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ABSTRACT

Governments introducing output parameters in the funding rule of universities believe that it will induce universities to raise their teaching efforts while educational standards will remain unaffected. We show that this presupposes positive interaction effects between students' abilities, students' efforts and universities' teaching efforts within the educational production function. Empirical data on success rates of Flemish university students reveal a strong correlation between students' probabilities of success and socioeconomic background. Moreover, we find a strong social clustering within universities. Hence, combining theory and empirics we conclude that output funding for Flemish universities would lead to socially undesirable effects. Universities attracting more students with a vulnerable socioeconomic background will not be rewarded for raising their teaching effort in the same way as other universities.

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1. Introduction

Traditionally, governments in Europe by and large fund the teaching activities of their universities on the basis of input parameters such as the number of enrolments. Recently, however, some countries (including Belgium (Flanders[1])) have introduced into the funding rule output parameters, such as the number of diplomas awarded or the number of credits obtained. This was done in order to encourage universities to improve their quality of education and to increase their teaching effort. Hence, efficiency is enhanced, resulting in more and better trained graduates entering the labour market. However, it is also argued that output funding leads to lower standards in higher education, as universities are tempted to lower the barriers for students to obtain a degree. Output funding can also induce educational elitism, as it creates an incentive for universities to admit the best students only.[2] Finally, it is argued that the system can have socially undesirable effects if students with specific socioeconomic characteristics (that negatively affect their chances of success) are not evenly distributed over the different universities.

This paper analyzes the validity of the above arguments. The first part of the contribution offers a theoretical framework that allows us to model the divergent effects of input-based funding and output-based funding on a single university's investment in teaching activities and on its exit productivity standard (i.e. the productivity level students must attain in order to obtain a degree). From the theoretical part we conclude that the government's desire to raise the universities teaching effort while leaving standards unaffected through output funding can only be fulfilled if there exist positive interaction effects between a student's ability, a student's effort level and a university's teaching effort within the educational production function.

The second part of the paper empirically analyzes the higher education student population in Flanders. The theoretical model assumes both student ability and effort positively influence a student's probability of success. Unfortunately, we cannot directly infer these factors from the empirical data. We do find a strong correlation between socioeconomic background and success probabilities. Hence, it is assumed that a student's socioeconomic background can be regarded as a signal for her educational ability and/or effort level. We also consider whether differences in graduation rates between universities can be explained in terms of the socioeconomic characteristics of the students the institutions attract. We find that this is the case for Flemish university education. Moreover, we show that students with some specific socioeconomic characteristics, that negatively affect their probability of success, are not evenly distributed among universities.

1 The Dutch speaking community in Belgium.

2 In Belgium universities are unable to select students at the gate. Entrance examinations can only be organized for specific fields of study, such as medicine.

Based on the theoretical model and the empirical analysis we conclude that output funding for Flemish universities will lead to some socially undesirable effects. Assuming that there exist positive interaction effects between ability, student effort and teaching effort, output funding will cause all universities to raise teaching effort. Educational standards will be maintained at a high level. However, universities attracting students with a more vulnerable socioeconomic background will not be rewarded for their increasing teaching effort in the same way as universities attracting more fortunate students.

2. Theoretical framework

In the theoretical model, there is a single university offering teaching to a given student population. The university applies an exit standard y (i.e. the educational productivity level a student must reach in order to obtain a degree) and makes a teaching effort/investment f.[3] Both the exit standard and the teaching effort of the university are public knowledge. The total student population equals 1. Students differ in educational ability a, and a is uniformly distributed on $[0,1]$[4]. A student knows her own ability. Having observed the exit standard and the teaching effort of the university, the student makes one or two further decisions. First, she must decide whether or not to enrol with the university. If she does enrol, then she must also decide on her own effort level e while studying at the institution. To summarize the sequence of events:

(1) The university announces its exit standard y and its teaching effort f.
(2) The student decides to enrol with the university or not (i.e. the enrolment decision).
(3) If enrolled, the student decides on her own effort level e (i.e. the effort decision).

We first analyze the enrolment and effort decisions of a student. Subsequently, we consider the university’s exit standard and teaching effort, while taking into account student behaviour.

3 We assume that the university cannot select its students when they enter the university. In other words, the university is not allowed to set "admission" standards.

4 In future work, we would like to investigate how the results of the model are affected when we assume another distribution for a student's ability.

2.1. The student

In this section we look at the decision problem facing the student[5], using backward induction. In the first subsection, we determine the student's optimal effort level e^*. Subsequently, on the basis of this optimal effort level, we determine whether the student enrols with the university or not.

2.1.1. The student's effort decision

The educational production function: Once enrolled, the student has to decide on her effort level *e*. She knows that, in order to obtain a degree, her productivity *y* has to exceed the exit productivity standard $\bar{y}$, set by the university. We use the following educational production function: a student's productivity *y* is increasing in her ability level *a*, in her effort level *e*, and in the teaching effort *f* of the university[6]:

$$y(a,e,f) \text{ with } y_a(a,e,f) > 0, \quad y_e(a,e,f) > 0, \quad y_f(a,e,f) > 0. \tag{1}$$

We assume constant or decreasing marginal returns:

$$y_{ee}(a,e,f) \leq 0, \ y_{ff}(a,e,f) \leq 0, \ y_{aa}(a,e,f) \leq 0. \tag{2}$$

The signs of the following cross-derivatives, however, are not imposed:

$$y_{ef}(a,e,f) \lesseqqgtr 0, \ y_{ea}(a,e,f) \lesseqqgtr 0, \ y_{af}(a,e,f) \lesseqqgtr 0. \tag{3}$$

In other words, we do not a priori impose: (I) whether or not the positive effect of an increase in a student's effort on her productivity is increasing or decreasing in the teaching effort of the university, (II) whether or not the positive effect of an increase in a student's effort on her productivity is increasing or decreasing in her ability, and (III) whether or not the

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5 This section bears some resemblance to De Paola and Scoppa (2007), who consider a policymaker's choice in setting an educational standard. We use the same educational production function and effort cost function. The differences with their paper are the following. First, the reason why students fail differs. In our model the student determines her own productivity with error, while in their model she is perfectly aware of her own productivity, but the school measures it with error. Second, in our model the student's future earnings depend on her obtaining a degree or not, as well as on the exit standard (as a proxy for the quality of the university). In the model of De Paola and Scoppa (2007), on the other hand, the effort made at school also positively influences the student's future earnings. Third, the model of De Paola and Scoppa (2007) imposes no participation constraint for the student (as it focuses on a secondary school). Hence, enrolment equals the total student population. Finally, De Paola and Scoppa (2007) were unable to determine how many students actually obtain the degree.

6 Both ability and effort might be influenced by socioeconomic background. We come back to this in Section 3.

positive effect of an increase in the teaching effort of the university on the productivity of a student is increasing or decreasing in the ability of the student. Note that the signs of the cross-derivatives in (3) are crucially important for the model outcome.

The probability of obtaining a degree: What makes higher education risky for the student is that the outcome of the educational production function in (1) is not known to her. In other words, the student determines her own productivity with error:

$$\tilde{y} = y(a, e, f) + \varepsilon$$

The error ε is uniformly distributed on $[-z,z]$, with density function $f(\varepsilon) = (1/(2z))$. The student obtains a degree if $y(a,e,f) \geq \bar{y}$ but when deciding on her effort level, she takes into account her probability of obtaining a degree,

$P(y(a,e,f) + \varepsilon \geq \bar{y})$:

$$\begin{aligned} P(y(a,e,f)+\varepsilon &\geq \overline{y}) = P(\varepsilon \geq \overline{y} - y(a,e,f)) \\ &= \int_{\overline{y}-y(a,e,f)}^{z} \frac{1}{2z} d\varepsilon = \frac{y(a,e,f)-\overline{y}+z}{2z} \quad \text{with } 0 \leq P(a,e,f,\overline{y}) \leq 1 \end{aligned} \tag{4}$$

Given (1) it follows that the student's probability of obtaining a degree is increasing in her ability ($P_a(.) > 0$), in her effort level $(P_e(.) > 0)$, and in the teaching effort of the university $(P_f(.) > 0)$. However, the probability of obtaining a degree is decreasing in the exit standard set by the university ($P_{\bar{y}}(.) < 0$). As stated above, the cross-derivatives of the student's educational production function are very important throughout the analysis. It will become apparent that most of the model outcomes depend on the following three relationships:

1. Depending on the sign of $y_{ef}(.)$, the positive effect of an increase in the student's effort on her chances of success is reinforced or constrained with an increase in the teaching effort of the university:

$$P_{ef} \geq 0 \Leftrightarrow y_{ef}(a,e,f) \geq 0.$$

2. Depending on the sign of $y_{ea}(.)$, the positive effect of an increase in the student's effort on her chances of success is reinforced or constrained with an increase in her ability:

$$P_{ea} \geq 0 \Leftrightarrow y_{ea}(a,e,f) \geq 0.$$

3. Depending on the sign of $y_{af}(.)$,, the positive effect of an increase in the teaching effort of the university on the student's chances of success is reinforced or constrained with an increase in her ability:

$$P_{af} \geq 0 \Leftrightarrow y_{af}(a,e,f) \geq 0.$$

The wage function: Given that the student obtains a degree, we assume that her wage is increasing in the exit standard of the university[7], and that they are independent of her ability *a*, her effort level *e*, and the teaching effort *f* of the university. More specifically, the wage function becomes

$$w(\overline{y}) \quad \text{with} \quad w_{\overline{y}}(\overline{y}) > 0 \text{ and } w_{\overline{y}\overline{y}}(\overline{y}) \leq 0. \tag{5}$$

If the student does not enrol with the university or does not obtain a degree, her wage is normalized to 0.[8]

The effort cost function: The student's effort may be expressed as a cost. This cost is measured by a function *v(e)* that is increasing and convex in the effort level of the student:

$$v(e) \quad \text{with} \quad v_e(e) > 0, \quad v_{ee}(e) > 0. \tag{6}$$

On top of the effort cost, the student incurs a fixed cost *c* while attending university.

The optimal effort choice: Using (4), (5) and (6), we determine a student's (risk neutral) utility U^{st} from enrolling with the university as follows

$$U^{st} = \frac{y(a,e,f) - \overline{y} + z}{2z} w(\overline{y}) - v(e) - c. \tag{7}$$

The student's effort choice problem becomes

$$\max_{e} \; U^{st}$$

In other words, the student's objective function is the maximization of the difference between her expected future wage and her effort cost. The first-order condition (*FOC*) for the problem becomes

7 There is substantial empirical evidence showing a positive relationship between educational qualifications and future earnings in the labor market. Moreover, it seems reasonable to assume a concave relationship: the positive effect becomes smaller for higher educational qualifications.

8 This means that we assume that an increase in the standard results in higher future wages for those who continue to meet the standard after the change, while leaving unchanged the wages of those who continue to fail to meet the standard. This is similar to Costrell (1994). Betts (1998), however, assumes that an increase in the standard increases the wages of both groups. The only students whose wages decline are those who fail to meet the higher standard due to the increase.

$$
\begin{aligned}
y_e(a,e,f)\frac{1}{2z}w(\overline{y}) - v_e(e) &= 0 \\
&\Leftrightarrow \quad y_e(a,e,f)\frac{1}{2z}w(\overline{y}) = v_e(e) \\
&\Leftrightarrow \quad mb_{effort} = mc_{effort}
\end{aligned}
$$

Hence, in the optimum of the student, the expected marginal benefit of effort should equal the marginal cost of effort.[9] As expected, the student's optimal effort level e^* depends on her own ability, and on the teaching effort and exit standard set by the university: $e^*(a,e,f)$. The question arises, though, how exactly ability, effort and exit standard influence a student's effort choice. Again, this depends on the cross-derivatives of the student's educational production function. Consider the following three propositions:

1. Higher ability students will choose to make a greater effort if and only if the positive effect of an increase in their effort on their productivity is reinforced by an increase in their ability (i.e. if the student's effort level and her ability are complements in the educational production function):

   $$e_a^*(a,f,\overline{y}) > 0 \Leftrightarrow y_{ea}(a,e,f) > 0$$

   In this case, an increase in ability increases the marginal benefit of effort. Conversely, higher ability students will choose to make a smaller effort if and only if the positive effect of an increase in their effort on their productivity is constrained by an increase in ability (i.e. if the student's effort and her ability are substitutes in the educational production function):

   $$e_a^*(a,f,\overline{y}) \leq 0 \Leftrightarrow y_{ea}(a,e,f) \leq 0.$$

2. An increase in the teaching effort of the university induces a student to increase her own effort if and only if the positive effect of an increase in the student's effort on her productivity is increasing in the teaching effort of the university (i.e. if the student's effort and the teaching effort of the university are complements):

   $$e_f^*(a,f,\overline{y}) > 0 \Leftrightarrow y_{ef}(a,e,f) > 0.$$

   Conversely, an increase in the teaching effort of the university induces the student to lower her own effort if and only if the positive effect of an increase in the student's effort on her productivity is decreasing in the teaching effort of the university (i.e. if the

9 The second order condition becomes $y_{ee}(a,e,f)\left(\frac{1}{2z}\right)w(y) - v_{ee}(e) < 0$. It is satisfied, since $v_{ee}(e) > 0$ and $y_{ee}(a,e,f) \leq 0$.

student's effort and the teaching effort of the university are substitutes) [10]:

$$e_f^*(a, f, \overline{y}) < 0 \Leftrightarrow y_{ef}(a, e, f) < 0.$$

3. An increase in the exit standard set by the university always induces the student to raise her own effort level:

$$e_{\overline{y}}^*(a, f, \overline{y}) > 0.$$

   This is due to the fact that an increase in exit standard raises the reward for obtaining the degree ($w_{\overline{y}}(\overline{y}) > 0$). Hence, the marginal benefit of effort becomes greater.

Formal proof is included in Appendix A.

2.1.2. The student's enrolment decision

In the previous subsection we derived the optimal effort choice $e^*(a, e, f)$ for a student, given that she has enrolled with the university. Next, we consider whether the student will actually enrol given her future effort choice.

Using (7), we define $V(a, f, \overline{y})$ as the maximal value function,

$$V(a, f, \overline{y}) \equiv U[e^*(a, f, \overline{y}), f, \overline{y}, a].$$

When deciding whether to enrol with the university or not, the student compares her utility of enrolling and exercising effort level $e^*(a, e, f)$ with the utility of her outside option (i.e. not to enrol with the university), which is normalized to zero:

$$V(a, f, \overline{y}) \geq 0$$

From this comparison we deduce the ability level $\hat{a}$ of an indifferent student:

$$V(\widehat{a}, f, \overline{y}) = 0 \quad \text{with} \quad \hat{a} = \phi(f, \overline{y}).$$

Students with an ability level higher than (or equal to) $\hat{a}$ will decide to enrol in the university, while lower ability students will decide not to. Relying on the assumption that ability is uniformly distributed, we

[10] This is also pointed out by De Fraja and Landeras (2006). They claim that resources devoted to improving school quality may not result in higher educational outcomes if student effort and school inputs are substitutes in the production function.

conclude that the number of students enrolled (*ne*) is determined as follows

$$ne = 1 - \hat{a} = 1 - \phi(f, \overline{y}) \qquad (8)$$

Below we analyze the behaviour of the university. Hence, we are now interested in the effect of a change in the exit standard $\overline{y}$ and the teaching effort *f* of the university on the number of enrolments, i.e. $ne_f(f,\overline{y})$ and $ne_{\overline{y}}(f,\overline{y})$. Consider the following propositions.

Proposition 1 - An increase in the teaching effort *f* of the university increases the number of students enrolling with the university.

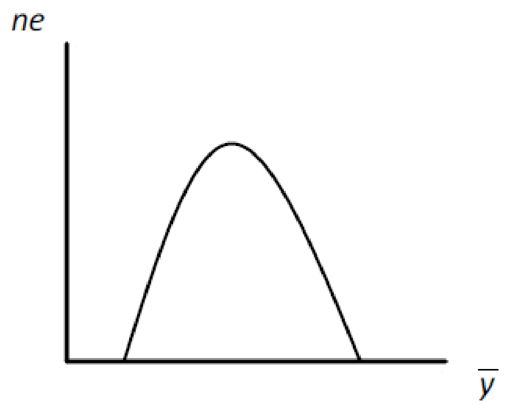
This is due to the fact that an increase in the teaching effort on the part of the university increases the student's productivity, and hence her probability of obtaining the degree if she decides to enrol. Formal proof is provided in Appendix B.

Proposition 2 - The effect function of an increase in the university's exit standard $\overline{y}$ on enrolments has an inverted U-shape. Enrolment initially increases and subsequently decreases with the exit standard of the university. More specifically,

$$\begin{aligned} ne_{\overline{y}}(f,\overline{y}) &> 0 \Leftrightarrow \frac{y(a,e,f)-\overline{y}+z}{2z} w_{\overline{y}}(\overline{y}) > \frac{1}{2z} w(\overline{y}) \\ ne_{\overline{y}}(f,\overline{y}) &< 0 \Leftrightarrow \frac{y(a,e,f)-\overline{y}+z}{2z} w_{\overline{y}}(\overline{y}) < \frac{1}{2z} w(\overline{y}). \end{aligned}$$

This is explained by the fact that, when a university toughens its graduation requirements (i.e. raises its exit standard), two opposite effects occur on the student's utility from enrolling with the university. On the one hand, since graduates will have learned more and be able to advertise greater personal ability to employers, the student's future earning potential is greater, which enhances her utility. On the other hand, the probability of her actually obtaining the degree decreases, which reduces her utility. Since we assumed that $w_{\overline{yy}}(\overline{y}) \leq 0$, we find that $ne_{\overline{y}}(f,\overline{y}) > 0$ for small values of the exit standard $\overline{y}$, while $ne_{\overline{y}}(f,\overline{y}) < 0$ for large values of the exit standard $\overline{y}$. See Appendix B for further details. Note that this inverted U-shape effect of an exit standard on enrolment is similar to Shmanske (2002). See Figure 1.

Figure 1. The relation between the exit standard and the number of enrolments with a university



2.1.3. The number of graduates

Given the optimal effort choice of a student $e^*(a,e,f)$, we can determine which students will actually obtain a degree. In order to graduate, a student's productivity *y* has to exceed the exit standard $\overline{y}$ applied by the university. More specifically,

$$\text{a student graduates} \Leftrightarrow y[a, e^*(a, f, \overline{y}), f] \geq \overline{y}.$$

The ability level $\tilde{a}$ of the marginal student solves

$$y[a, e^*(\tilde{a}, f, \overline{y}), f] = \overline{y} \quad \text{or} \quad y[a, e^*(\tilde{a}, f, \overline{y}), f] - \overline{y} = 0 \quad \text{with} \quad \tilde{a} = \rho(f, \overline{y}).$$

Assuming that ability is uniformly distributed, we know that the number of students who graduate (*ng*) can be determined as follows

$$ng = 1 - \tilde{a} = 1 - \rho(f, \overline{y}) \tag{9}$$

In order to be able to analyze the university's behaviour, we need to know how changes in the exit standard and the teaching effort of a university affect graduation numbers. In other words, we are interested in the signs of $ng_f(f,y)$ and $ng_{\overline{y}}(f,\overline{y})$. However, Appendix C shows that these effects cannot be determined without introducing explicit functional forms for the educational production function (1), the wage function (5) and the effort cost function (6), which will happen in section 2.3. First, in section 2.2, we describe the characteristics and the decision problem of the university.

2.2. The university

The university is engaged in two traditional activities: producing university graduates through teaching, and conducting research. Moreover, it reveals information to employers about the productivity of its students. Through examinations, the university is able to determine whether the productivity of an enrolled student is above or below a certain predefined level $\overline{y}$. Students with $\overline{y} \geq y$ obtain a degree, while students with $\overline{y} < y$ do not. In this model, the cutoff point $\overline{y}$ is a decision variable of the university. Moreover, by investing in teaching, the university adds to the productivity level of its students. The teaching effort (or investment) *f* is a second decision variable of the university.

Teaching cost function: The teaching effort (or investment) *f* of the university represents a cost. We assume the following teaching cost function[11]

$$C = f^2. \tag{10}$$

Budget constraint: The university receives funding *F* from public resources. Funding consist of a fixed part *B* and a variable part. The variable part is a combination of input-based funding (*IBF*) and output-based funding (*OBF)* is used, i.e.

$$F = B + s(\alpha ne + (1-\alpha)ng) \quad \text{with} \;\; 0 \leq \alpha \leq 1. \tag{11}$$

As the parameter *s* increases, the variable funding grows relative to the fixed funding *B*. An increase in *α* implies that, within the variable part, *IBF* grows relative to *OBF*. Note that this may be regarded as an "open-ended" funding rule (as opposed to a "closed budget"). If the university attracts more students and/or produces more graduates, total funding increases.

Objective function: The amount managed by the university equals the total amount in public funding received minus the university's teaching costs

$$M(f, \overline{y}) = F - C = B + s(\alpha ne + (1-\alpha)ng) - f^2. \tag{12}$$

This implies that we assume the university to maximize the amount of funding available for other activities such as research.[12] The fact that in practice research is often supported through separate funding channels is ignored here. However, in Flanders, universities receive teaching and research funds as a lump sum to spend at their discretion.

Decision problem: Using (), the university solves the following decision problem:

$$\max_{\overline{y},\, f} \; M(f, \overline{y}) \tag{13}$$

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11 This teaching cost function implies a public good assumption: the costs associated with the teaching effort of the university are independent of the number of students who benefit from the teaching activities. While we concede that a university will incur some costs that do depend on the university's size (i.e. enrolment number), using the following cost function $C = f^2 + k(ne)$ would not fundamentally change our results.

12 In a previous version of the model we assumed the university to maximize the following weighted sum of its teaching and research activities: $f + \gamma[B + s(\alpha ne + (1-\alpha)ng) - f^2]$. The parameter γ measures the university's preference for research versus teaching. We found that this parameter does not influence the effect of the type of funding mechanism on the university's decision variables *f* and *y*. Hence, we simplified the objective function by assuming that the university manages the research funds only (i.e. γ goes to infinity).

Of course, enrolment cannot exceed the total student population with size one. Moreover, the number of graduates cannot be negative, and it cannot exceed the number of enrolments. More specifically, after solving (13), we need to ascertain ex-post that

$$0 \leq ng \leq ne \leq 1$$

2.3. The effect of the funding mechanism on university behaviour

Given the uncertainty concerning the effect of changes to the university's exit standard $\overline{y}$ and/or teaching effort f on enrolment and graduation numbers, it is not possible to solve (13) without introducing explicit functional forms for the educational production function $y(a,e,f)$, the wage function $w(y)$ and the effort cost function $v(e)$ of the student. The above analysis would appear to suggest that the results depend largely on the cross derivatives of the student's educational production function. That is why (13) was solved for a limited number of sets of functional forms for this production function. The results are presented in Table 1.[13]

Table 1. A comparison of three different educational production functions

Case 1	Case 2	Case 3
$y(a,e,f) = a + e + f$	$y(a,e,f) = aef$	$y(a,e,f) = e + af$
$w(\overline{y}) = \overline{y}$	$w(\overline{y}) = \overline{y}$	$w(\overline{y}) = \overline{y}$
$v(e) = ve^2$	$v(e) = ve^2$	$v(e) = ve^2$
$e^* = \frac{\overline{y}}{4vz}$	$e^* = \frac{af\overline{y}}{4vz}$	$e^* = \frac{\overline{y}}{4vz}$
$f^* = \frac{s}{2}$	$f^* = \overline{\frac{s(-4c\sqrt{vz}(-1+\alpha)+2\sqrt{cv(8c-z)}\alpha)^{\frac{1}{3}}}{c^{\frac{1}{3}}2^{\frac{2}{3}}}}$	$f^* = (s(-\frac{z\alpha}{2} + \frac{\sqrt{c\alpha}\sqrt{-2+8vz+\alpha}}{2\sqrt{v}}))^{\frac{1}{3}}$
$\overline{y}^* = \frac{4\sqrt{cv\alpha z}}{\sqrt{-2+8vz+\alpha}}$	$\overline{y}^* = 4c$	$\overline{y}^* = \frac{4\sqrt{cv\alpha z}}{\sqrt{-2+8vz+\alpha}}$
$f^*_\alpha = 0$	$f^*_\alpha < 0$	$f^*_\alpha < 0$
$\overline{y}^*_\alpha > 0$	$\overline{y}^*_\alpha = 0$	$\overline{y}^*_\alpha > 0$
$ne^*_\alpha > 0$	$ne^*_\alpha < 0$	$ne^*_\alpha > 0$
$ng^*_\alpha < 0$	$ng^*_\alpha < 0$	$ng^*_\alpha < 0$

In the first case, we assume the educational production function to be additive, i.e. there are no interaction effects between ability, student effort and teaching effort. It follows that a funding rule with an increasing

13 Calculations are available from the authors on request.

emphasis on input-based funding induces the university to raise its exit standard while its teaching effort remains unaffected. Alternatively, output-based funding leads to lower educational standards, but does not have an effect on teaching investments.

In the second case, we use a multiplicative educational production function, i.e. the interaction effects between ability, student effort and teaching effort are assumed to be strictly positive. We find that an increasing emphasis on input-based funding does not influence the university's choice of exit standard, whereas it does lower its teaching investment. In other words, output-based funding raises the university's teaching effort while leaving unaffected its exit standard.

Finally, the third case contains an educational production function in which the interaction effect between a student's ability and the university's teaching effort is strictly positive, while the other interaction effects are absent. For this case, we conclude that raising the weight of input-based funding versus output-based funding implies a lower teaching investment and a higher exit standard. Put differently, greater emphasis on output in the funding rule leads to lower standards and higher teaching effort.

2.4. Conclusions based on theory

From the theoretical part we conclude the following. Governments introducing output parameters in the funding rule for universities should be aware that the presumed effects such as increasing teaching effort and maintaining (high) standards will not be realized if the educational production function is not characterized by positive interaction effects between a student's ability, a student's effort and the university's teaching effort. Moreover, in the next section we investigate a complementary factor which could be of great importance for predicting the possible effects of the introduction of output funding for universities.

3. Output funding and the socioeconomic background of students: empirical estimates for Flanders

3.1. The political rationale for output funding

According to the theoretical model described above case 2 can be regarded as the most optimistic one: due to output funding teaching efforts will increase while standards will remain unaffected. This presupposes positive interaction effects between ability, student effort and teaching effort. Support for the idea of introducing output-based funding in Flemish higher education precisely builds on this presupposition. Proponents argued that emphasis on output indicators will raise the quality of education and will encourage institutions to optimize student support. Society (i.e. the tax payer) invests in higher education institutions because they deliver a return in quantity and quality, more specifically many and highly educated individuals (Vandenbroucke, 2006). However, the use of output indicators can also have socially undesirable effects, which are at odds with the objectives of democratization and equal opportunities (see also Jongbloed and Vossensteyn, 2001; Vossensteyn, 2004). Students with less favourable socioeconomic characteristics have a lower probability of success in higher education than others. When universities are funded on the basis of output parameters, this provides an incentive to attract only students from the more privileged backgrounds, as this leads to an increase in the number of graduated students. Institutions that attract more vulnerable students will be penalized when switching from input to output-based funding.

If a student's ability and/or effort is highly correlated with socioeconomic background, the theoretical model presented thus far rightly assumes that a lower socioeconomic background reduces a student's probability of success. See (4). The theoretical model does, however, not take into account social clustering within institutions. If this proves to be important, then it is crucial for policy makers to account for them in the choice between input and output-based funding. In this empirical part of the paper, we first consider which factors might determine differences in the probability of students' success rates at different educational institutions in Flanders. Second, we examine whether the characteristics that influence the success probability are distributed equally over the different institutions of higher education. Finally, we investigate to what extent the probability of succeeding is influenced by the different characteristics.

3.2. Higher education in Flanders

The three most important characteristics of Flemish higher education are the following. First, universities are all financed by government in exactly the same way and the total budget for university education is fixed (i.e. a closed envelope). Second, universities charge very low tuition fees which do not differ between universities. Finally, there is free entrance (i.e. no entrance examinations except for medicine). Higher education institutions in Flanders are either universities or colleges. Colleges focus primarily on teaching and they offer mostly occupation-oriented study programs. Universities offer academic study programs and they also conduct research (Kelchtermans and Verboven, 2010).

In the present paper, we focus on the Flemish universities. To test the hypothesis that differences in the probability of succeeding can be explained by the divergent socioeconomic backgrounds of the students we analyze data on first-year students at the five Flemish universities in the 2004-2005 academic year. We use administrative data from the "Databank Tertiair Onderwijs Studenten (DTO)" (database of tertiary education students). This database is managed by the Department of

Higher Education of the Ministry of Education and it contains data on students and their registration at the universities and colleges in Flanders. Ideally, we would have wanted to disentangle empirically the respective effects of ability, effort and socioeconomic characteristics of students on their success probability, as well as the potential interaction effects. Unfortunately, the DTO database does not contain information that can be used as direct measures of ability and effort. This means that the focus of the empirical analysis is on the effects of socioeconomic characteristics on success probabilities. We selected several variables from the database as possible indicators of the prior schooling and socioeconomic backgrounds of the students. As such, it provides a highly relevant complement to the theoretical framework presented in section 2.

3.3. Which factors influence success probability?

In our search for student characteristics that might influence their likelihood of succeeding, we first consider students' high school pathways prior to higher education. We take due account of the nature of the students' secondary schools: we consider whether it is situated in a rural or an urban environment and whether the school is a so-called equal opportunities or GOK school. GOK schools receive additional government funding because at least 10% of students in the first two years and 25% of those in the final four years have vulnerable socioeconomic backgrounds. Pupils with learning difficulties can thus benefit from extra tutoring, either in group or individually. The type of education previously enjoyed by the student might also be an important indicator. In Belgium, there are four main types of secondary education. ASO is general secondary education providing a broad theoretical training as a foundation for the student to move on to higher education. ASO may be subdivided into four categories depending on whether the focus is on Latin, mathematics, science, economics or modern languages (ASO1, ASO2, ASO3 and ASO4[14]). In technical secondary education (TSO), the main emphasis is on specialized technical-theoretical training, though a sufficiently broad basis is provided for pupils to prepare for higher education. KSO is art secondary education. It lies somewhere in between ASO and TSO. Finally, BSO is vocational secondary education, with a strong focus on practical training. Graduates from BSO may continue in higher education, but only after taking further courses during an additional seventh year of study (Kelchtermans and Verboven, 2010).

As regards the socioeconomic background of the students, we have at our disposal information on gender and nationality. As a proxy for household income, we use a binary variable that indicates whether or not the student is on a scholarship.

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[14] ASO1: Latin-Greek, Greek-Mathematics, Greek-Sciences, Latin-Mathematics, ASO2: Latin-Sciences, Sciences-Mathematics, ASO3: Latin-Modern languages, Mathematics-Modern languages, Economics-Mathematics and ASO4: other

Table 2 summarizes the likelihood of success by various indicators of prior education and socioeconomic background. It is clear that the type of secondary school attended and the kind of secondary education received have great impact on the student's success probability. Students from education types with focus on mathematics or Greek and/or Latin enjoy a significantly higher probability of succeeding than other students. Students from TSO and BSO are quite unlikely to succeed in their first year at university.

Students who attended secondary school in an urban area have a significantly lower probability of succeeding at university than students who attended school in a rural environment. Students who come from GOK school, i.e. a school with a high proportion of pupils from vulnerable socioeconomic backgrounds, have a significantly lower success probability than their peers from non-GOK schools. In relation to gender, we find that female students have a significantly greater probability of succeeding than their male counterparts. As for nationality, here we observe that Belgian students enjoy a much greater success probability than foreign students. Scholarship students, who are assumed to come from financially more vulnerable families, have a significantly lower probability of succeeding. These analyses prove that the success probability of students in their first year at university is determined in part by socioeconomic characteristics and by the prior educational pathways of the students.

Table 2. Characteristics of the students who succeed

		% succeeded	**Sig.**	**Cramer V**
Gender	Male Female	43.6 52.2	.000	.0867
Nationality	Belgian Inside EU Outside EU	49.5 30.3 16.2	.000	.116
Type of prior education	ASO1 ASO2 ASO3 ASO4 TSO BSO KSO unknown	70.4 60.1 51.3 34.6 17.7 6.3 20.6 26.1	.000	.3297
High school environment	Urban Rural	42.9 49.2	.000	.0478
Type of school	GOK Non-GOK	42.2 49.7	.000	.0598
Scholarship	Yes No	42.3 49.7	.000	.0599

3.4. Dispersion of students over the different universities

Table 3 provides an overview of the dispersion of students over the five Flemish universities. Clearly there are important differences between the institutions in question. The most important and striking difference concerns the student success rates. Students at University A have a 61.1% probability of succeeding, compared to a first-year success rate of just 44% at University D. The other findings are however also important. From Table 2, it is clear that the probability of succeeding depends on a variety of student characteristics. Moreover, Table 3 shows that students with certain characteristics that influence their success probability negatively are not distributed equally over the five universities. For example, the university with the lowest success probability (D) attracts significantly more male students, foreign students, students from TSO and BSO, students from schools in urban environments students from GOK-schools, and scholarship students.

Table 3. Dispersion of the students' characteristics over the different universities

n=18191	**A**	**B**	**C**	**D**	**E**	**Total**	**Sig.**	**Cramer V**
% of students who succeed	**61.1**	**53.6**	**44.5**	**44.0**	**46.1**	**48.2**	**.000**	**.0918**
% of male students	46.8	47.5	45.4	50.3	48.1	47.1	.001	.0328
% of Belgian students % of EU foreign students % of non-EU foreign students	95.4 1.4 3.2	94.5 3.0 2.5	95.5 2.9 1.7	90.9 7.2 1.9	95.7 2.5 1.8	94.5 3.5 2.0	.000	.088
Type of prior education % ASO1 % ASO2 % ASO3 % ASO4 % TSO % BSO % KSO % unknown	 12.0 15.3 20.8 34.7 6.9 0.5 0.9 8.8	 18.6 32.2 17.8 18.5 4.6 0.1 0.5 7.8	 14.1 30.2 17.5 24.3 6.2 0.4 1.3 6.0	 11.3 20.2 19.5 26.4 8.2 1.6 0.9 11.9	 10.6 20.8 16.5 30.9 10.5 1.2 1.1 8.5	 15.0 28.4 17.8 23.3 6.3 0.5 0.9 7.8	.000	.0993
% of schools in urban environment	26.4	7.1	18.3	35.5	24.7	17.2	.000	.2524
% students from GOK schools	23.1	17.3	20.6	28.2	29.4	21.4	.000	.1077
% of scholarship students	19.0	19.3	20.9	22.3	23.3	20.8	.001	.0328

3.5. Determinants of differential success probabilities

In this subsection we use logistic regression to determine the extent to which the success probabilities are influenced by the choice of university and by the other student characteristics. The dependent binary variable represents whether the student succeeds in her first year at university. We estimate two models: in the first model we take into account only the university and the field of study. In the second model we also control for the other student characteristics.

Table 4. Logistic regression of students' success probability

	Model 1 (n=18191)			Model 2 (n=18190)		
	Coef.	**Z**	**Sig.**	**Coef.**	**Z**	**Sig.**
University A[a]	0.473	3.30	.001	0.724	4.74	.000
University C	-0.299	-8.35	.000	-0.248	-6.49	.000
University D	-0.306	-6.20	.000	-0.004	-0.07	.947
University E	-0.223	-4.16	.000	0.096	1.66	.097
Theology and religious studies[b]	-0.492	-1.75	.080	-0.224	-0.71	.478
Linguistics and literature	0.140	1.08	.280	-0.296	-2.08	.037
History	0.0501	0.36	.716	-0.0853	-0.57	.569
Archaeology and art sciences	0.0227	0.15	.880	-0.00656	-0.04	.968
Law, notarial studies and criminology	-0.901	-0.73	.468	-0.361	-2.66	.008
Psychology and educational sciences	0.00581	0.05	.964	-0.350	-2.52	.012
Business and economics	0.278	2.19	.029	-0.117	-0.84	.400
Political and social sciences	-0.142	-1.12	.263	-0.318	-2.29	.022
Social health sciences	0.994	4.63	.000	0.277	1.22	.223
Kinesiology & rehabilitation sciences	0.0656	0.48	.634	-0.297	-1.98	.047
Sciences	-0.0169	-0.13	.896	-0.536	-3.78	.000
Applied sciences	0.117	0.89	.374	-0.573	-3.97	.000
Applied biological sciences	0.531	3.53	.000	-0.207	-1.28	.202
Medicine	1.667	10.8	.000	0.913	5.48	.000
Dentistry	1.228	4.49	.000	0.751	2.55	.011
Veterinary sciences	-0.431	-2.88	.004	-0.832	-5.08	.000
Pharmaceutical sciences	0.467	3.09	.002	-0.272	-1.65	.099
Biomedical sciences	1.911	1.73	.083	2.284	2.00	.045
Combined studies	-0.0563	-0.39	.699	-0.692	-4.36	.000
Unknown	-0.0445	-0.29	.772	-0.0279	-0.17	.867
ASO1[c]				0.391	7.36	.000
ASO3				-0.443	-8.67	.000
ASO4				-1.111	-22.30	.000
KSO				-1.846	-9.14	.000
TSO				-1.852	-21.34	.000
BSO				-3.076	-7.23	.000
Unknown				-1.387	-16.39	.000
Male[d]				-0.392	-11.37	.000
High school in rural area[e]				-0.187	4.11	.000
GOK-high school[f]				-0.182	4.38	.000
Non-Belgian EU citizen[g]				-0.941	-6.03	.000
Non-Belgian non-EU citizen				-0.237	-2.16	.031
Scholarship[h]				-0.171	4.28	.000
Constant	-0.0031	-0.03	.979	1.111	3.83	.000
Pseudo R^2	0.0274			0.110		
APER	43.15%			34.34%		

Reference point: (a) University A (b) Philosophy and moral sciences (c) ASO2 (d) Female (e) High school in urban area (f) no GOK-high school (i.e. no extra support because of many students with vulnerable socio-economic background (g) Belgian nationality (h) no scholarship

There are clearly significant differences in terms of students' success probability between the five universities, as shown by the outcomes of model 1 (see Table 4). The model has a coefficient of determination of 2.7% which is low, indicating that the different universities only partly explain the differences in success probability. The apparent error rate is 43.15%, which means that 56.85% of the observations in our sample are correctly classified by the model.

In model 2 socioeconomic characteristics and the secondary education of the student are added as explanatory variables. The coefficient of determination rises to 11%, which is acceptable for this type of research. In this model 65.66% of the observations are correctly classified. After addition of these covariates, there is no longer a significant difference in success probability between universities B and E and between universities B and D. The differences between the other universities remain significant though. The results for the other covariates are as expected, providing confirmation of the findings presented in Table 2. The type of secondary education enjoyed has a significant impact on the success probability. ASO students have the highest probability of succeeding; students from BSO succeed least often. As is often found in this type of research, male students have a lower success probability than female students. Students who attended secondary school in an urban area, students who attended a GOK-school and scholarship students also succeed less often. Finally, it can be concluded from Table 4 that non-Belgian students are less likely to succeed than their Belgian counterparts[15]. These conclusions are similar to those reached by Arias Ortiz and Dehon (2008). They analyze students' probability of succeeding in the first year[16] at ULB (Université Libre de Bruxelles) taking into account individual characteristics, prior schooling and socioeconomic backgrounds. They find that the socioeconomic background of a student influences their success rate at university in a significant way. More specifically, the mother's level of education and the father's occupational activity appear to be influential. Moreover, they observe that Belgians and foreigners perform similarly in the first year if one corrects for the students' socioeconomic backgrounds.

4. Discussion

The theoretical part of this paper considered the case of a single university that wishes to set an exit productivity standard for its students, as well as a teaching effort. The university determines these two variables with a view to maximizing its public funds minus teaching costs. The government applies a funding rule whereby input (i.e. the enrolment number) and output (i.e. the graduation number) are weighted.

Students face one or two subsequent decisions: first they must decide whether or not to enrol with the university and, once enrolled, they must determine an effort level. Whether students graduate or not depends on whether their educational production meets the standard set by the university. We assume that educational ability, individual effort and teaching effort on the part of the university all increase a student's educational productivity. However, we do not impose the cross-derivatives of this educational production function. Instead, we compare the outcome of the model for three different educational production functions. It follows that the results of the theoretical model depend largely on the functional form of the educational production function. The following three cases were considered.

[15] Similar analyses were conducted for the Flemish colleges, yielding similar results.
[16] Hence, they focus on newly enrolled students.

First, without interaction effects between ability, student effort and teaching effort in the educational production function, increasing the weight of output (versus input) in the funding rule is found to lead to the setting of a lower exit standard by the university. On the other hand, the university's teaching effort (or investment) is unaffected. Second, if all interaction effects are strictly positive, greater emphasis on output has no effect on the exit standard, while it nonetheless leads to a more substantial teaching investment. Finally, if we assume the positive effect of ability on educational production to be increasing in teaching effort, an increased weight of output in the funding rule results in a greater teaching investment and a lower exit standard on the part of the university. To sum up, the most optimistic effects of output-based funding, namely an increase in teaching effort and preservation of (high) standards, presupposes positive interaction effects between ability, student effort and teaching effort.

It are precisely these positive interaction effects that are the underlying assumptions for policy makers in Flanders to introduce output-based funding in the universities. The proponents argued that emphasis on output indicators would raise the quality of education and increase a university's teaching effort. In our empirical analysis for the five universities in Flanders we use socioeconomic background of the student as a signal for their ability and effort. We find that - in line with our theoretical model - a lower socioeconomic background substantially reduces a student's probability to succeed. The analyses show that there are significant differences between the five institutions in terms of students' probability of succeeding. Further analysis (logistic regression) indicates that these differences do not result from differential teaching efforts, but are due almost entirely to variations in socioeconomic characteristics of the students. Typically, universities in urban environments attract more of these vulnerable students. This explains their lower graduation rates.

5. Conclusion

Even in the most optimistic case of positive interaction effects between ability, student effort and a university's teaching effort our theoretical model shows that output funding will induce all universities to raise their teaching effort while not lowering their educational standards. For Flanders, however, we presented empirical data showing that a student's probability of success is partly determined by socioeconomic characteristics (which could be interpreted as a signal for a student's educational ability and/or effort level), a factor that is often ignored in the debate on output-based funding of higher education. Moreover, it appears that students with weaker socioeconomic characteristics are not evenly distributed over the different universities. Based on the theoretical model and the empirical data we conclude that output funding will lead to undesirable effects: universities attracting the most vulnerable students will not be rewarded as they should be for their increasing teaching effort. This factor is often ignored in the debate on output-based funding of higher education.

Appendix A

In order to determine the signs of $e_a^*(a,f,\overline{y})$, $e_f^*(a,f,\overline{y})$ and $e_{\overline{y}}^*(a,f,\overline{y})$, we apply the Implicit Function Theorem (IFT):

$$\begin{aligned}
y_{ee}(.)\frac{1}{2z}e_a^*(.)w(.) + y_{ea}(.)\frac{1}{2z}w(.) - v_{ee}(.)e_a^*(.) &= 0 \Leftrightarrow \\
e_a^*(.)\underbrace{[y_{ee}(.)\frac{1}{2z}w(.) - v_{ee}(.)]}_{SOC} &= -y_{ea}(.)\frac{1}{2z}w(.) \Leftrightarrow \\
e_a^*(.) &= \frac{-\overset{?}{y_{ea}}(.)\frac{1}{2z}w(.)}{\underset{-}{SOC}} >< 0
\end{aligned}$$

$$\begin{aligned}
y_{ee}(.)\frac{1}{2z}e_f^*(.)w(.) + y_{ef}(.)\frac{1}{2z}w(.) - v_{ee}(.)e_f^*(.) &= 0 \Leftrightarrow \\
e_f^*(.)\underbrace{[y_{ee}(.)\frac{1}{2z}w(.) - v_{ee}(.)]}_{SOC} &= -y_{ef}(.)\frac{1}{2z}w(.) \Leftrightarrow \\
e_f^*(.) &= \frac{-\overset{?}{y_{ef}}(.)\frac{1}{2z}w(.)}{\underset{-}{SOC}} >< 0
\end{aligned}$$

$$\begin{aligned}
y_{ee}(.)\frac{1}{2z}e_{\overline{y}}^*(.)w(.) + y_e(.)\frac{1}{2z}w_{\overline{y}}(.) - v_{ee}(.)e_{\overline{y}}^*(.) &= 0 \Leftrightarrow \\
e_{\overline{y}}^*(.)\underbrace{[y_{ee}(.)\frac{1}{2z}w(.) - v_{ee}(.)]}_{SOC} &= -y_e(.)\frac{1}{2z}w_{\overline{y}}(.) \Leftrightarrow \\
e_{\overline{y}}^*(.) &= \frac{-y_e(.)\overset{+}{\frac{1}{2z}}w_{\overline{y}}(.)}{\underset{-}{SOC}} > 0
\end{aligned}$$

Appendix B

We apply the IFT, and find that:

$$\begin{aligned}
V_a(.)\phi_f(f,\overline{y}) + V_f(.) &= 0 \quad \Rightarrow \phi_f(f,\overline{y}) = -\frac{V_f(.)}{V_a(.)} = -\frac{+}{+} < 0, \\
V_a(.)\phi_{\overline{y}}(f,\overline{y}) + V_{\overline{y}}(.) &= 0 \quad \Rightarrow \phi_{\overline{y}}(f,\overline{y}) = -\frac{V_{\overline{y}}(.)}{V_a(.)} = -\frac{?}{+} \underset{?}{\lessgtr} 0.
\end{aligned}$$

Using the assumption that ability is uniformly distributed, we know that the number of students enrolled ne equals $1-\phi(f,\overline{y})$. This implies that

$$\begin{aligned} ne_f(f,\overline{y}) &= -\phi_f(f,\overline{y}) > 0, \\ ne_{\overline{y}}(f,\overline{y}) &= -\phi_{\overline{y}}(f,\overline{y}) \gtrless 0. \end{aligned}$$

Appendix C

We apply the IFT, and find that

$$\begin{aligned} y_a()\rho_f(.) + y_e(.)e_a^*(.)\rho_f(.) + y_e(.)e_f^*(.) + y_f(.) &= 0 \Rightarrow \rho_f(.) = -\frac{y_e(.)e_f^*(.) + y_f(.)}{y_a() + y_e(.)e_a^*(.)} \\ &\Rightarrow \rho_f(.) = -\frac{(+?)+(+)}{++(+)(?)} \underset{?}{\lesseqgtr} 0 \\ y_a()\rho_{\overline{y}}(.) + y_e(.)e_a^*(.)\rho_{\overline{y}}(.) + y_e(.)e_{\overline{y}}^*(.) - 1 &= 0 \Rightarrow \rho_{\overline{y}}(.) = \frac{1 - y_e(.)e_{\overline{y}}^*(.)}{y_a() + y_e(.)e_a^*(.)} \\ &\Rightarrow \rho_{\overline{y}}(.) = \frac{1-(+)(+)}{++(+)(?)} \underset{?}{\lesseqgtr} 0 \end{aligned}$$

Using the assumption that ability is uniformly distributed, we know that the number of students who graduate ng equals $1-\rho(f,\overline{y})$. This implies that

$$\begin{aligned} ng_f(f,\overline{y}) &= -\rho_f(f,\overline{y}) \underset{?}{\lesseqgtr} 0, \\ ng_{\overline{y}}(f,\overline{y}) &= -\rho_{\overline{y}}(f,\overline{y}) \underset{?}{\lesseqgtr} 0. \end{aligned}$$

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