized as follows. Section 2 provides the theoretical results. Section 3 discusses higher education in Flanders and introduces the data. Section 4 sets out the empirical model and section 5 contains the empirical results. Section 6 simulates the marginal fiscal recovery rate and the maximal tuition. Section 7 performs some robustness checks. A final section 8 concludes.

2 Theoretical model

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 highlight the policy importance of the marginal fiscal recovery rate. In particular, we show that if the marginal fiscal recovery rate exceeds one, then a small increase in subsidies to higher education is unambiguously desirable. Unambiguous means that increasing subsidies increases both welfare and revenues, irrespective of the degree of inequality aversion, general equilibrium effects on wages, externalities, and credit constraints. We also provide a decomposition of the marginal fiscal recovery rate based on three empirically observable statistics. We start with a description of the model and introduce the policy evaluation afterwards.

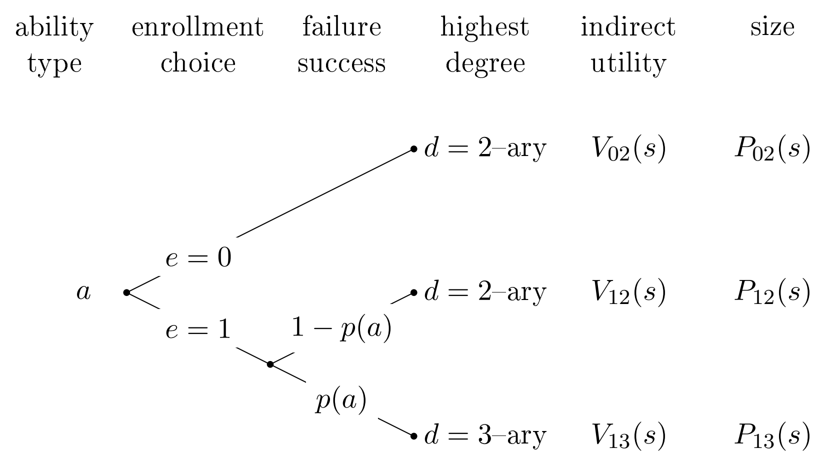
[8]An increase in the private cost of higher education should not necessarily be implemented via tuition increases; see, e.g., Diris and Ooghe (2018) for a discussion of income-contingent loans and graduate taxes.

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 our 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 $p(+\infty) \to 1$. Indirect utilities are denoted $V_{ed}(s)$. 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.,

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

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[9]

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

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

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

Labour hours Workers in the labour market differ in wages, depending on their highest educational degree $d \in \{2, 3\}$.[10] 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 and t the demogrant and 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),[11] $\mathbf{1}[\cdot]$ 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 $ed = 02, 12, 13$), which were introduced already in the previous subsection, 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 ($d = 3$).[12] In a competitive environment, wages are

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

[11] 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 (without interest without loss of generality) afterwards. As we discuss later on, credit constraints do not alter our main theoretical result. Yet, we will relax this assumption in the empirical model (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).

[12] We assume that $Q(0, L_3) = Q(L_2, 0) = 0$, i.e., both types of labour are necessary to have production. 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, 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 the wage rates must have opposite signs. 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.[13]

[13] 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. 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 by one from above, the last statistic—the ratio reported in the introduction based on OECD data—is an upper bound for the marginal fiscal recovery rate. We will see in section 6.3 how equation (10) allows to approximate the MFRR based on these three statistics.[14]

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 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 (2019), one could add heterogeneity in parental income to the hetero-

[14] We deliberately write *approximate* because, as we will discuss later on, the approximation does not take student heterogeneity into account

geneity 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, 2019) 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.

3 Institutional context

We apply our analysis to Flanders, the northern Dutch-speaking region of Belgium. We introduce our datasets and provide some descriptive statistics of study decisions of high school graduates, first-year success, drop-out, and degree completion in higher education. Finally, we show labor market outcomes of graduates from secondary and tertiary education.

3.1 Enrollment and first-year success in higher education

Bachelor and master programs are offered at two types of institutions. Universities offer academic programs and colleges offer both academic and professional programs. Academic programs consist of two cycles, a three-year bachelor program, usually followed by a one- or two-year master program. Professional programs only consist of a three-year bachelor program. All high school graduates are allowed to start at almost all programs in higher education, regardless of their specific high school degree.[15] Tuition fees are currently around 930 euro in academic year 2019-2020. Students can receive a scholarship if the family income is below a certain threshold. The amount of the scholarship depends on the income of the parents.

To study enrollment and success in the first year in higher education, 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 3.1 shows enrollment of high school graduates and success rates of students in their first year of higher education. 70.04% of high school graduates enrolls in higher education. 23.61% of high school graduates starts at university, while 8.30% and 38.13% chooses an

[15]The government imposes entry exams for only very few programs: medicine/dentistry at universities and some artistic programs at colleges.

academic program at college or a professional program at college, respectively. Students succeed on average only for 66.28% of the courses in their first year. Success rates are similar in the different programs. The second panel shows that males and pupils who repeated at least one grade during primary or secondary education are less likely to enroll in higher education and succeed for fewer courses in the first year.

High school background also plays a major role in the study decision in the first year. There are four types of programs in secondary education: general secondary education, technical secondary education, artistic secondary education, and vocational secondary education. Programs in general secondary education provide pupils with a theoretical background and prepare them for higher education. Programs in technical secondary education provide pupils with a theoretical and technical background to prepare them either for professional higher education or the labor market. Programs in artistic secondary education prepare pupils for either higher education or a profession. Programs in vocational secondary education prepare pupils for the labor market, but they can also start at college or university after having completed an extra year of high school. 95.76% of graduates from general secondary opt for higher education, while only 13.3% of graduates from vocational secondary education enroll in higher education. Students from general secondary education are also more successful during their first year in higher education. They succeed on average for 73.46% of their courses, while students from vocational secondary education succeed on average for only 32.13% of their courses.

Finally, socio-economic status also influences participation and success. We measure socio-economic status of the student by the following variables: educational degree of the mother, language spoken at home, and having received a study grant in secondary education. The study grant variable is a proxy for household income because low-income families obtain a scholarship for their children in high school. The educational degree of the mother has an important effect on study decisions. The higher the educational degree of the mother, the higher the participation rates. If the mother has a degree in higher education, 86.85% of the students enrolls, while only 50.26% does so if the mother has not finished secondary education. Pupils who do not speak Dutch at home or students from low income families are less likely to participate, but the gaps are smaller compared to the education level of the mother. Students from disadvantaged socio-economic backgrounds are less successful in their first year in higher education.

Table 1: Enrollment and success in the first year of higher education

Characteristics	Enrollment	Success
All pupils	70.04	66.28
University	23.61	67.00
Academic college	8.30	66.03
Professional college	38.13	65.89
Gender and study delay		
Male	65.55	61.67
Female	74.25	70.09
Study delay	51.88	49.45
No study delay	78.22	71.31
High school background		
General high school	95.76	73.46
Technical high school	72.43	59.18
Artistic high school	86.33	59.70
Vocational high school	13.40	32.13
Socio-economic status		
Mother no secondary education degree	50.26	55.68
Mother secondary education degree	66.00	64.55
Mother higher education degree	86.85	71.56
Dutch at home	70.52	67.39
No Dutch at home	61.60	44.08
High income	71.79	67.69
Low income	63.42	60.25

Note: Enrollment rates in 2008 or 2009 are expressed as a percentage of 56,672 students graduating from high school in 2008. First-year success rates are expressed as a fraction of the course credits for which a student has succeeded.

Table C1 and C2 in Appendix C show enrollment and success in the first year at university, academic college and professional college. We also distinguish between different study programs within general and technical secondary education that we will include in the estimation of the choices and success in the first year. We also observe large differences in study decisions according to the specific program followed in secondary education. Pupils graduating from programs in mathematics or classical languages in general secondary education are most likely to start at university and have the highest success rates.

3.2 Drop-out and degree completion in higher education

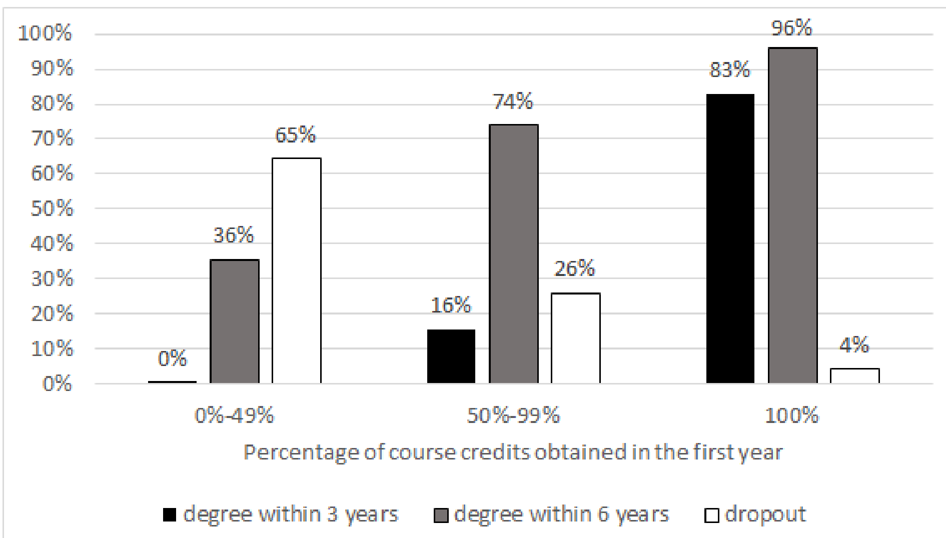
The policy of open access to higher education in Flanders leads to low first-year success rates as show in Table 3.1. Conditional upon the study result in the first year, many students drop out or switch to a different study program. Figure 3.2 shows drop-out and degree completion for all students who started higher education in 2005.[16] It describes the number of students who drop out without a degree (dropout) and the number of students who complete a degree

[16]In contrast to the 2008 cohort of students used in Table 3.1, 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.

within three or six years conditional upon their study program and success in the first year of higher education.

83% and 96% of students who succeeded for all course credits in their first year obtains a bachelor degree within three and six years of studying, respectively. Only 4% of these students dropout without a degree. In contrast, 65% of the students who failed more than half of their courses in the first year drop out without a degree.[17] Success in the first year turns out to be an important predictor of graduation and dropout. Table C3 in Appendix C shows the probability of obtaining a degree at university, academic college, and professional college for all entrants in higher education. Many students switch to a different program during their higher education. A substantial fraction of students who did not perform well in the first year at university, eventually obtains a degree at college. Contrary to starters at academic programs who fail in their first year, considerably more starters at professional programs who fail their first year drop out without a degree.

Figure 2: Degree completion and dropout in higher education



Note: Dropout and degree completion are expressed as a percentage of starters in higher education in 2005 conditional upon success (0-40%, 50-99% and 100% of course credits) in the first year.

3.3 Earnings, taxes, and labor market participation

To predict tax contributions of graduates from secondary and tertiary education, we use two datasets. First, a large survey dataset, 'Vacature salarisenquête', contains earnings and tax information for workers in Flanders in 2006. Second, the EU-SILC data for Flanders, contains additional information on labour market participation of different groups.

[17] 16% of the students who suceeded for between 50% and 99% of their courses in the first year still obtains a degree at within 3 years of studying. This is possible because students who fail for only one or two courses in their first year can still start all courses of the second year and simultaneously repeat those courses for which they failed.

Panel A of Table 3.3 shows montly net wages, monthly income tax contributions, and the fraction of workers that is in full-time employment computed from the 'Vacature salarisenquête'. Graduates from higher education programs earn higher wages, pay higher tax contributions, and are more likely to work full-time. Earnings and income tax contributions are largest for graduates from university programs.

Panel B of Table 3.3 shows the fraction of graduates from secondary and higher education that was employed, unemployed ,or inactive in 2006, computed from the EU-SILC dataset. The EU-SILC dataset only allows to distinguish between high school graduates and graduates from higher education and shows that graduates from higher education are more likely to be in employment and less likely to be unemployed or inactive than graduates from secondary education.

Table 2: Labor market outcomes

Panel A: Earnings, taxes and time worked of employed individuals				
	Secondary education	Professional college	Academic college	University
Net wage (euro)	1685	1797	2022	2154
Income tax (euro)	889	1081	1404	1535
% working full-time	88.3%	90.6%	95.8%	93.9%
Observations	10408	14258	5417	8789
Panel B: Participation in the labor market				
	Secondary education	Higher education		
Employment	79.8%	87.1%		
Unemployment	7.6%	4.5%		
Inactivity	12.5%	8.3%		
Observations	1713	1669		

Note: Net monthly wage, monthly income tax contributions and the percentage of time worked in panel A are computed from the 'Vacature Salarisenquête' 2006 which contains information of individuals being employed in Flanders. Wages and taxes are expressed in euro (2006). The fraction of employed, unemployed or inactive is computed from the EU-SILC dataset which contains information on both labor market participants and non-participants in Flanders.

4 Empirical model

To assess whether additional subsidies to higher education generate fiscal externalities, we develop and estimate a discrete choice model of study decisions and success in higher education. First, we discuss enrollment in higher education, first-year success, and degree completion. Afterwards, we explain how we predict labor market outcomes of graduates.

4.1 Enrollment and success in higher education

4.1.1 Enrollment

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 gender, high school background, and socio-economic status (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.[18] The parameter β_{0j}^u is an alternative-specific constant. The parameters in β_{1j}^u measure the impact of gender, high-school background, and socio-economic status on the utility of studying. The parameter β_2^u measures the sensitivity to the costs of education. Students are heterogeneous in their sensitivity to costs. The parameters in β_3^u interact socio-economic status with the cost variable to see whether and how socio-economic status influences the sensitivity to costs.

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.[19] 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. Nielsen et al. (2010) and Lundborg et al. (2014) face similar problems and compute the amount of the grant based on the algorithm that the authorities use. As we do not observe family income, 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).[20] 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.[21] 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

[18] The cost of studying for students CS_{ij} corresponds with $k_{ij} - s_i$ in the model in section 2.

[19] In Flanders, tuition fees are already low (approximately 562 euro in 2008 and currently around 930 euro in 2019). Students who receive a scholarship have to pay a tuition fee of only 104 euro.

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

[21] 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%.

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).[22] 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).[23] 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. 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 $\lambda = 1$.

4.1.2 Success in the first year

At the end of their first year in higher education, we observe for how many courses a student succeeded. Success in the first year in study program j is given by $\beta_{0j}^s + \beta_{0j}^s X_i + \epsilon_{ij}^s$, 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 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

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

[23] 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.

logit model to estimate success.

4.1.3 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. We use observed dropout and degree completion as in Table C3 in Appendix C. Conditional upon the type of program in the first year (professional bachelor at college, academic bachelor at college, or academic bachelor at university) and the degree of success in the first year, we predict, for each enrolled student, the probability of drop-out and the probabilities of obtaining a bachelor degree in each study program after 3, 4, 5, or 6 years. 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.

4.2 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%.[24] 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).[25] As we focus on marginal changes in subsidy levels, it is safe to assume that the 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 4.1.1. subsidies to higher education also consist of study grants g_i for low-income students.

[24] The discount rate is used by the OECD to compute the public return to higher education. To check robustness, we will look at other values later on.

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

4.3 The labor market

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.[26] 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.

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. Altough we use data from students starting tertiary education in 2005 or 2008 and data 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.[27] 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.[28] We approximate the expected discounted net tax revenues of individual i graduating from study program j by

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

[27]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

[28]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.

$$\sum_{t=1}^{T} 0.98^{t-1}(p_{ijt}(emp) \cdot h_{ijt} \cdot tax_{ijt} - 0.62 p_{ijt}(unemp) \cdot w_{ijt}).$$

one

4.4 Retirement

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.[29] This net income includes net earnings and unemployment benefits. As individuals pay consumption taxes (10.2%), total pension expenses for the government are 58.9% of the average yearly net income of an individual. We assume that all individuals live during 89 years.[30]

5 Empirical results

In this section, we discuss the estimates of the models for enrollment, success in the first year of higher education, and labor market outcomes. While these results are of stand-alone interest, they mainly serve as building blocks for the computation of the fiscal externalities in the next section.

5.1 Enrollment

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.[31] We obtain the following main findings.

First, males are more likely to choose the no-study option than females. Second, pupils who graduate from high school with some years of study delay are more likely to choose the drop-out option. If they decide to participate in higher education, they are most likely to choose a professional bachelor program at college. Next, academic ability, measured by high school background, determines choices in higher education. Students graduating from general, technical, or artistic secondary education are less likely to choose the no-study option compared to pupils from vocational secondary education. Students from programs in general secondary education are most likely to choose academic programs at university or college. Next, socio-economic status significantly determines study decisions after controlling for previous schooling. Students from disadvantaged backgrounds (lower educational degree of their mother, low family income or speaking a foreign language at home) are less likely to enroll

[29] OECD (2019, Table 5.5)

[30] 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.

[31] 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.

in higher education. Finally, students are sensitive to the costs of education. Furthermore, socio-economic status determines the sensitivity to the costs of education. Students from disadvantaged backgrounds are more sensitive to the costs of education.

5.2 Success

In Table C5 in Appendix C, we present the results of the ordered logit regression for success in the first year of higher education. Success is measured by an ordinal variable consisting of three categories (successfully completing less than 49% of the courses; completing between 50% and 99% of the courses; successfully completing all courses). Gender and high school background significantly affect success in the first year. Students graduating from programs in general secondary education have the highest success rates. These students were also most likely to enroll in higher education as shown in Table C4 in Appendix C. Socio-economic status also affects study success in the first year. Students from disadvantaged backgrounds are less likely to perform well in the first year.

5.3 The labor market

Table C6 in Appendix C shows the output of the fractional multinomial logit model for the probability of being employed, unemployed, or inactive. For these outcomes, we cannot distinguish between graduates from professional bachelor and master programs. Results have to be interpreted relative to the reference category of being employed. Graduates from higher education and men are less likely to be unemployed or inactive. The effect of gender does not differ between high school graduates and graduates from higher education. There is a non-linear effect of work experience on the probability of being unemployed or inactive. The probability of being unemployed decreases over time, but at a decreasing rate.

Table C7 in Appendix C shows the OLS estimates of the yearly net earnings of full-time workers (column 1), yearly tax contributions (column 2), and the estimates of the fractional logit model for the number of hours worked as a fraction of a full-time equivalent (column 3). Men obtain higher wages, pay more taxes, and work more hours compared to women. The earnings premium for men is larger for university graduates, but smaller for graduates from a professional bachelor or a master program at college. The gender gap in the number of hours worked is smaller for university graduates. Workers earn higher wages and pay more taxes when they have more work experience. This effect is largest for graduates from university programs. The positive effect of work experience decreases over time.

6 Fiscal externalities

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. Finally, we follow an alternative way to compute the marginal fiscal recovery rates based on the decomposition in the theoretical part of this paper.

6.1 Uniform changes in tuition subsidies

Figure 6.1 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 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.[32] 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%).[33] Degree completion within 3 and 6 years would increase by respectively 0.07 and 0.15 percentage points. Table 3 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. Remember that graduates from university programs have the highest earnings and are most likely to work (full-time). As a consequence, additional tuition subsidies mainly increase enrollment in programs with relatively lower labor market returns.

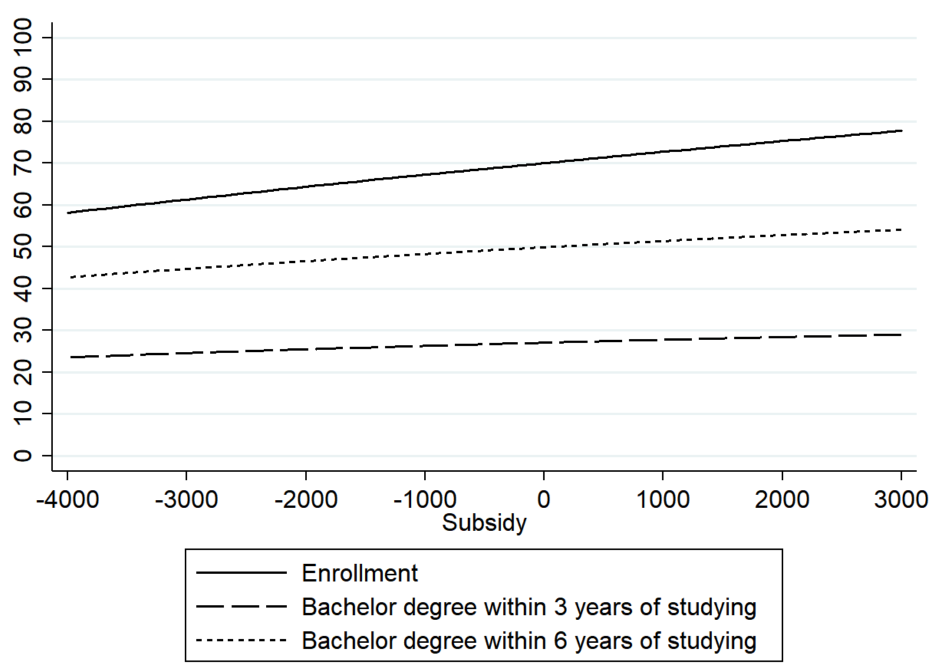
Changes in tuition subsidies have a proportionally smaller effect on degree completion than on enrollment because they mainly encourage participation of students of, on average, lower ability. Table C8 in Appendix C shows the increase in enrollment caused by a uniform tu-

[32] Predicted enrollment rates of high school graduates of 2008 in Table C8 in Appendix C are equal to the observed enrollment rates in Table C1 in Appendix C. Predicted degree completion of these students cannot be compared with actual degree completion because the probability of graduating from higher education is computed from a separate dataset.

[33] We consider here a small change in subsidies by 100 euro to reflect a marginal change in subsidies. However, for comparison with the international literature, our model predicts that a 1000 euro tuition fee increase would lower enrollment by 2.67 percentage points. This effect is in line with previous studies that 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).

ition subsidy of 100 euro for students graduating from the different programs in high school. Enrollment of students from general secondary 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. Table C9 in Appendix C further shows the differences between average students (those who are predicted to participate under the status quo) and marginal students (those who are predicted to enroll only when tuition subsidies are increased with 100 euro). It shows that marginal students (1) are more likely to choose for professional college programs that lead to lower labor market returns, (2) are less likely to obtain a degree, and (3) pay less taxes.

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 3: 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	467904	+231
Net government revenues	450990	-86
Marginal fiscal recovery rate		0.73
Net tax revenue maximizing subsidy		-2000

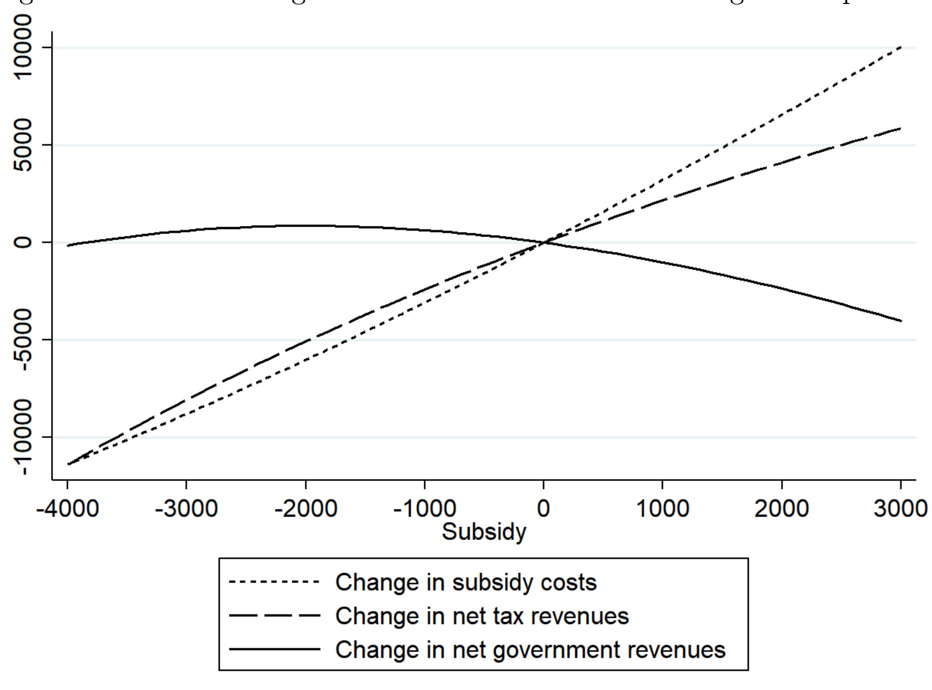
Note: Enrollment and degree completion in the status quo are expressed as a percentage of high school graduates. Results of the counterfactual are expressed as percentage point changes relative to the status quo. Subsidy costs, net tax and net government revenues are expressed in euro per high school 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 3 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 231 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 0.73, meaning that increasing subsidies with one euro raises the net fiscal revenues with only 0.73 euro.

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 2000 euro would be maximal.

This corresponds to a yearly tuition fee of approximately 2600 euro (to be compared with tuition of 600 euro at the time of our analysis and 930 euro now).

Figure 4: Uniform change in subsidies: Enrollment and degree completion



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

6.2 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). On the other hand, Table C5 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 C10 in Appendix C. For the group of students from disadvantaged backgrounds, we compute a larger marginal fiscal recovery rate of 0.88. As this rate is still below one, a further increase in scholarships for disadvantaged students cannot be justified from a fiscal perspective. Given that this rate is almost equal to one, we find that tuition fees could be raised by at most 800 euro for this group of students (to be compared with a tuition fee of about 100 euro).

6.3 An approximation of the marginal fiscal recovery rate

We can also approximate the marginal fiscal recovery rate by making use of equation (10) derived in the theoretical model. This equation provides a decomposition of the marginal fiscal recovery rate based on the following three 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.

$$MFRR(s) = \frac{\eta(s)}{1+\eta(s)} \cdot p(a^*(s)) \cdot \frac{t_3(s) - t_2(s)}{s}, \tag{11}$$

Because the theoretical model did not include student heterogeneity, this decomposition provides an approximation of the true marginal fiscal recovery rate that we computed before.

From the nested logit model of the enrollment decision, we predicted that a 100 euro increase in tuition subsidies would increase enrollment with 0.27 percentage points. This results in an elasticity of enrollment with respect to subsidies $\eta(s) = 0.25$.[34] The marginal student has a probability $p(a^*(s))$ of 56.8% of obtaining a degree (See Table C9). Next, we compute that average discounted government revenues of someone who completed at most secondary education (t_2) are equal to 451983 euro and average discounted government revenues of someone who completed higher education (t_3) are equal to 643101 euro. Finally, the denominator in the last term of equation (11) is the total discounted cost for the government expressed per graduate from higher education and is equal to 33896 euro.[35] Based on these statistics, we can compute the marginal fiscal recovery rate as follows:

$$MFRR(s) = \frac{0.25}{1+0.25} \cdot 0.568 \cdot \frac{643101 - 451983}{33896} = 0.64. \tag{12}$$

We find a smaller marginal fiscal recovery rate of 0.64 (to be compared with our baseline estimate of 0.73). Both approaches give slightly different results because the underlying assumptions in the computation of discounted subsidy costs and tax revenues are different. Our preferred approach in section 6.1 allows for student heterogeneity in the return to and study duration in higher education. In contrast, the approximation in this section is based on an average study duration and average discounted tax revenues. Such averages neglect the fact that, as documented in Table C9, marginal students are more likely to enroll in professional bachelor programs and less likely to graduate within the theoretical duration of the program. As the approximation provides fairly similar results, it suggests that heterogeneity matters, but only to a limited extent.

As another alternative way, we can also make use of the net fiscal revenue gain and the subsidy cost of a degree in tertiary education as reported in the Education at a Glance series

[34] We compute that average variable subsidies to higher education are 6639 euro per year per participating student. At the status quo, 70.0% of students participates. The participation elasticity with respect to subsidies can be computed as follows: $\eta(s) = \frac{0.00267}{100} \cdot \frac{6639}{0.700} = 0.253$.

[35] The discounted cost per high school graduate is 16914 euro and 49.9% of high school graduates obtains a degree in higher education (See Table 3). The discounted cost per graduate from higher education is 16914/0.499 = 33896 euro.

of the OECD (2018). As already reported in the introduction, the ratio of both, or the third term in equation (11), is 5.13 for both men and women in Belgium.[36] Using the statistics reported by the OECD, together with the participation elasticity and the success probability of the marginal student computed by us gives us a marginal fiscal recovery rate equal to 0.70 (to be compared with our baseline estimate of 0.73).[37]

7 Robustness checks

Table 7 assesses how 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.[38]

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 0.75.

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

[36] For Belgium and expressed in PPP US$ of 2015, the net fiscal revenues based on income taxes, social security contributions, welfare transfers, and unemployment benefits are equal to 268500 US$ for a man and 245600 US$ for a woman (OECD, Tables A5.2a and A5.2b, column 8) and the average subsidy costs including the direct costs and the foregone taxes on earnings over an average study period are equal to 52300 US$ for a man and 47800 US$ for a woman (OECD, Tables A5.2a and A5.2b, column 3).

[37] We adapt the participation elasticity to the level of subsidies reported by the OECD (2018). The OECD reports an average cost per student per year of 11812 US$ (measured in 2015). Based on the PPP deflator of 2015 (0.80 euro per dollar) and the CPI index, we compute a yearly cost of subsidies of 8353 euro in 2008. The participation elasticity with respect to subsidies can be computed as follows: $\eta(s) = \frac{0.00267}{100} \cdot \frac{8353}{0.700} = 0.319$.

[38] It is observed that highly educated individuals live on average longer than lower educated individuals. Because we assume that all individuals live until their 89th 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.

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).

Table 4: 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	467904	+231
Net government revenues	450990	-86
Marginal fiscal recovery rate		0.73
Net tax revenue maximizing subsidy		-2000
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	467904	+231
Net government revenues	453581	-77
Marginal fiscal recovery rate		0.75
Net tax revenue maximizing subsidy		-1800
Panel D: Discount factor = 0.97		
Discounted government expenditures and tax income		
Subsidy costs	16624	+312
Net tax revenues	397816	+156
Net government revenues	381192	-156
Marginal fiscal recovery rate		0.50
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	+330
Net government revenues	524343	+8
Marginal fiscal recovery rate		1.02
Net tax revenue maximizing subsidy		+200

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

8 Conclusion

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

As a first theoretical contribution, we showed that if the marginal fiscal recovery rate is larger than one, then a small increase in subsidies is unambiguously desirable. We also derived a decomposition of the marginal fiscal recovery rate based on three statistics and used it to approximate the true marginal fiscal recovery rate.

As a second empirical contribution, we applied our analysis to the region of Flanders, where higher education is highly subsidized and students pay only a small part of the total costs of higher education. We developed a discrete choice model of enrollment, degree completion, and drop-out in higher education and labor market decisions of graduates. Our model allows for uncertainty in degree completion and the time to obtain the a degree. On the labor market, we allow for periods of unemployment and inactivity and the possibility that people work part-time. To evaluate the impact of an increase in tuition subsidies to higher education on fiscal externalities, we simulate how a change in tuition subsidies affects 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.

We find that an increase in tuition subsidies to higher education increases enrollment, but mainly of students with lower expected success rates. Higher subsidies will lead to a higher degree completion, but also to more unsuccessful drop-out. We find that additional subsidies raise future discounted tax revenues, but they do not cover the increase in the cost of subsidies. We estimate that the marginal fiscal recovery rate of subsidies to higher education is 0.73 euro, meaning that per extra euro of subsidies 0.73 euro is recovered through future net tax revenues. For students from disadvantaged families, the marginal fiscal recovery rate is larger (0.88), but still smaller than one.

We also computed the level of subsidies where the marginal fiscal recovery rate is equal to one. The corresponding tuition fee can be interpreted as a maximal tuition because higher subsidies would be Pareto inferior (lower welfare and lower revenues). We find that this maximal tuition fee is around 2600 euro (which can be compared to the current tuition of 930 euro for regular students). For low-income students, we find that tuition fees could be raised to at most 900 euro (to be compared with a tuition fee of about 100 euro for low-income students).

Our results have the following implications for higher education policy. First, fiscal externalities exist in higher education, but there is no free lunch. Increasing subsidies, whether uniformly or targeted, has a cost, albeit a limited one because a large part—up to 88%—of the subsidy cost is recovered in the fiscal system. Second, our findings contribute to the discussion on the optimal level of tuition fees. While the computation of optimal tuiton subsidies is not possible without information on other externalities, fiscal externalities alone allow to compute maximal tuition fees. These maximal ones are up to 2600 euro for regular students and up to 900 euro for low-income students.

The results in this study are specific for the region of Flanders Nevertheless, other countries can also learn from our results. Recall that the marginal fiscal recovery rate is essentially based on three statistics: the participation elasticity, the marginal success probability, and the ratio of the fiscal gain and the subsidy cost of a degree in higher education. Other countries can obviously differ in each of these three statistics. While a detailed discussion for each country is beyond the scope here, it is useful to highlight a plausible link between these statistics and some rough characteristics of higher education and labour market institutions. Recall that in Flanders there are (almost) no admission standards, low tuition fees, moderate pre-tax earnings differences, and high and progressive taxes. First, the absence of admission standards is likely to increase the participation elasticity, ceteris paribus, but this effect is somewhat attenuated by the presence of low fees. From an international perspective, the participation elasticity in Flanders is therefore neither small, nor large. Second, both the absence of admission standards and low fees have probably lead to fairly low success probabilities in Flanders. Third, moderate pre-tax earnings differences cause moderate fiscal gains of a higher education degree in Flanders, but this gain is strengthened, however, by high and progressive taxes. All in all, Flanders is likely to have a low to moderate marginal fiscal recovery rate from an international perspective. We leave a more detailed cross-country analysis for further research.

9 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

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

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

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

and

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

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: 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 C2: 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 C3: 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 C4: Enrollment in the first year of higher education

	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: 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 C6: 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 C7: 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)
Experience²	-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)
Experience²	-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)
Experience²	-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)
Experience²	-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 C8: 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

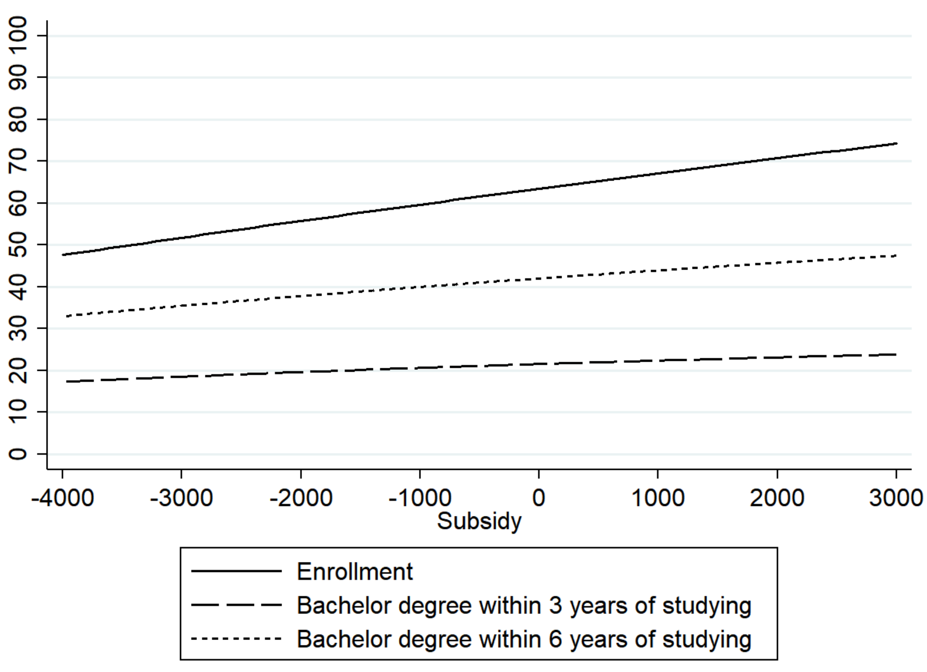
Note: Predicted enrollment rates are expressed as a percentage of 56,672 students graduating from high school in 2008. Results of the counterfactual are expressed as percentage point changes relative to the status quo.

Table C9: Average and marginal students

	Average students	Marginal students
Enrollment	100.00	100.00
University	33.77	11.77
Academic college	11.84	7.77
Professional college	54.40	80.47
Degree within 3 years	38.65	26.81
University	13.65	3.33
Academic college	4.18	1.94
Professional college	20.82	21.54
Degree within 6 years	71.25	56.80
University	22.07	6.45
Academic college	7.97	4.24
Professional college	41.21	46.07
Discounted government expenditures and tax income		
Subsidy costs	24149	20828
Net tax revenues	504814	459900
Net government revenues	480665	439072

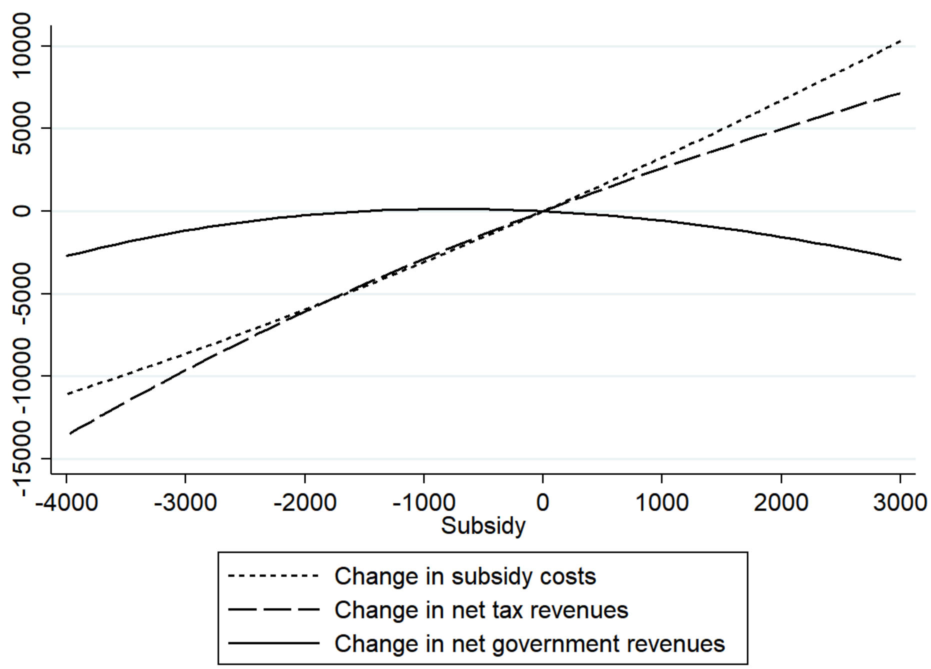
Note: Enrollment and degree completion are expressed as a percentage of average and marginal students, respectively. Average students are students that are predicted to participate in the status quo. Marginal students are students who are predicted to enroll by a marginal increase in tuition subsidies by 100 euro.

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 C10: 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	436328	+279
Net government revenues	417384	-39
Marginal fiscal recovery rate		0.88
Net tax revenue maximizing subsidy		-800

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.