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University Funding Policies: Buildings or Citizens?

Pier-AndrÃl’ Bouchard St-Amant
Queen s University

Department of Economics
Queen’s University
94 University Avenue
Kingston, Ontario, Canada
K7L 3N6

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Pier-André Bouchard St-Amant*

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Summary

Governments fund public universities based on the number of registered students and lump sum transfers. Such policy induces universities to compete for student recruitment. I show that such rule can lead to an inefficient allocation of resources in which universities compete for the same students. I suggest a more efficient policy that achieves the social optimum for any given level of funding. Such funding rule should not be solely based on university's own enrolement, but also on enrolment in competing universities.

Keywords: University, Funding Policies, Decentralized Decisions.

JEL Classification Numbers: H52, I23, I28

*Queen's University, Department of Economics, 94 University Ave., Kingston, Ontario, Canada K7L 3N6, pabsta@econ.queensu.ca. The Social Sciences and Humanities Research Council (SSHRC) provided financial support for this research. I am thankful to Laurent Gauthier, Nicolas Marceau and Robin Boadway for useful comments. The most up-to-date version of this draft can be found at http://pabsta.qc.ca/en/research/campuses .

1 Introduction

Public universities are peculiar creatures from an economic perspective. They are largely subsidized through taxes, making them somewhat of a public service. On the other hand, it is generally recognized that universities should remain free to choose how they allocate their funds because they are better positioned to direct research and create educational programs than the government. This leaves very little room for governments to have their say on the way universities spend the money they receive. So governments usually rely on a particular policy to determine universities' levels of funding.

A popular scheme is based on enrolment. Such rule allocates an amount of money per student in order to cover the costs associated with such student. Hence, an enrolment-based funding policy naively maintains a constant level of funding per student.

Such policy however overlooks the incentives the policy bestows on universities. In particular, this funding policy encourages establishments to increase efforts in recruitment to raise revenues. If universities compete for the same students, this generates social losses. It therefore follows that such a policy can lead to an inefficient allocation of resources by universities. Hence a change in the funding rule can increase funds available for teaching or research by modification of the incentives given to universities.

In this article, I use a simple theoretical model to look at the effect of an enrolment based policy and derive an optimal funding policy. A university's funding rule should depend on its enrolment as well as the enrolment in competing universities. If the government prefers an aggressive enrolment strategy, the optimal funding policy will put less weight on the number of registered students in other establishments. If the cost of competing for the same students is however too high, the government will prefer to put more weight on students in a competing establishment. By using these two channels of the funding rule, the government can achieve an efficient allocation of resources.

The remainder of this paper is organized as follows. In section 2, I show why this work is important and how it can affect various jurisdictions across the world. In section 2.1, I show how this paper relates to the existing literature. Then, I present the model in section 3 and the main propositions. A brief conclusion follows.

2 Why Is This Important ?

When it comes to university funding, the debate often boils down to questions about the level of tuition fees or public spending on universities. One the one hand, university presidents seek to increase funding to reach their institutional goals, while on the other hand, governments seek to strike a balance between public funding of universities, student pressure to keep tuition low, and other priorities. In this debate, very little is said about the incentives given to universities and what can be done to ensure they efficiently spend the money already raised.

In a public hearing on the quality of universities, the principal of the Université Laval, a publicly funded university in Canada's province of Québec, said that the prevailing funding policy in Québec causes universities to compete against each other:

> And what struck me, among other things, is that in order to have a balanced budget, ... we must necessarily have an increase in enrolment.... We are thus subjected to a system such that if our recruitment office is not extremely efficient, we will face a deficit next year. And even if I understand the logic behind the actual funding scheme — and that it seems reasonable that universities should be funded on an headcount basis — ... the Université Laval and perhaps inevitably, in the future, other institutions [in other cities of the province] will be led to adopt actions that do not appear to be of the nature of a university. (Translated from [15])

In the following years, some Quebec universities have built off-campus facilities to attract new students (see Crespo & Al. [2]). Regional universities have built facilities close to metropolitan areas, where other universities offer similar programs. Crespo also shows that some metropolitan universities built new facilities in areas with increasing shares of young adults, competing for the students in the region. In some cases, universities threatened by new campuses responded by building facilities close to the newly built one.

In 2011, the province of Ontario, Canada, decided to change its funding mechanism to reduce their endless pursuit for increases in the student body:

> Ontario is overhauling the way it finances universities and colleges, replacing some per-student funding with performance-based support intended to discourage an attitude of "growth at all costs" that has been acknowledged to have harmed quality. (Bradshaw, 2011 [1])

In Table 1, I provide the structure of the funding schemes in various jurisdictions in Canada and Europe. They fall into four broad categories: funding based on enrolment, lump-sum funding, output-based funding and funding based on achieving contractual targets. Contractual targets are written contracts between the university and the funding body stating what the university has to achieve in order to obtain funding.

In Canada, five provinces rely on the student body as the main indicator to determine transfers. The other five provinces rely mostly on unconditional transfers.

In Europe, there is a wide diversity of funding schemes. England sets teaching funds on the basis of a targeted number of students set nationally and research funds based on competition between universities. In Denmark, most of the funding for teaching is based on the success of students at passing exams, while research funding is partly lump sum and partly driven by a competition between universities. Some German länder set contractual targets in exchange for funding. Contracts are for a period of three to five years and ensure universities receive stable funding, provided they achieve their objectives.

Table 1 shows that different jurisdictions provide different incentives to universities. Some prefer to restrain academic liberty through "performance contracts", while others establish some rules and let institutions make their own decisions given those rules. It also shows that a significant number of jurisdictions choose a combination of lump-sum transfers and enrolment.

Table 2 shows the spending in immobilization as a percentage of total university spending from 1982 to 2004 in two provinces. The first one, British Columbia, has had a funding rule that fixed enrolment in the period ranging from 1982 to 2004. The second one, the province of Québec had a policy shift in 2000. Before 2000, transfers to university were based on past funding (or lump sum). Afterwards, the province moved to a enrolment based funding policy. The current data suggests that the difference in spending could be due to the funding rule, as there is a 5% shift in immobilization spending in Québec that does not follow the trend in British Columbia. The dataset provided is however limited and such evidence should be interpreted with caution.

To sum up, the way rules to transfer funds to universities are devised changes their behaviors and these rules are different from one jurisdiction to another. Such rules might harm quality, enrolment or inter-institutional coordination (Darling & coll. [3]), depending on their composition. So the question is: what should be a good rule?

2.1 How This Paper Relates to Other Contributions

The focus of this paper is on a single decision of a university to create a new facility (new campus). It looks at the impact of the university's behavior on other universities when they compete in a region. In particular, it shows that it may not be socially efficient to have two facilities in a region competing for the same students. It also compares a set of funding policy schemes and determines which one leads to a social optimum.

The model draws some inspiration from the tax competition and fiscal federalism literatures. If one substitutes universities, funding policies and enrolment for competing jurisdictions, taxes and economic activity, the model below would be close to a canonical model (see [18] for a review). The solution presented, however, is quite novel and draws from the fact that universities are mostly funded under one jurisdiction.

The results of the model bears also resemblance with merger analysis: if two firms compete too much for the same market share, investors in those firms have incentives in merging the firms and gain value from the loss of spending for market shares. In the case of universities, the government has incentives to reduce competition between the two universities to generate some efficiencies.

The impact of funding schemes has been explored by del-Rey [4] and Gary-Bobo & Trannoy [7]. Del-Rey explores the relationship between university goals, competition and

Table 1: Funding Schemes for Public Universities In Given Jurisdictions

Jurisdiction	Share of Funding By Source	Reference
British Columbia, Canada	90% lump sum, 10% strategic.	See [14]
Alberta, Canada	85% FTE 10% strategic funding, 5% performance	See [14]
Saskatchewan, Canada	94% lump sum, 6% unspecified	See [14]
Manitoba, Canada	94% lump sum, 6% unspecified	See [14]
Ontario, Canada	74% FTE, 3.5% strategic, 22.5% unspecified	See [14]
Québec, Canada	80.5% FTE, 10% output, 9.5% strategic	See [11]
New Brunswick, Canada	75% lump sum, 25% enrolment	See [14]
Nova Scotia, Canada	84% FTE, 10% strategic, 6% unspecified	See [14]
Newfoundland & Labrador, Canada	95% lump sum, 5% facilities	See [14]
Prince Edward Island, Canada	100% lump sum	See [14]
Norway	60% lump sum and strategic, 15% research output, 25% graduate output	See [6]
Sweden	55% lump sum, 45% enrolment	See [17]
Finland	89.4% enrolment & research contract, 6.2% strategic, 4.3% ouput, 0.1% unspecified	See [12]
England	60% enrolment contract, 29% output in research, 11% strategic	See [9]
Denmark	22% lump-sum, 13% performance, 65% graduation output	See [16]
Baden-Württemberg, Germany	80% lump-sum, 20% output	See [8]
Bayern, Germany	100% contractual target	See [8]
Nordrhein-Westfalen, Germany	80% contractual target, 20% output	See [8]
France	40% contractual target, 60% FTE	See [10]
Austria	80% contractual target, 20% output	See [10]
Valencia, Spain	87% FTE, 10% output, 3% unspecified	See [10]
Italy	Part funding rule, part lump sum (% unspecified)	See [10]
Portugal	67% FTE, 24% output (prior to 2007)	See [5]

FTE: full-time enrolment, strategic refers to additional funding for specific goals set by the government, output refers to what is created by universities (graduates, research, etc).

Table 2: Difference in Average Immobilization Spending In Terms of Total Spending

Province	1982-1999 (std. error)	2000-2004 (average) (std. error)	Difference (std. error)
British Columbia	0.10	0.08	-0.02
	(0.013)	(0.014)	(0.016)
Québec	0.09	0.12	0.03
	(0.010)	(0.014)	(0.025)
Difference	-0.01	0.04	0.05
	(0.010)	(0.014)	(0.024)

Source : Statistics Canada, CANSIM 478-008 and estimation.

the impact of funding policies. Her focus is on the allocation of funds between research and teaching, and under what circumstances the government can influence a university's decisions. She finds that aside from extreme behaviors (corner solutions), a decentralized funding policy can lead to the optimal allocation of funds between teaching and research.

Gary-Bobo and Trannoy explore the impact of a funding scheme solely based on enrolment. They however include moral hazard from universities and show that the scheme induces universities to adopt a "funnel" behavior where more students are admitted than will graduate. They suggest adding a graduation component to the funding scheme to correct such behavior.

I make three contributions to the existing literature. First, I show that enrolment-based funding policies gives incentives to universities to attract more students. If universities compete for the same students, an optimal funding scheme depends either on the number of students at competing universities. Second, I show that the optimal policy increases quality or enrolment, holding the level of overall university funding constant, as compared to a funding rule that depends solely on the enrolment in a university.

3 The Model

The model can be broadly described in the following terms:

1. Prospective students in a given region decide if they apply or not to a university. Such decision depends on quality of teaching (t_i), on the program available (p) and on the ability of the student. Such decision forms the demand for programs in the region.

2. There are two identical universities i and j who must decide to open or not a facility

in a region. If so, they maximize profits[1] from this facility to fund a given institutional goal (like research on the main campus). If they decide to open the facility, they must choose the teaching quality, the size of the facility and a single program taught. This forms the supply in the region.

3. There is a common resource problem. If i opens a new facility while j is already opened, it creates a competitive alternative and some students that would go to j will enroll in i. Hence, university i's actions influence j's decision because they compete in part for the same students. The degree of competition is measured by $\rho \in [0, 1/2]$. The higher is ρ, the more universities compete in the same market.

4. The equilibrium concept studied is a Nash equilibrium between universities. The decision of a university to open a program depends on student demand, but also the funding rule of the government. Prevalent rules gives an amount based on the number of registered students in a university. I explore a rule which also depends on students enrolled in competing universities.

In the section 3.1, I model how students decide to go to university to generate demand for programs. I then present the funding rule made available by the government. Finally, I model in section 3.3 how universities exploit such environment when making the decision. Then, some analysis on funding rules is performed in sections 3.4 and 3.5.

3.1 Student Demand

For the sake of the discussion, I assume that there is one university in the region. In such region, there is a density of students $F(\tau)$, where $\tau \in [0, 1]$ is a measure of talent of individuals. An individual student with talent τ values the life term benefits of a program from a strictly increasing function $V_p(t_i\tau)$. Such benefit accounts for future earnings, but also for accrued social benefits of having a university degree.

If a student chooses to go to university, she bears a cost C_p that depends on tuition, foregone income during studies and other characteristics. Students can observe the quality of teaching and therefore weights if the benefits are higher than the costs C_p. This generates demand $D_p(t_i)$ for university programs.

If there is only one university in the region, all students who apply go to such university. However, if there are two universities, a fraction of students apply to both universities and choose where they decide to go. For simplicity, such fraction is fixed to ρ. This means that there are $\rho D_p(t_i)$ students that will go to facility j if i opens a new campus. This fraction is assumed to be independent of programs for simplicity[2]. Such fraction is a measure of the

[1] A broader generic objective function is discussed later.

[2] One could imagine a similar fraction $\rho(p, p')$. By assuming that the fraction is constant, I avoid all the discussion on asymmetric equilibria, but keep the main insights, that is that some students move from one campus to another.

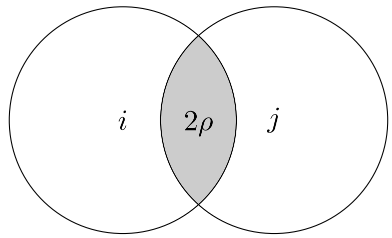

Figure 1: Student demand for i and j overlap by a factor of 2ρ.

degree of competition between universities, or the market shares at stake by competition. A depiction is given in Figure 1.

This leads to the following proposition:

Proposition 1. *Assume the previous behavior for students and assume a facility is opened in one region with a program p and quality t_i. Then:*

1. *All students above some given talent $\tau_p(t_i)$ apply to university;*
2. *The higher is the teaching quality t_i, the more the new campus will attract students:*

$$\frac{\partial \tau_p(t_i)}{\partial t_i} < 0.$$

   Conversely, the more the university attracts students, the less an additional student is talented.

3. *Total demand for program p is given by $D_p(t_i) \equiv F(1) - F(\tau_p(t_i))$, with $D_p(0) = 0$.*

Proof. See appendix A.1. □

The first statement says that above some talent threshold, potential students chooses to go to university because they weight the whole benefits higher than the costs. Such talent has to be greater than $\tau_p(t_i)$, which is implicitly defined by $V_p(t_i\tau_p(t_i)) = C_p$. In such context, an increase in teaching quality will make it marginally profitable for students with less talent. Therefore, the number of students applying increases with teaching quality and each additional student is less talented.

3.2 The Funding Rule

The government announces a funding rule and commits to it. Such rule transfers funds to universities through three components (see equation (1)). The first component is a lump-sum transfer for each facility. Such component encompasses general and particular transfer a university might receive for a given facility in the university. For instance, administration costs of the facility. I denote such transfer T_i for university i.

The second component depends on the number of students enrolled. It gives a certain amount of money per student enrolled in a given program at a given level (bachelor, masters, PhD). So one can think of an index p covering the set P of all possible programs at all levels. The government gives an amount α_p for each student enrolled in a program in a given university. So if there are $D_p(t_i)$ students registered in program p at university i, the amount given to the university through such component is $\alpha_p D_p(t_i)$. I will refer to such component later as the direct component of the funding rule.

The third component is the novel aspect of this paper. As for the second one, it fixes an amount per student in each program, which I will denote β_p. However, it depends on the number of enrolled students in the competing facility (j). So I will refer to such component as the indirect component.

So with this third component, the total subsidy S_i to university i is given by:

$$S_i \equiv T_i + \sum_{p \in P} \alpha_p D_{p,}(t_i) + \sum_{p \in \text{competing facility}} \beta_p D_p(t_j). \tag{1}$$

Such funding rule generalizes the existing scheme by introducing a component that depends on the other university. If β_p equals zero for all programs, the rule boils down to most existing rules. As an example, such restricted scheme prevailed[3] in the province of Ontario, Canada, from 1967 to 2011 (see [1] and [13]). It is also the current policy in the province of Québec, Canada (see [11]), although it is currently being reviewed. In those provinces, the rule gives relative weights to different programs p and each of these weight is multiplied by a base amount in dollars. In Ontario, these weights ranged from 1.0 to 7.5 while in Québec, they ranged up to 10.7, depending on the program. Such rule shows that if all universities increase enrolment and if the base amount does not change, the government increases funding.

3.3 Universities i and j

Universities conduct research and teaching. I assume throughout that their primary goal when opening a facility is to maximize funds available for research. In the context of this model, this means that they seek to maximize profits coming from the new facility. In section 4, I discuss that a broader objective for the facility leads to a similar qualitative analysis.

[3]These types of funding rules are actually based on moving averages of enrolled students in the past years to avoid steep variations. As I am not interested in the effects of time, I assume it depends solely on enrolment in past periods.

If a university opens a new facility, it must choose the programs offered in it. For the purpose of clarity in this paper, I assume a single program is offered. Programs are indexed by p in the set of all possible programs $P \equiv \{p_1, p_2, \ldots, p_k\}$ subsidized by the government.

The university must also choose the size f_i of the facility and the teaching quality t_i in the program. Teaching quality is measured in terms of dollars per student.

Each university charges the same fees whether its on the main campus or in the new facility. This can be so either because fees are regulated by the jurisdiction, or because the university wants to charge consistent prices with its main campus. So fees can be thought as exogenous when opening the new program. From the standpoint of this paper, they are implicitly accounted in the coefficients α_p.

In order to build a new facility, the university has to pay a fixed cost B and a linear component that increases with the size f_i of the facility. So the total cost is $f_i + B$.

For a given facility size f_i and a given student demand $D_p(t_i)$, the university i has a number of enrolled students given by the minimum between the facility size and the student demand:

$$\min\left(f_i, D_p(t_i)\right). \tag{2}$$

This means there cannot be more students enrolled than what the facility can withhold or, if smaller, the number of students interested by the program.

Now, recall that if two campuses are open in the same region, they compete to some degree for the same students. Such degree of competition is measured by $\rho \in [0, 1/2]$. If ρ is equal to zero, there is no competition. Conversely, if $\rho = 1/2$, there is full competition between the two institutions. Hence, when two universities are in the region, the demand is given by:

$$\min\left(f_i, D_p(t_i) - \rho D_{p'}(t_j)\right). \tag{3}$$

There will thus be two types of equilibrium. In the first one, only one university is opened in the region and the second one does not find profitable to open a facility. In such case, enrolment in the open university (assuming it is i) is given by (2). In the second case, there is a symmetric equilibrium where both universities open a facility and demand is given by (3). Since $D_{p'}(0) = 0$ when the campus is not opened, (3) encompasses (2).

When university i decides to open a facility with a program $p \in P$ and a given facility size, it can generate additional profits given by:

$$\begin{aligned}\Pi_i(f_i, t_i, p, f_j, t_j, p') \equiv \quad & \underbrace{\alpha_p \left[\min(f_i, D_p(t_i) - \rho D_{p'}(t_j))\right]}_{\text{Income from enrolment in } i} \dots \\ & \dots + \underbrace{\beta_{p'} \left[\min(f_j, D_{p'}(t_j) - \rho D_p(t_i))\right]}_{\text{Income from enrolment in } j} \dots \\ & \dots - \underbrace{t_i \left[\min(f_i, D_p(t_i) - \rho D_{p'}(t_j))\right]}_{\text{Cost of teaching quality in } i} \dots \\ & \dots + T_i - \underbrace{(f_i + B)}_{\text{Cost of building facility } i}\end{aligned} \tag{4}$$

where p' is the program chosen in the competing facility j.

The first component measures the additional income generated by enrolment in facility i. It is the amount given per student α_p multiplied by the number of students who go in such program. The second component measures the income based on the facility built by the competing university j. The third term measures the cost of teaching quality. Since the university commits to a quality level t_i in the new program, the university cover the costs of t_i for every student. The last component measures the additional income from lump-sum transfers and the costs of building the facility of size f_i.

By opening a new facility, the university seeks to maximize Π_i. The following proposition characterizes the two equilibria.

Proposition 2. *Let universities maximize the profits (4) and assume a funding rule as in (1). Then:*

1. *A symmetric Nash equilibrium where i and j both open a facility happens if for some $\alpha_{p^{2*}}, \beta_{p^{2*}}$ if profits are positive for both universities:*

$$(\alpha_{p^{2*}} + \beta_{p^{2*}} - t_i^{2*} - 1)(1-\rho)D_{p^{2*}}(t_i^{2*}) + T_i > B,$$

   where $f_i^{2*}(\alpha_{p^{2*}}, \beta_{p^{2*}}), t_i^{2*}(\alpha_{p^{2*}}, \beta_{p^{2*}}), p^{2*}$ are the optimal choices of each university. In such case:

   (a) The facility size equals demand ($f_i^{2*} = (1-\rho)D_{p^{2*}}(t_i^{2*})$);

   (b) The quality of teaching increases with the direct component of the funding rule and decreases with the indirect component. Likewise, the size of the facility increases in $\alpha_{p^{2*}}$ and decreases in $\beta_{p^{2*}}$.

2. *There exists two asymmetric Nash equilibria where a single facility is opened with solution $f_i^*(\alpha_{p^*}, \beta_{p^*}), t_i^*(\alpha_{p^*}, \beta_{p^*}), p^*$ if profits are positive for one university:*

$$(\alpha_{p^*} - t_i^* - 1)D_{p^*}(t_i^*) + T_i > B, \tag{5}$$

but not for two:

$$(\alpha_{p^{2*}} + \beta_{p^{2*}} - t_i^{2*} - 1)(1-\rho)D_{p^{2*}}(t_i^{2*}) + T_i < B. \tag{6}$$

In such case:

(a) The facility size equals demand ($f_i^* = D_{p^*}(t_i^*)$);

(b) The quality of teaching and the size of the facility increase with the direct component of the funding rule while the indirect component has no influence.

Proof. See Appendix A.2 □

These results show the nature of the two possible types of equilibria. In the first one, both universities open a facility and this happens if it generates some additional funds for both. In particular, this is always the case if the marginal income is greater than the marginal cost ($\alpha_p + \beta_p > 1$) and if there are no fixed costs to such construction ($B = 0$) attached. Universities will select the program that yields the highest profits, as measured by the term $(\alpha_p + \beta_p - t_i - 1)f_i^{2*}$.

In such equilibrium, both channels of the funding rule (direct and indirect) have an impact on the decision of universities. Increasing α_p increases both the quality of teaching and thus, demand. Increasing β_p as the opposite effect. One can thus see how the government can play with those channels to influence the behaviour of universities. Intuitively, increasing β_p increases the penalty that the university incurs by stealing students from the other university while increasing α_p increases the reward of recruitment, whether there is competition or not.

In this equilibrium, there can be a social loss. Because two university enters the market, it becomes harder to recruit students for each university. Each must thus spend more to recruit. If this spending is too high, it would be efficient to have only one facility. These is explored in details in the next sections.

In the second equilibrium, only one university opens a facility. This is so because the funding rule or the region cannot support positive profits if two facilities are opened. In such case, one of the two universities does not enter the market. Again, this might not be socially efficient. Two universities might allow to enroll more students, even if it is not profitable to compete.

When there is only one university, only the first component of the funding rule has an impact on the behaviour of the university since the indirect component is multiplied by zero. There is no competition. The expense in the facility and the quality of teaching increases with the direct funding component (α_p).

Notice also that the size of the facility is a measure of quality. In laymen's terms, "the bigger, the better". This means that an increase in the direct funding component (α_p) will increase both the quality of teaching in the new facility and the size of the facility.

The following proposition describes what happens to these optimal solutions when the degree of competition (ρ) increases:

Proposition 3. *Let the university problem be as decribed by (4) and assume a symmetric equilibria. Then:*

1. *If per-student profits generated solely from the direct component of enrolment in the facility are greater than the per-student income generated by the indirect component, the quality in the new facility increases with the degree of competition:*

$$\alpha_{p^{2*}} - t_i^{2*} - 1 > \beta_{p^{2*}} \Rightarrow \frac{\partial t_i^{2*}}{\partial \rho} > 0$$

   Conversely, if the per-student income from students in the competing facility is greater than net profits, the degree of competition reduces teaching quality.

2. *Such results also apply to the size of the facility as there is a one to one relationship between size and teaching quality.*

3. *In particular, under a standard funding scheme ($\beta_p = 0\ \forall p$), the quality always increases with the degree of competition.*

Proof. See Appendix A.3. □

This proposition shows how the indirect component affects quality and the size of the facility. If per-student profits from the facility are greater than the loss of income from the competing facility, the university will still compete by increasing teaching quality. In such case, it is worthwhile to steal students from the other facility. When the income per-student of the other facility is greater, the university finds it worthwhile to attract less students in its own new facility.

Notice that such result does not depend on the value of $\alpha_{p^{2*}}$ and $\beta_{p^{2*}}$ by themselves, but rather their relative difference.

One can see right away that if $\beta_p = 0\ \forall p$, as in a standard funding rule, the competition necessarily increases quality. Since the losses incurred in the other institution is not taken into account, this might lead to an inefficiency. In the next section, I show when this is the case.

3.4 An Optimal Centralized Recruitment Policy

In this section, I abandon the decentralized framework and assume the government can implement the decision to build facilities or not. I thus derive the government's preferred strategy if it had the power to make universities' decisions. The government seeks to maximize the welfare of individuals going to university in the region. It has a fixed amount G available to achieve such goal. If it decides to open two facilities in the region, it seeks to solve:

$$\begin{aligned}
\max_{t_i,p}\ & 2(1-\rho)\int_{\tau_p(t_i)}^{1}(V_p(t_i\tilde{\tau})-C_p)dF(\tilde{\tau}) \\
\text{s.t. } & G \geq 2\left(t_i(1-\rho)\left[F(1)-F(\tau_p(t_i))\right]+B+f_i\right) \\
& f_i=(1-\rho)\left[F(1)-F(\tau_p(t_i))\right]
\end{aligned} \tag{7}$$

If there is only one facility, the program is however:

$$\begin{aligned}
\max_{t_i,p}\ & \int_{\tau_p(t_i)}^{1}(V_p(t_i\tilde{\tau})-C_p)dF(\tilde{\tau}) \\
\text{s.t. } & G \geq t_i\left[F(1)-F(\tau_p(t_i))\right]+B+f_i \\
& f_i=F(1)-F(\tau_p(t_i))
\end{aligned} \tag{8}$$

The two problems are almost similar, saved for the budget constraint, which depends on the number of facilities built. The following proposition characterizes under which circumstances two competing facilities is better than one.

Proposition 4. *Consider the government problem of building one or two facilities as in (7) and (8). Then, it will build only one facility if the share of the fixed costs for building a facility is greater than the ratio of students unexposed to competition to those exposed to competition:*

$$\frac{B}{G} \geq \frac{1-2\rho}{2\rho}.$$

Proof. It is sufficient to notice that the two budgets constraints, taking into account the technology constraint, can be re-written in the following fashion:

$$\frac{G}{2(1-\rho)}-\frac{B}{1-\rho} \geq (t_i+1)\left[F(1)-F(\tau_p(t_i))\right] \qquad \text{(two facilities)}$$

$$G-B \geq (t_i+1)\left[F(1)-F(\tau_p(t_i))\right] \qquad \text{(one facility)}$$

Building one facility thus yields more income per student if

$$G-B > \frac{G}{2(1-\rho)}-\frac{B}{1-\rho},$$

which leads to the desired result. □

The ratio $\frac{1-2\rho}{2\rho}$ can be easily understood with figure 1. It is a measure of (the inverse of) "fixed costs" of competition. If competition is too costly (e.g. if the right hand side is too low), then the government prefers to open only one facility to save the extra fixed cost of a facility. In such case, competition is inefficient as it costs too much of public funds.

Let $\left(f_1^{opt}, t_1^{opt}, p_1^{opt}\right), \left(f_2^{opt}, t_2^{opt}, p_2^{opt}\right)$ be the solution to the problem of the government where there is respectively one or two facilities required. Such solution is what the government is trying to implement given a decentralized policy.

3.5 An Optimal Decentralized Policy

In this section, I return to the original problem, where universities have control over how to allocate funding between programs, and show that there is an optimal policy that can achieve the first-best outcome. I still assume that the government wishes to spend G on universities, but instead lets universities make their own decisions given the government's choice of $T_i, T_j, \alpha_p, \beta_p$.

The next proposition is a simple corollary of the equilibrium analysis in proposition 2:

Corrolary 1. *A funding rule composed only of transfers and a direct component (e.g.: $\beta_p = 0\ \forall p$) cannot always achieve the social optimum.*

A trivial case is when there is full competition between the two universities ($\rho = 1/2$). In such case, it is better to let one university build a facility. However, if fixed costs are small enough, both universities will engage in competition.

Another trivial case is when the two universities do not compete at all ($\rho = 0$). The symmetric equilibrium is then the social optimal, but if the fixed costs are too high, both universities might not receive the right incentives solely through the direct component.

This shows that a funding rule that solely depends on direct enrolment and transfers cannot refrain universities to compete even if that would not be socially optimal from a social point of view. In both cases, the government has only two instruments to satisfy three constraints. He must thus let go one of its objectives: either budget balance, the optimal facility size, or let go incentives for universities to compete.

The next proposition shows that a funding rule with an indirect component can achieve the first best.

Proposition 5. *A funding rule with transfers, a direct and an indirect facility reaches the first best:*

1. *If the social optimum is to build one facility, one efficient rule solves:*

$$
\begin{aligned}
f_i^*(\alpha_p^{opt}, 0) &= f_1^{opt} \textit{ for } p = p_1^{opt}, \\
\alpha_p^{opt} &= 0 \ \forall p \neq p_1^{opt}, \\
\alpha_p^{opt} + \beta_p^{opt} &= 0 \ \forall p \\
T_i^{opt} &= \alpha_p^{opt} f_1^{opt} - G \textit{ for } p = p_1^{opt}.
\end{aligned}
$$

2. *If the social optimum is to build two facilities, one efficient rule solves:*

$$
\begin{aligned}
f_i^*(\alpha_p^{opt}, \beta_p^{opt}) &= f_2^{opt} \textit{ for } p = p_2^{opt} \\
\alpha_p^{opt} + \beta_p^{opt} &> \frac{B}{f_2^{opt}} + 1 + t_2^{opt} \textit{ for } p = p_2^{opt}, \\
\alpha_p^{opt} + \beta_p^{opt} &= 0 \ \forall p \neq p^{opt} \\
T_i^{opt} &= (\alpha_p^{opt} + \beta_p^{opt}) f_2^{opt} - \frac{G}{2} \textit{ for } p = p_2^{opt}.
\end{aligned}
$$

Proof. See appendix A.4 □

This show that there exists at least one solution that reaches the first best outcome, whatever that first best is. Compared to the current funding scheme, the third channel β_p acts either as a penalty if the optimal choice is to open only one facility, or as an additional incentive to engage in competition if required.

This proposition and corollary (1) show that in general, a policy with solely lump-sum transfers and a direct component can lead to an inefficient allocation of quality and facility size. In particular, if two facilities are opened while there should be one, there is overspending. This means that for a given level of government spending, quality can be increased by introducing a component on β_{p^*} to correct for the decision to open a second facility while increasing α_p to increase quality. This mechanism works since income from the third channel is viewed as exogenous from the perspective of the university. Hence, with a new parameter in the funding policy, the government is able to increase quality and correct the inefficiency (if any).

4 Quality and Income

In the previous discussion, it is assumed that the goal of a university in establishing an off-campus facility is to maximize profits from the facility to fund some other activities (like research). In this section, I assume instead that they seek to strike a balance between quality of teaching and profits generated through a strictly concave utility function U. By doing so, the university still wants to extract some profits out of the facility, but also fosters quality of teaching as a goal in itself (rather than seeing as a tool to extract profits). The goal of the university is thus:

$$\max_{t_i,p} \quad U\left(t_i, \Pi(f_i, t_i, p, f_j, t_j, p')\right), \tag{9}$$
$$\text{s.t.} f_i = \begin{cases} (1-\rho)\left[F(1) - F(\tau_p(t_i))\right], & \text{If two facilities} \\ \left[F(1) - F(\tau_p(t_i))\right], & \text{If one facility} \end{cases}$$

One can then show the following proposition:

Proposition 6. *Assume universities behave according to (9). Then there exists an optimal decentralized solution $T_i^{opt}, \alpha_p^{opt}, \beta_p^{opt}$ that matches the first best outcome.*

This proposition summarizes the idea that regardless the university's objective, the government can reach budget balance and the optimal outcome through a decentralized scheme as long as there are enough parameters in the funding rule.

5 Conclusion

The previous analysis provides a few insights about university funding policies. It studies the decision of a university to open a new campus given an enrolment based funding policy. It shows that such policy gives incentive for universities to do so, even such decision might not be efficient.

A government that cares about the quality of teaching and research cannot simply provide funding based on a linear function of the students enrolled in each establishment. If universities compete for the same students, such a policy increases spending in recruitment while it may not be socially efficient. This is so when the "cost of competition", namely the additional cost to recruit students in the presence of a competitor, is too high. To avoid such effect, the government can introduce a funding channel that depends on the number of students in a competing university. By doing so, the government can increase the efficiency of universities while spending the same amount.

Such new component of the funding rule acts as a penalty, or a tax, when two universities compete for the same students. An efficient policy thus implement such penalty when competition costs too much in taxpayers dollars. The policy can then be used to keep the desirable effects of competition (fostering quality) by increasing the component that depends on enrolled students, but by penalizing universities who enter the market when it is not efficient. It can thus increase funds available for academic activities.

A Proof of various propositions

A.1 Proposition 1

Proof. 1. A student wit talent τ will go to university if $V_p(\tau t_i) > C_p$ and since V is strictly increasing, this is equivalent to :

$$\tau > \frac{V_p^{-1}(C_p)}{t_i}$$

hence, there exists a value of $\tau_p(t_i) = \frac{V_p^{-1}(C_p)}{t_i}$ that is decreasing with quality. Such number represents the marginal student indifferent between going to university or not.

2. By the definition of $\tau_p(t_i)$, we have that:

$$V_p(t_i \tau_p(t_i)) = C_p$$

The differentiation of such expression with respect to t_i yields:

$$\frac{\partial \tau_p(t_i)}{\partial t_i} = -\frac{\tau_p(t_i)}{t_i} < 0.$$

□

A.2 Proposition 2

Proof. As a shorthand, I denote $D_p^{''}, D_p^{'}$ for the second and first derivatives of D_p with respect to t_i.

1. For any p, t_i, the min operator implies that :

$$f_i = D_p(t_i) - \rho D_{p'}(t_j)$$

and by symmetry, $D_p(t_i) = D_{p'}(t_j)$. Thus:

$$f_i = (1-\rho)D_p(t_i) \tag{10}$$

at the optimum. For this equilibrium to be sustainable, it must be that both universities generate profits. That is:

$$\Pi(f_i^{2*}, t_i^{2*}, p^{2*}, f_i^{2*}, t_i^{2*}, p^{2*}) > 0,$$
$$\Leftrightarrow (\alpha_{p^{2*}} + \beta_{p^{2*}} - t_i^{2*} - 1)(1-\rho)D_{p^{2*}}(t_i^{2*}) + T_i > B$$

2. If there is only one university opened, for any p, the min operator implies :

$$f_i = D_p(t_i)$$

at the optimum. For this equilibrium to be sustainable, it must be profitable that one university opens a facility:

$$\Pi(f_i^*, t_i^*, p^*, 0, 0, p) > 0,$$
$$\Leftrightarrow (\alpha_p - t_i^* - 1)D_p(t_i^*) + T_i > B.$$

However, it must not be profitable for two universities to compete:

$$(\alpha_p + \beta_p - t_i^* - 1)(1-\rho)D_p(t_i^*) + T_i < B.$$

3. I focus on the first order condition in the case of the symmetric equilibrium. The results for the other equilibria can be found by setting $\rho = 0$ as it is equivalent of not having any competing facility in the region. Since $\tau_p(t_i)$ is strictly decreasing in t_i and that the density F is strictly decreasing in τ, there is a unique solution to equation (10). It can be thus replaced in (4), which yields:

$$\Pi_i(t_i, f_i, p, t_j, f_j, p') = (\alpha_p - t_i - 1)(D_p(t_i) - \rho D_{p'}(t_j)) + \beta_p(D_{p'}(t_j) - \rho D_p(t_i)).$$

The first order condition then satisfies:

$$(\alpha_p - t_i - 1 - \beta_p\rho)D_p'(t_i) = D_p(t_i) - \rho D_{p'}(t_j). \tag{11}$$

which defines a unique $t_i^*(\alpha_p, \beta_p, p, t_j, p')$. Since this is a maximum, the second order condition is negative at the optimum:

$$0 > (\alpha_p - t_i^* - 1 - \beta_p\rho)D''(t_i^*) - 2D'(t_i^*). \tag{12}$$

Imposing symmetry, one gets:

$$(\alpha_p - t_i^* - 1 - \beta_p\rho)D_p'(t_i^*) = (1-\rho)D_p(t_i^*) \tag{13}$$

The derivative of t_i^* with respect to α_p is given by the derivation of the implicit function in (13):

$$0 = 1 + \left[(\alpha_p - t_i^* - 1 - \beta_p\rho)D''(t_i^*) - (2-\rho)D'(t_i^*)\right]\frac{\partial t_i^*}{\partial \alpha_p},$$
$$\Rightarrow \frac{\partial t_i^*}{\partial \alpha_p} = \frac{-1}{(\alpha_p - t_i^* - 1 - \beta_p\rho)D''(t_i^*) - (2-\rho)D'(t_i^*)} > 0.$$

With similar calculations, the derivatives with respect to β_p can be found to be:

$$\frac{\partial t_i^*}{\partial \beta_p} = \frac{\rho}{(\alpha_p - t_i^* - 1 - \beta_p \rho) D''(t_i^*) - (2-\rho) D'(t_i^*)} < 0.$$

By (10), this implies that:

$$\frac{\partial f_i^*}{\partial \alpha_p} = (1-\rho) D_p'(t_i^*) \frac{\partial t_i^*}{\partial \alpha_p} > 0$$
$$\frac{\partial f_i^*}{\partial \beta_p} = (1-\rho) D_p'(t_i^*) \frac{\partial t_i^*}{\partial \beta_p} < 0$$

Now the selection of the program p^* will be the one that maximizes income. Since the set of programs is finite, this p^* exists and the university will open a new facility if the generated income is positive.

□

A.3 Proposition 3

Proof. From equation 13, the implicit function yields the following derivative with respect to ρ:

$$\frac{\partial t_i^{2*}}{\partial \rho} = -\frac{1}{1-\rho} \frac{(\alpha_{p^{2*}} - t_i^{2*} - 1 - \beta_{p^{2*}}) D_p'(t_i^{2*})}{(\alpha_{p^{2*}} - t_i^{2*} - 1 - \rho \beta_{p^{2*}}) D_p''(t_i^{2*}) - (2-\rho) D'(t_i^{2*})}.$$

Now, from equation 10 :

$$\frac{\partial f_i^{2*}}{\partial \rho} = (1-\rho) D_{p^{2*}}'(t_i^{2*}) \frac{\partial t_i^{2*}}{\partial \rho},$$

which completes the proof. □

A.4 Proposition 5

Proof.

1. Since $f_i^*(\alpha_{p_1^{opt}}, 0)$ is strictly increasing in $\alpha_{p_1^{opt}}$, there exists a value $\alpha_{p_1^{opt}}^{opt}$ that reaches the optimal facility size. Now, set $\alpha_{p_1^{opt}} + \beta_{p_1^{opt}} = 0$, so that opening a second university will generate negative profits under competition:

$$(-t_i^{2*} - 1) f_i^{2*}(\alpha_{p_1^{opt}}, \beta_{p_1^{opt}}) < 0 < B \ \forall t_i^{2*} > 0.$$

By setting all other parts of the direct component to zero, the government ensures that only the right program will be opened as they all generate smaller profits.

2. Consider the set of equations:

$$f_i^*(\alpha_{p^{opt}}, \beta_{p^{opt}}) = f_2^{opt}$$
$$\beta_p^{opt} = \underbrace{\frac{B}{f_2^{opt}} + 1 + t_2^{opt} + \epsilon}_{\equiv C} - \alpha_p^{opt} \text{ for } p = p_2^{opt},$$

for some $\epsilon > 0$. By construction, the first equation $f_i^*(\alpha_{p^{opt}}, C - \alpha_{p^{opt}})$ is strictly increasing in $\alpha_{p^{opt}}$ and thus has a solution. It guarantees that the facility chosen is of optimal size. The second equation ensures that the funding rule is incentive compatible for two facilities. Since it satisfies the inequality

$$(\alpha_p^{opt} + \beta_p^{opt} - t_i^*(\alpha_p^{opt}, \beta_p^{opt}) - 1)f_i^* > B.$$

Finally, since all programs except p^{opt} have $\alpha_p + \beta_p = 0$, the only incentive compatible program to open a facility is p^{opt}. The optimal transfer is then set to satisfy the budget constraint.

$\square$

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