Tuition and Wealth at American Colleges

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Abstract

Since 1980 both the level and dispersion of tuition fees at American colleges have increased dramatically. These trends are particularly pronounced among private colleges. This paper contributes to explaining the behavior of tuition fees in private colleges, establishing a link between tuition fees and colleges' wealth with an original matching model of the market for higher education. The main claim is that the performance of the economy after 1980, reflected in the buoyancy of the stock market, has translated into greater wealth across colleges, which has reinforced the positive effect of the steady growth in the returns on college education on tuition fees. The empirical analysis demonstrates the importance of the link between colleges' wealth and tuition fees both in the period 1980-2005 and earlier periods of the twentieth century.

1 Introduction

In the last twenty five years, both the level and the dispersion of tuition fees at American colleges have increased dramatically. In 2005, the average and the standard deviation of tuition fees at four-year colleges were more than double their levels in 1980, in constant dollars. Even though in the same period financial aid has increased in absolute terms, the level and the dispersion of tuition fees after financial aid have followed very similar patterns.

These trends are more pronounced at private colleges. The increase in average tuition at private four-year colleges between 1980 and 2005 is five times the increase in public four-year colleges. In the case of dispersion, the increase in the standard deviation of tuition fees at private four-year colleges in the same period is more than three times the increase in public four-year colleges.

These observations have been the focus of several studies in the economic literature. Among the works that have addressed the increase in the level of tuition fees are Kirshtein et al. (1990), Clotfelter (1996), Hoxby (1997), Ehrenberg (2000) and Vedder (2004). Of those, only Hoxby simultaneously addressed the growth in dispersion.

The purpose of this paper is to contribute to explaining the rapid increase in tuition fees at private four-year colleges after 1980. To do so, this paper develops an original matching model of the higher education market that links tuition fees to colleges' wealth and the returns on college education.

In the model, when the more talented students attend the more expensive colleges, a proportional increment in colleges' wealth leads to increases in tuition fees and can also result in greater dispersion. The reason is that as colleges become wealthier they increase their expenditures in order to improve their position in college rankings. Greater expenditures imply colleges provide education and other services of higher quality. Since the additional quality is valued by students, colleges can increase the tuition fees they charge.

An increment in the returns on college education also generates higher tuition fees and may result in increases in their dispersion. A greater return raises the valuation students place on the expenditures made by colleges and therefore they are willing to pay more to attend a college with a given level of expenditures.

The effects of colleges' wealth on tuition fees are reinforced by increases in the return on college education and vice versa. A greater return raises the valuation students place on the expenditures made by colleges, and greater wealth across colleges makes college education more attractive.

The financial wealth of colleges consists essentially of their endowment. An important fraction of the endowments is kept in stocks. At the same time endowment additions come from gifts, which are particularly responsive to stock prices. Thus the performance of the stock market has an important effect on colleges' wealth.[1]

The main claim of this paper is that the performance of the economy observed after 1980, reflected in the buoyancy of the stock market, has translated into greater wealth across colleges, which in turn has resulted in higher tuition fees. The effect has been reinforced and magnified by the steady growth in the returns on college education in the same period.

The empirical analysis demonstrates the importance of the link between colleges' wealth and tuition fees both in the period 1980-2005 and earlier periods of the twentieth century in which tuition fees have followed similar patterns. It also suggests that the increases in both colleges' wealth and the returns on college education can be the reasons behind the increases in the dispersion of tuition fees.

The structure of the paper is as follows. In section 2, the model of the higher education market is developed and some claims characterizing the equilibrium and the comparative statics are formulated. Sections 3 and 4 present the empirical counterpart of those claims for the periods 1970-2005 and 1900-1968, respectively. Concluding remarks are presented in section 5.

2 The Model

There are several theoretical models of the higher education market in the economic literature. Among the most relevant are those in Rothschild and White (1995), Hoxby (1997), Goethals, Winston and Zimmerman (1999) and Epple, Sieg and Romano (2003). Except for Hoxby, these models focus primarily on how prices are determined when there are spillovers among students in the same college that can be internalized through price discrimination within institutions. In Hoxby, the emphasis is on geographical segmentation of the higher education market and how changes in this segmentation affect prices.

The purpose of the model developed in this paper is to understand the determination of tuition fees across and not within colleges. Therefore no spillovers are assumed to occur between students in the same college. With-

[1] An explanation of how endowments work can be found at Ehrenberg (2000), chapter 2.

out spillovers, the higher education market can be modeled as a one-to-one matching problem. Generally speaking, on one side of the market are students. They differ in talents and want to attend the colleges offering the best combination of quality of education and price. On the other side of the market are colleges. They differ in wealth and want to enroll the students most likely to succeed after they graduate. Tuition fees are the transfers that make the assignment of students to colleges an equilibrium.

The presentation of the model is divided into four parts. The first part describes the student side of the problem. The second part describes the college side. The third part characterizes the equilibrium and the fourth presents the comparative statics analysis. The claims that have an empirical counterpart analyzed in sections 3 or 4 are specifically marked (*Claims 1-7*).

2.1 Students

Students are assumed to differ in talent. Differences in talent are reflected in differences in earning ability. Assume there are n students who could potentially attend college. Students are indexed according to their position in a ranking according to talent. Student i is more talented than student j if $i < j$, for student i is in the i-th position and student j is in the j-th.

The earnings of student i without college education are given by a_i. The earnings of this same student if she attends college are given by $a_i + b_i rx$. The coefficient b_i is understood as the return on college education specific to student i, r is the market return on the skills developed by college education, and x stands for the amount of resources that the college attended spends per student. I assume $a_i \geq 0$, $b_i \geq 0$, $a_i > a_{i+1}$ and $b_i > b_{i+1}$.

If student i attends a college that spends x per student and charges a tuition fee t, his payoff is given by the difference between his earnings and the tuition fee he pays:

$$a_i + b_i rx - t$$

b_i and r are assumed such that $b_i r < 1$ for all i. This assumption implies that if a student had to finance his education with no subsidy whatsoever, he would prefer not to attend college. This is not a central part of the model and it is only a consequence of assuming linear payoffs in x (if $b_i r > 1$ then students would find it optimal to invest as much as they could).

Students are assumed to take a passive role accepting or rejecting offers made by colleges. The offers consist of expenditures per student and tuition fees. Students rank those offers according to the payoff of each of them.

2.2 Colleges

Colleges are assumed to differ in an exogenous source of resources, namely their financial wealth. They are also assumed to maximize their prestige, which in this model is defined as their position in a ranking of colleges according to the earnings of their graduates. Taking as given what other colleges do, maximizing prestige for a college is equivalent to maximizing the earnings of its graduates.

For a given college there are two ways to increase the earnings of its graduates: either selecting more talented students or increasing the students' earnings ability by spending more per student. For simplicity, assume each college enrolls one student and that there are n colleges with strictly positive wealth.

Colleges are indexed according to their position in a ranking of wealth. The wealth of college j is denoted by e_j. Since e_j is ranked in the j-th position and e_k in the k-th, if $j < k$ then college j is wealthier than college k.

The problem for college j is to maximize the earnings of its graduate by making take-it-or-leave-it offers to students, subject to two constraints. First, the budget constraint: expenditures must equal wealth plus tuition revenues. Second, the participation constraint: the student has to accept the offer. This means the offer made by college j has to be better than any other offer made by other colleges to the same student.

2.3 Equilibrium

The equilibrium consists of an assignment of students to colleges and a set of tuition fees charged at each college to the student enrolled, so that no college is interested in making a feasible offer to any other student and that student is willing to accept it.

The assignment of students to colleges can be represented by a one-to-one mapping from the ranking of talent to the ranking of wealth. Under assignment φ student i attends college $\varphi(i)$. Tuition fees at each college can be represented by a mapping from the ranking of wealth to the set of real numbers. Under tuition mapping τ the tuition fees at college j are given by τ_j.

The assignment of students to colleges defined by the mapping φ together with the tuition fees defined by the mapping τ constitute an equilibrium if there is no triplet $(i, j, t) \in \{1, ..., n\} \times \{1, ..., n\} \times \mathbb{R}$ such that:

$$a_i + b_i r[e_{\varphi(i)} + \tau_{\varphi(i)}] - \tau_{\varphi(i)} \leq a_i + b_i r[e_j + t] - t \tag{1}$$
$$a_{\varphi^{-1}(j)} + b_{\varphi^{-1}(j)} r[e_j + \tau_{\varphi^{-1}(j)}] \leq a_i + b_i r[e_j + t]$$

with at least one of the inequalities being strict.

The equilibrium has five properties:

(i) Monotonicity of payoffs. In the case of students, the more talented have greater net earnings (after subtracting tuition fees). In the case of colleges, the graduates from wealthier colleges have greater gross earnings (before subtracting tuition fees). In order to prove these claims assume φ and τ constitute an equilibrium. Suppose the net earnings of students are not increasing in talent. Then there is a pair of students i and j such that i is more talented than j, i.e. $i < j$, and i's payoff is smaller than j's:

$$a_i + b_i r[e_{\varphi(i)} + \tau_{\varphi(i)}] - \tau_{\varphi(i)} < a_j + b_j r[e_{\varphi(j)} + \tau_{\varphi(j)}] - \tau_{\varphi(j)}$$

Thus college $\varphi(j)$ can offer student i enrollment at a tuition fee $\tau_{\varphi(j)}$ and both would be better off. The payoff of student i would be greater than the payoff of student j, which is greater than student i's equilibrium payoff:

$$a_j + b_j r[e_{\varphi(j)} + \tau_{\varphi(j)}] - \tau_{\varphi(j)} < a_i + b_i r[e_{\varphi(j)} + \tau_{\varphi(j)}] - \tau_{\varphi(j)}$$

College $\varphi(j)$ would charge the same fee but enroll a more talented student, and its payoff would exceed its equilibrium payoff:

$$a_j + b_j r[e_{\varphi(j)} + \tau_{\varphi(j)}] < a_i + b_i r[e_{\varphi(j)} + \tau_{\varphi(j)}]$$

The same happens in the case of colleges. Assume the payoff of colleges is not increasing in wealth. Then there is a pair of colleges k and l such that college k is wealthier than l, i.e. $k < l$, and k's graduates have lower gross earnings than l's:

$$a_{\varphi^{-1}(k)} + b_{\varphi^{-1}(k)} r[e_k + \tau_k] < a_{\varphi^{-1}(l)} + b_{\varphi^{-1}(l)} r[e_l + \tau_l]$$

Then college k can offer student $\varphi^{-1}(l)$ enrollment at a tuition fee τ_l and both would be better off. Since college k is wealthier than college l, its payoff would be greater than college l's:

$$a_{\varphi^{-1}(l)} + b_{\varphi^{-1}(l)} r[e_l + \tau_l] < a_{\varphi^{-1}(l)} + b_{\varphi^{-1}(l)} r[e_k + \tau_l]$$

For the same reason, the payoff of student $\varphi^{-1}(l)$ would be greater than what he gets in equilibrium:

$$a_{\varphi^{-1}(l)} + b_{\varphi^{-1}(l)} r[e_l + \tau_l] - \tau_l < a_{\varphi^{-1}(l)} + b_{\varphi^{-1}(l)} r[e_k + \tau_l] - \tau_l$$

Thus if colleges' payoffs are not increasing in wealth and students' payoffs are not increasing in talent, the allocation is not an equilibrium.

(ii) Assortative matching. (Claim 1) In equilibrium the more talented students attend wealthier colleges. Suppose φ and τ constitute an equilibrium in which the most talented student does not attend the wealthiest college. Then $\varphi(1) = l \neq 1$ and $\varphi^{-1}(1) = k \neq 1$. Let t_j^i denote the offer that college j makes to student i such that college j is indifferent with its equilibrium payoff. Then t_j^i can be expressed as:

$$t_j^i = \frac{1}{b_i r}\{a_{\varphi^{-1}(j)} - a_i + re_j[b_{\varphi^{-1}(j)} - b_i] + b_{\varphi^{-1}(j)} r\tau_j\} \tag{2}$$

In particular, the offer of college 1 (the wealthiest) to student 1 (the most talented) is:

$$t_1^1 = \frac{1}{b_1 r}\{a_k - a_1 + re_1[b_k - b_1] + b_k r\tau_1\} \tag{3}$$

If student 1 is not willing to accept this offer it must be that his equilibrium payoff is greater or equal than the payoff he would get. This implies that the tuition fee student 1 pays at college l is bounded above:

$$\tau_l \leq \frac{b_1 r}{1 - b_1 r}[e_l - e_1] + t_1^1 \tag{4}$$

If the tuition fee charged at college l is bounded above, the payoff of college l is also bounded above. Plugging 3 into 4, and the resulting bound into college l's payoff, we get an upper bound for the payoff of college l in equilibrium:

$$a_k + b_k r\tau_1 + b_k re_l - \frac{b_1^2 r^2}{1 - b_1 r}[e_1 - e_l] - r(b_1 - b_k)(e_1 - e_l) \tag{5}$$

However, if college l made an offer to student k leaving him indifferent with what he gets in equilibrium, the payoff of college l would be:

$$a_k + b_k r\tau_1 + b_k re_l - \frac{b_k^2 r^2}{1 - b_k r}[e_1 - e_l] \tag{6}$$

The value in 6 is strictly greater than the value in 5, which yields a contradiction. Therefore, in equilibrium the most talented student attends the wealthiest college.

Once the pair formed by the most talented student and the wealthiest college is removed, the analysis continues in the same fashion for the second most talented student and the second wealthiest college. Proceeding this way the equilibrium has to be assortative.

Under assortative matching one ranking can be used to refer to both colleges and students. Tuition fees at a given college can also be indexed by the ranking of the student's talent.

(iii) Partial extraction of students' surplus. Even though colleges make take-it-or-leave-it offers to students, they do not extract all of the students' surplus. Each college leaves its student indifferent with the offer made to the same student by the college immediately below in the ranking of wealth. The least talented student is left indifferent with not attending college. In order to prove this claim assume φ and τ constitute an equilibrium. By the assortative matching property, $\varphi(i) = i$. From the definition of t_i^k in equation (2) and the property of monotonicity of payoffs:

$$a_k + b_k r[e_i + t_i^k] > a_k + b_k r[e_{i+1} + t_{i+1}^k]$$

This inequality implies $e_i + \tau_i > e_{i+1} + t_{i+1}^k$. Let us compare the offers made by colleges i and $i+1$ to student k versus what they offer to student i. By definition, these offers are such that the payoffs of the colleges are identical to what they get in equilibrium:

$$\begin{aligned} a_i + b_i r[e_i + \tau_i] &= a_k + b_k r[e_i + t_i^k] \\ a_i + b_i r[e_{i+1} + t_{i+1}^i] &= a_k + b_k r[e_{i+1} + t_{i+1}^k] \end{aligned}$$

Consider two cases. First, if $k < i$ (which means we compare the offers made to students of greater talent) then the inequality $e_i + \tau_i > e_{i+1} + t_{i+1}^k$ implies the gain of enrolling a more talented student ceteris paribus is greater for college i and therefore this college is able to offer a greater cut in tuition:

$$\tau_i - t_i^k > t_{i+1}^i - t_{i+1}^k > 0$$

Considering these inequalities together with the equilibrium condition given by:

$$a_i + b_i r[e_i + \tau_i] - \tau_i \geq a_i + b_i r[e_{i+1} + t_{i+1}^i] - t_{i+1}^i$$

the offer made by college i to student k is strictly better than the offer made by college $i+1$:

$$a_k + b_k r[e_i + t_i^k] - t_i^k > a_k + b_k r[e_{i+1} + t_{i+1}^k] - t_{i+1}^k$$

Therefore in equilibrium the offers made by college i to students more talented than i are strictly better than the ones made to the same students by any less wealthy college.

The second case is when $k > i+1$ (which means we compare the offers these colleges make to less talented students). The inequality $e_i + \tau_i > e_{i+1} + t_{i+1}^k$ implies it is more costly to enroll less talented students for college i ceteris paribus, and therefore this college has to increase tuition more than the less wealthy college:

$$0 > t_{i+1}^i - t_{i+1}^k > \tau_i - t_i^k$$

Considering these inequalities together with the equilibrium condition given by:

$$a_{i+1} + b_{i+1} r[e_i + t_i^{i+1}] - t_i^{i+1} \leq a_{i+1} + b_{i+1} r[e_{i+1} + \tau_{i+1}] - \tau_{i+1}$$

the offer made by college $i+1$ to student k is strictly better than the offer made by college i:

$$a_k + b_k r[e_i + t_i^k] - t_i^k < a_k + b_k r[e_{i+1} + t_{i+1}^k] - t_{i+1}^k$$

Therefore the offers made by college $i+1$ to students less talented than student $i+1$ are strictly better than the ones made to the same students by any wealthier college.

In equilibrium the only relevant offers to student k are the offers made by colleges $k+1$ and $k-1$. However, for the most talented student, there is only one relevant offer, the one made by the second wealthiest college. The wealthiest college sets the tuition fee to extract all the surplus with respect to this option. Since in general the two most talented students cannot both be indifferent between the offers of the two wealthiest colleges[2], the second wealthiest college makes the second most talented student indifferent with the offer of the third wealthiest college. The process continues this way until college n makes student n indifferent with no college at all. Other than this student, all have a positive surplus over the non-college option.

[2] This is only possible when $b_1[1 - b_1 r] = b_2[1 - b_2 r]$, which is not generically true.

The properties of assortative matching and surplus extraction with respect to the offer made by the college immediately below in the ranking allow a complete characterization of tuition fees in equilibrium. Only one index is needed because of assortative matching. For colleges $i = 1, 2, ..., n-1$:

$$\tau_i = \frac{b_i r[e_i - e_{i+1}]}{1 - b_i r} + \frac{a_{i+1} - a_i}{b_i r} + \left(\frac{b_{i+1}}{b_i} - 1\right) e_{i+1} + \frac{b_{i+1}}{b_i}\tau_{i+1} \tag{7}$$

and

$$\tau_n = \frac{b_n r e_n}{1 - b_n r} \tag{8}$$

Equation (7) results from the indifference of student i with the offer made by college $i+1$. Equation (8) results from college n making student n indifferent with the outside option. Equations (7) and (8) allow the exploration of the next two properties of the equilibrium.

(iv) Possible non-monotonicity of tuition and expenditures. In equilibrium, tuition and expenditures might not be increasing in talent. According to equation (7), the values of a_i, b_i and e_i do not affect the equilibrium tuition fees at colleges $i+1, i+2, ..., n$. Then take $\tau_{i+1}, \tau_{i+2}, ..., \tau_n$ as given and consider tuition at college i. According to equation (7):

$$\tau_i - \tau_{i+1} = \frac{b_i r[e_i - e_{i+1}]}{1 - b_i r} + \frac{a_{i+1} - a_i}{b_i r} + \left(\frac{b_{i+1}}{b_i} - 1\right)[e_{i+1} + \tau_{i+1}]$$

Thus given e_i and b_i, it is always possible to find a_i such that $a_i > a_{i+1}$ and $\tau_i < \tau_{i+1}$. Additionally, if e_i is picked very similar to e_i (i.e. $e_i \approx e_{i+1}$) then $e_i + \tau_i < e_{i+1} + \tau_{i+1}$. Similarly, given a_i and b_i, it is always possible to find e_i such that $e_i > e_{i+1}$ and $\tau_i > \tau_{i+1}$. Thus tuition fees can be higher or lower at college i than at college $i+1$, regardless of how they are related across colleges $i+1, i+2, ..., n$.

More generally, tuition fees are determined by the relative scarcity of talent and wealth. If students of very similar talents are matched to colleges greatly differing in wealth, the wealthier colleges are able to extract most of the students' surplus through high tuition fees–they face little competition from poorer colleges. In this case tuition would be increasing in talent. If on the contrary, colleges with very similar wealths are matched to students who greatly differ in talents, the more talented students are able to keep most of their surplus through lower tuition fees–they face little competition from the less talented students. In this case tuition would be decreasing in talent.

The relative scarcity can vary across the support of talents and wealth. It is a local concept. Consequently, tuition fees and expenditures (given by wealth plus tuition) can be non-monotone in talent.[3]

(v) Possible rationing. In the model colleges are restricted to enroll one student only. Therefore rationing is not interpreted here as limiting the quantity at a given price. Rather, rationing is understood as not increasing tuition even though a number of students are willing to enroll at its observed level. This is the case when the distribution of b_i is very compressed, or in an extreme case $b_i = b$. In this case the payoff student k would get from attending college i at the observed price is given by:

$$\begin{aligned}[a_k + br(e_i + \tau_i) - \tau_i] &= a_k + bre_i + (br-1)\left[\frac{br[e_i - e_k]}{1-br} + \frac{a_k - a_i}{br} + \tau_k\right] \\ &= a_k + bre_k + (br-1)\left[\frac{a_k - a_i}{br}\right] + (br-1)\tau_k\end{aligned}$$

This payoff can be compared with what student k gets in equilibrium. If $i < k$ then:

$$[a_k + br(e_i + \tau_i) - \tau_i] - [a_k + br(e_k + \tau_k) - \tau_k] =$$

$$= br[e_i - e_k] + (1 - br)\left[\frac{a_i - a_k}{br}\right] > 0$$

The positive gain means if accepted students with lower talents would enroll in the colleges attended by students with greater talents, at the fees they charge. Thus, ceteris paribus the more compressed the distribution of specific returns on education is, the more likely it is to observe this type of rationing.

Partial extraction of students' surplus and the possibility of rationing are two separate properties of the equilibrium. The fraction of the student's surplus that is extracted by a college is not determined by what the college could get from admitting the students queuing up to attend this college (there could be no queue at all). Instead, it is determined by the best offer made by the rest of the colleges to the student.

[3] This result is analogous to Sattinger's (1979) rent splitting principle between firms and workers, but in this model the output is imperfectly transferable. Tuition fees play the role of the transfers.

2.4 Comparative Statics

A. Price externalities

Assume college k experiences a marginal increase in wealth that does not improve its position in the ranking. Equation (7) implies there is no effect on less wealthy colleges. The effect on college k itself is an increase in tuition:

$$\frac{d\tau_k}{de_k} = \frac{b_k r}{1 - b_k r} > 0$$

As the college gets wealthier, it generates a greater surplus to the student. The increase in the surplus is partially extracted by charging higher tuition.

The effect on wealthier colleges comes through prices. For $i < k$:

$$\begin{aligned}\frac{d\tau_i}{de_k} &= \frac{b_k}{b_i}\left[\frac{b_k r}{1 - b_k r}\right] + \frac{b_{k-1}}{b_i}\left[-\frac{b_{k-1} r}{1 - b_{k-1} r} + \frac{b_k}{b_{k-1}} - 1\right] \\ &= \frac{1}{b_i}\left[\left(\frac{b_k^2 r}{1 - b_k r} + b_k\right) - \left(\frac{b_{k-1}^2 r}{1 - b_{k-1} r} + b_{k-1}\right)\right] < 0\end{aligned}$$

When college k gets wealthier, it makes a more attractive offer to student $k-1$. Then college $k-1$ has to reduce tuition to keep its student. Since now the match to student $k-1$ yields a lower payoff to college $k-1$, this college is willing to make an offer to student $k-2$ with a lower tuition fee. Then college $k-2$ has to reduce tuition. The process continues until the wealthiest college is reached. The magnitude of the negative effect on tuition at each college is decreasing in wealth (the effect is the same constant for all colleges divided by b_i).

The price externality depicts the two forces that relate wealth and tuition fees. As colleges get wealthier, they can create greater surplus and extract it by charging higher tuition fees. At the same time, wealthier colleges have more resources to compete more fiercely for students' talents. This pushes tuition fees down.

When considering the effects of wealth increases on average tuition fees, which force dominates depends on the way the increase in wealth takes place. Particularly interesting is the case of a proportional increment. If colleges' wealth is held in an asset denoted by s which has a price p, then college i's wealth is given by $e_i = ps_i$. In this case an increase in p would imply a proportional increase in wealth, which is analyzed below.

B. Proportional increase in wealth

According to equation (7), the effect of a proportional increase in colleges' wealth on the tuition fee at college i is given by:

$$\frac{\partial \tau_i}{\partial p} = \frac{b_i r[s_i - s_{i+1}]}{1 - b_i r} + \left(\frac{b_{i+1}}{b_i} - 1\right) s_{i+1} + \frac{b_{i+1}}{b_i}\frac{\partial \tau_{i+1}}{\partial p} \tag{9}$$

The model is general enough to produce a wide range of comparative statics results that depend on the distributions of talents and wealth. However, only a subset of those distributions is consistent with what is observed in the market for higher education: *(Claim 2) the more talented students pay higher tuition fees.* Restricting the analysis to the distributions of talents and wealth consistent with this observation, I get the following prediction.

(Claim 3) A proportional increase in wealth results in an increment in the tuition fees at every college. If the more talented students pay higher tuition fees, i.e. $\tau_i > \tau_{i+1}$, then:

$$\frac{b_i r[e_i - e_{i+1}]}{1 - b_i r} + \left(\frac{b_{i+1}}{b_i} - 1\right) e_{i+1} > \frac{a_i - a_{i+1}}{b_i r} \geq 0$$

The first inequality comes from equation (7). The second inequality comes from assuming earnings are increasing in talent. Without loss of generality p can be assumed to be one. In this case, the first two terms in the above inequality are equal to the first two terms at the right hand side of equation (9). Then the effect on tuition at college i is equal to a positive fraction of the effect at college $i+1$ plus a positive number. Since the effect at college n (the least wealthy) is positive:

$$\frac{\partial \tau_n}{\partial p} = \frac{b_n r e_n}{1 - b_n r} > 0$$

then the effect of a proportional increase in wealth on tuition fees is positive at every college.

C. Returns on college education

In the case of the general return on college education r, the effect on the tuition fees is given by:

$$\frac{\partial \tau_i}{\partial r} = \frac{b_i[e_i - e_{i+1}]}{(1 - b_i r)^2} + \frac{a_i - a_{i+1}}{b_i r^2} + \frac{b_{i+1}}{b_i}\frac{\partial \tau_{i+1}}{\partial r} \tag{10}$$

The first two terms at the right hand side are positive. The effect at the least wealthy college is:

$$\frac{\partial \tau_n}{\partial r} = \frac{b_n e_n}{(1 - b_n r)^2} > 0$$

Therefore, *(Claim 4) an increment in the general return on college education results in an increase in tuition fees at every college.*

D. Interaction of colleges' wealth and the returns on college education

The interaction between colleges' wealth and the returns on college education is given by the cross derivative:

$$\frac{\partial^2 \tau_i}{\partial r \partial p} = \frac{b_i[s_i - s_{i+1}]}{(1 - b_i r)^2} + \frac{b_{i+1}}{b_i}\frac{\partial^2 \tau_{i+1}}{\partial r \partial p} \tag{11}$$

which is positive because the first term at the right hand side is positive and the cross derivative for the least wealthy college is greater than zero:

$$\frac{\partial^2 \tau_n}{\partial r \partial p} = \frac{b_n s_n}{(1 - b_n r)^2} > 0$$

Therefore, *(Claim 5) a proportional increase in wealth has a greater impact on tuition fees when the returns on college education are higher, and the effect of an increase in the returns is greater when colleges are proportionally wealthier.*

E. Changes in the ranking of colleges

Suppose there is a change in the distribution of colleges' wealth that modifies the ranking of colleges. By the property of assortative matching, *(Claim 6) if a college moves up k positions in the ranking of wealth, then in the new equilibrium it enrolls a student k positions higher in ranking of talent.* Additionally, *(Claim 7) if in equilibrium the more talented students pay higher tuition fees both before and after the change in wealth distribution, then the same college becomes more expensive than k colleges.* In other words, in a ranking according to expensiveness, this college moves up k positions.

The generality of the model allows one to draw specific comparative statics predictions in terms of dispersion of tuition fees if some rather stringent assumptions are made. Some of the assumptions under which the dispersion of tuition fees is positively related to a proportional increase in colleges' wealth and to an increase in the return on college education are presented in Appendix A.

3 Empirical Evidence: 1970-2005

This section is divided into two parts. In the first part I analyze the trends of tuition fees, endowments and the returns on college education in the period 1970-2005. In the second part I present the empirical counterpart of *Claims 1-7* formulated in the previous section. The evidence presented throughout corresponds to private not-for-profit four-year colleges.

3.1 Trends in tuition, endowment and the college premium

Several studies in the economic literature, such as Kirshtein et al. (1990), Clotfelter (1996), Hoxby (1997), Ehrenberg (2000) and Vedder (2004), have documented the rapid increase in tuition fees at American colleges over the last twenty five years. Of these studies, only Hoxby has also pointed out the increase in the dispersion of tuition fees.

Figure 1 shows several percentiles of the distribution of tuition fees for the period 1970-2005, in dollars of 2005, according to the Higher Education General Information Survey (HEGIS) from 1970 to 1978 and Integrated Postsecondary Data System (IPEDS) from 1980 to 2005. Even though the panel is not balanced, using a subsample with such property produces a very similar picture. Between 1970 and 1980 the average and the standard deviation of tuition fees remained roughly at the same level. From 1980 to 2005 they have steadily grown.

The existence of financial aid to students generates a difference between what colleges announce and report as tuition fees and what they actually receive per student. Using the financial data reported in HEGIS and IPEDS I constructed an approximation of average tuition fees after aid by dividing net tuition revenues by total full-time-equivalent enrollment.[4] Figure 2 shows several percentiles of the distribution of this measure in dollars of 2005. As before, the panel is not balanced but using a balanced subsample does not change the picture. The patterns of tuition and net tuition revenues per student are very similar.

According to the model presented in the previous section, one of the determinants of tuition fees is colleges' wealth. Figure 3 shows several per-

[4]The criterion to compute full-time-equivalet enrollment is using a weight of .33 on part time enrollment.

centiles of the distribution of endowment (at market value) per full-time-equivalent student in private not-for-profit four-year colleges for the period 1969-2005, in dollars of 2005. The data on endowment come from Voluntary Support to Education (VSE) and the data on enrollment from HEGIS and IPEDS. There is a difference in the trends before and after 1980. It should also be noticed that the percentiles shown move in a parallel way, which means the changes in endowment per student have been proportional in the aggregate.

The increases in endowments are the result of increments in the value of the assets in which they are held and additions coming from gifts. An important fraction of the endowment is held in stocks, therefore its value is positively related to the stock prices. At the same time, giving to higher education seems to be very responsive to the stock prices. Appendix B presents a simple model and some evidence of the connection between endowments, gifts and the stock prices.

Another determinant of tuition fees according to the theoretical model is the return on college education. Figure 4 presents the college premium according to the Current Population Survey. The sample includes white males working at least 50 weeks last year and at least 35 hours a week in the previous week, ages 25 to 60. The premium was computed as the ratio of the net present value of college graduates' earnings to the net present value of highschool graduates' earnings. To compute the net present value of earnings I used synthetic age-earnings profiles for each year and a discount rate of 5%.[5]

The college premium decreased slightly during the seventies and started increasing in the early eighties. This pattern has been documented by Katz and Murphy (1992) and other subsequent studies.

3.2 Regression Analysis

Based on the evidence for the period 1970-2005, the empirical counterpart of *Claims 1-7* is presented below.

Claim 1. In equilibrium the more talented students attend wealthier colleges

To support this claim I use SAT scores as a measure of students' talent and endowment per student as a measure of colleges' wealth. SAT scores come from IPEDS. Each college reports the 25th and 75th percentiles of verbal

[5] The college premium usually refers to the ratio of wages minus one. Here I refer to the ratio of discounted lifetime earnings without substracting one.

and quantitative SAT scores of its student body. The sample consists of over 440 colleges, depending on the availability of each variable.

Table 1 shows the correlation coefficients between these measures of talent and wealth. The coefficients are positive and significant. The lowest correlation coefficient between endowment per student and SAT scores is .59. If instead of the level of endowment per student, the logarithm is considered, the positive correlation is even stronger. The lowest correlation coefficient is .72.

Claim 2. The more talented students pay higher tuition fees

Table 2 shows the correlation coefficients of tuition fees, SAT scores and endowment per student. As before, the sample includes over 440 colleges (the exact number varies depending on the number of reports of each variable). The correlation between tuition fees before any aid and SAT scores is positive and significant. The lowest coefficient is .68. In the case of the average tuition after aid (net tuition revenues per student), the coefficients are lower but also positive and significant. The lowest coefficient is .56.

Table 2 also shows the correlation coefficients of tuition and wealth. Even though they are also positive and significant, though lower. The correlation between the logarithm of endowment per student and tuition before aid is .58. The correlation between the logarithm of endowment per student and net tuition revenue per student is .42.

Claim 3. A proportional increase in wealth results in an increment in the tuition fees at every college

Table 3 shows the results of regressing tuition fees on the logarithm of endowment per student, including other regressors, in the period 1970-2005. The logarithm was used because of goodness of fit. Population in college age comes from Census Bureau yearly estimates for the population 18 to 22 years old. It is included to capture aggregate demand shifts coming from demographic changes. Average faculty wages are reported by the National Center for Education Statistics, and they intend to capture the cost of one of the main inputs at colleges. Enrollment in each college comes from HEGIS and IPEDS, and it allows to account for increasing or decreasing marginal costs in the size of the student body. There are two dummy variables corresponding to the periods where major financial aid program were introduced: Pell Grants in 1973, and Stafford unsubsidized loans in 1993.[6]

[6] Stafford subsidized loans were established in 1966 and PLUS loans in 1981. However PLUS loans' magnitude makes them much less important.

Column A shows the OLS estimates. Column B includes fixed college effects, which capture differences in colleges that are time invariant, such as the proximity to a city or the weather condition of a college. Column C reports the average coefficient when an OLS regression is run for each college with the same regressors. The standard deviation of the resulting estimates is reported in parentheses and the R-square is the square of the correlation between predicted and observed values. This last column shows the heterogeneity in the responsiveness of tuition fees to the regressors.

One concern in the estimation is the possibility of endogeneity of the endowment. For instance, if tuition worked as a signal of commitment of a college to quality, then if donors prefer giving to institutions of higher quality, an increase in tuition fees could imply more giving and higher endowment. To avoid such potential problem, the last three columns in Table 3 use the logarithm of the Dow Jones index (contemporary plus nine lags) as an instrumental variable. Columns D and E show the estimates without and with college fixed effects, respectively. Column F reports average coefficients when an IV regression is run for each college. As before, the standard deviation of the resulting estimates is reported in parentheses and the R-square is the square of the correlation between predicted and observed values. Columns C and F include fewer observations because the colleges with less than twelve observations were dropped.

The effect of the (logarithm of) endowment per student on tuition is positive and significant in the OLS regressions and even greater in when the Dow Jones is used as an IV. The results in columns C and F also show how the response is heterogenous across colleges.

Table 4 is analogous to Table 3, but the dependent variable is net tuition revenues per student. The magnitude of the coefficients is smaller, but they are positive and significant.

Claim 4. An increment in the general return on college education results in an increase in tuition fees at every college

Tables 5 and 6 show the results of including the college premium in the previous regressions. Its effect is positive and significant in both cases. Columns C and F show the coefficient varies across colleges in an important way. Using IV increases the coefficient on the logarithm of endowment and reduces the coefficient on the premium.

Claim 5. A proportional increase in wealth has a greater impact on tuition fees when the returns on college education are higher, and the effect of an increase in the returns is greater when colleges are proportionally wealthier

Tables 7 and 8 are similar to the preceding tables, but the effects of the logarithm of endowment per student and the college premium are summarized in their product. In this specification the coefficient on the interaction has a direct interpretation. The effect of an increase in the logarithm of the endowment per student is equal to the coefficient on the interaction times the college premium. At the same time, the effect of an increase in the college premium on the tuition charged at a given college is the same coefficient times the logarithm of the endowment per student at that college. The coefficients are positive and significant.

Claim 6. If a college moves up k positions in the ranking of wealth, then in the new equilibrium it enrolls a student k positions higher in ranking of talent

To test this claim I constructed two samples of colleges. One consists of the colleges for which data on both endowment and verbal SAT scores are available for 1981 and 2004. The other sample consists of the colleges for which data on both endowment and ACT scores are available for 1981 and 2004.

The data on endowments come from VSE. For 1981, the data on scores were hand-entered from Barron's (1982), and they are median scores at each institution. For 2004, the data come from IPEDS and they correspond to the 75th percentile at each institution.

For each sample two rankings of colleges were constructed, one for 1981 and another for 2004, using the fitted values of a regression of endowment per student on the Dow Jones index, contemporaneous and nine lags, for each college. Also, for each sample, two rankings of talents were constructed using the scores for 1981 and 2004.

In order to make the interpretation of the results easier, all rankings were transformed into percentiles: if a college is at the 1st (100th) percentile, it is at the bottom (top) of the ranking of wealth.

The first column in Table 9 presents the results of regressing the change in score percentile between 1981 and 2004 on the change in the percentile of predicted endowment per student between 1981 and 2004, using the verbal SAT sample. The second column shows the results using the ACT sample instead. The coefficients are positive though not significant.

The last two columns show the results using the scores in points in 2004 as the dependent variable and including the scores in 1981 as a control, for each of the two samples. The coefficients are positive and significant. According to the estimates, if a college went from the 25th percentile of endowment per student to the 75th, the 75th percentile of verbal SAT scores would increase by 17 points, and the 75th percentile of ACT scores by one point.

Claim 7. If in equilibrium the more talented students pay higher tuition fees both before and after the change in wealth distribution, then if a college moves up k positions in the ranking of wealth it becomes more expensive than k colleges

Following a similar process as in the empirical analysis of *Claim 6*, two samples were created. One includes the colleges for which data on endowment and tuition are available for 1980 and 2004. The other sample includes colleges for which data on endowment and net tuition revenues per student are available for 1980 and 2004. The data on tuition and tuition revenues come from IPEDS.

In the case of the rankings of colleges, as before I used fitted values. For each of the samples, two rankings of tuition or net tuition revenues were created, one for 1980 and another two for 2004. The rankings were transformed into percentiles.

The first column in Table 10 presents the results of regressing the change in tuition percentile on the change in the percentile of predicted endowment per student. The second column shows the results using the change in the percentile of net revenue per student. The coefficients are positive and significant. According to the estimates, if a college went from the 25th percentile of endowment per student to the 75th, tuition before aid would increase 8 percentiles and tuition after aid 5 percentiles.

The last two columns show the results using the level of tuition or net tuition revenues per student in 2004 as the dependent variable and including the level in 1980 (in dollars of 2004) as a control. According to the estimates, if a college went from the 25th percentile of endowment per student to the 75th, it would experience an increase of 2,000 in tuition and of 1,300 in net tuition revenues per student, both in dollars of 2004.

4 Empirical Evidence: 1900-1968

Most of the analysis of tuition fees at American colleges refers to the recent episode of sustained increases, 1980-2005. This section presents evidence of other periods of rampant tuition fees during the twentieth century that provide additional support for the link between tuition fees and colleges' wealth established in the theoretical model.

I use a hand-entered data set of tuition and endowment at book value for one hundred private not-for-profit four-year colleges for the period 1900-1968.[7] The years included are: 1900-1912 every other year, 1916-1922 every other year, 1928, 1933, 1936, 1940, 1948-1968 every four years. The data come from several sources: the Annual Report of the Commissioner of Education and the Biennial Survey of Education, both of the Department of Education, the College Blue Book, and American Universities and Colleges.

4.1 Trends in tuition, endowment and the college premium

Figure 5 shows several percentiles of tuition fees for this sample for the period 1900-1968, in dollars of 2005[8], together with the years 1970-2005 (from HEGIS and IPEDS). After a period of stability in the first two decades of the century, average tuition rose 86% in real terms between 1923 and 1933 (an annual average rate of 6.4%). From the mid thirties to the mid fifties it was stable again. Then, it rose 182% between 1952 and 1970 (an annual average rate of 5.9%). Then average tuition was stable during the seventies, and between 1980 and 2005 it rose 142% (an annual average rate of 3.6%).

In terms of dispersion, the periods when the inter quartile difference of tuition fees has increased coincide with the periods in which average tuition has risen. However, in the periods when average tuition has remained relatively flat, the inter quartile difference has decreased.

Based on this evidence the rapid increase in the level and dispersion of tuition fees observed after 1980 does not seem unprecedented. On the contrary, there have been other two episodes of rampant tuition fees and increasing dispersion that can be analyzed in the light of the model presented above.

Figure 6 shows several percentiles of endowment (at book value) in dollars of 2005 in logarithmic scale. The endowments of the colleges in this sample grew at roughly similar rates after 1910. As seen in Appendix B, behind these patterns seems to be the performance of the stock market.

Figure 7 shows median tuition and median endowment (at book value) in dollars of 2005. The episodes of increasing value of median endowment coincide with the periods of increasing median tuition.

In terms of the dispersion, in the periods when the dispersion of endowments has increased, the dispersion of tuition fees has also increased. Figure

[7] The list of these one hundred colleges is available upon request.

[8] The index used to deflate the series is published by the Federal Reserve Bank of Minneapolis, and is available at:
http://minneapolisfed.org/research/data/us/calc/hist1800.cfm

8 shows the inter quartile differences for tuition fees and endowments. The relation seems positive.

The other determinant of tuition fees laid out in the model is the return on college education. Unfortunately, the information is very limited when it comes to computing an indicator of this return, such as the college premium, for the years prior to 1960. Figure 9 shows decennial estimates of the college premium using Census data, from 1939 to 1999 and the same definition used in the previous section with the CPS. The college premium seems to have decreased in the forties, and grown during the fifties and sixties. Then it decreased again during the seventies, and after 1980 started increasing. These general trends seem compatible with what happened to tuition fees in this period in the light of the theoretical model: periods of increasing returns are associated with periods of increasing tuition fees.

4.2 Regression Analysis

Because of data limitations for this period, only *Claims 3-5* can be addressed in this section.

Claim 3. A proportional increase in wealth results in an increment in the tuition fees at every college

Table 11 presents the results of regressing tuition fees on the logarithm of endowment. For the period 1900-1968 I used the endowment at book value and for the period 1970-2005, the market value, scaled down to match the book value at each college.[9] Column A shows the OLS estimates and column B includes college fixed college. Column C reports the summary of the coefficients when an OLS regression is run for each college. The standard deviation of the resulting estimates is reported in parentheses and the R-square is the square of the correlation between predicted and observed values. Columns D, E and F are analogous to A, B and C but the logarithm of the Dow Jones index (contemporary plus nine lags) are used as instrumental variables.

The coefficients on the logarithm of endowment are positive and significant. Even in the case of columns C and F, where one regression is run for each college, the average coefficient is twice the standard deviation of the coefficients.

[9] I used the years 1956, 1960, 1964 and 1968, when both market and book value of endowment are reported, to find a matching scale for each college.

Claim 4. An increment in the general return on college education results in an increase in tuition fees at every college

Since the college premium is only available for the Census years before 1961, I used a subsample of the years in which tuition and endowment are available, matching the Census years, 1939 to 1999. If tuition and endowment data were not available for a Census year, the closest year available was used. The number of observations for each of the one hundred colleges is seven.

Table 12 shows the results. The effect of the college premium is positive and significant. However, it makes the coefficient on the logarithm of endowment not significant or even negative.

Claim 5. A proportional increase in wealth has a greater impact on tuition fees when the returns on college education are higher, and the effect of an increase in the returns is greater when colleges are proportionally wealthier

Table 13 shows the results using the product of endowment and the college premium as the only regressor. The effect is positive and significant. The fit is slightly worse than in the previous specification but the heterogeneity of the coefficients in columns C and F is much smaller. The average of the coefficients is three times the standard deviation.

5 Concluding Remarks

The theoretical model developed in this paper established an original link between colleges' wealth and the tuition fees they charge in a market setting. According to the model, if in equilibrium the more talented students attend more expensive colleges, then a proportional increase in colleges' wealth generates an increase in tuition fees at every college. The effect of an increase in the returns on college education on tuition fees is also positive at every college. The interaction of an increase the returns on college education with a proportional increase in wealth is positive: it reinforces the increase in tuition fees.

Regarding the link between wealth and tuition fees, the key feature of the model is that as colleges get wealthier they are able to provide educational services of higher quality and therefore they can charge higher tuition fees to students. In a detailed case study Clotfelter (1996) analyzes the causes of increases in expenditures in four colleges (Harvard, Duke, Chicago and Carleton) between the early eighties and the early nineties. In his words, "perhaps the most important conclusion that arises from the scrutiny of spending increases ... is that a large portion of increases simply cannot be attributed easily to any identifiable cause. Such widespread expenditure growth is consistent with across-the-board commitments to quality improvement and service enhancement" (p. 251).

The evidence analyzed supports the hypothesis of the changes in colleges' wealth and the returns on college education driving an important fraction of the increases in the level and dispersion of tuition fees at private not-for-profit four-year colleges both in the 1980-2005 and earlier periods of the twentieth century.

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Appendix A. Predictions about dispersion

A.1. Proportional increase in wealth

If the distribution of talents is very compressed in a_i, in b_i or in both, then a proportional increase in wealth results in an increase in the dispersion of tuition fees.

Let us first assume the distribution of a_i is compressed to a single value. Since the effect of an increase in p on the tuition fee at the least wealthy college is equal to the level of the tuition fee times the price p:

$$\frac{\partial \tau_n}{\partial p} = \frac{b_n r s_n}{1 - b_n r} = p\tau_n$$

then equations (7) and (9) imply:

$$p[\tau_i - \tau_{i+1}] = \frac{\partial \tau_i}{\partial p} - \frac{\partial \tau_{i+1}}{\partial p}$$

Then if the more talented students pay higher tuition fees, the increase in tuition fees is greater in the more expensive colleges. This implies an increase in the dispersion of tuition fees.

If instead the distribution of b_i is compressed to a single value b, then the recursive equation for the effect on tuition at college i is:

$$\frac{\partial \tau_i}{\partial p} = \frac{br[s_i - s_{i+1}]}{1 - br} + \frac{\partial \tau_{i+1}}{\partial p}$$

Since the first term is positive ($s_i > s_{i+1}$) and the effect at the least wealthy college is also positive, the increases in tuition fees are greater at the more expensive colleges. As before, this implies an increase in the dispersion of tuition fees.

From equation (9) it can be seen that if the effect of a proportional increase in wealth on the level and the dispersion of tuition fees is positive, the general return on college education r would magnify these effects.

A.2. Increase in the returns on college education

If the distribution of b_i is very compressed or the distribution of a_i is sufficiently widespread then the dispersion of tuition fees increases with the general return on college education.

In the first case, assume the distribution of b_i is compressed to a single value b. Then from equation (10):

$$\frac{\partial \tau_i}{\partial r} = \frac{b[e_i - e_{i+1}]}{(1-br)^2} + \frac{a_i - a_{i+1}}{br^2} + \frac{\partial \tau_{i+1}}{\partial r} > \frac{\partial \tau_{i+1}}{\partial r}$$

The three terms at the right hand side of the equality are positive, which implies greater increases in the more expensive colleges.

In the second case, given the distributions of b_i and e_i if the distribution of a_i is such that for all i the following inequality holds:

$$a_i - a_{i+1} > b_i r^2 \left\{ \frac{b_i - b_{i+1}}{b_i} \cdot \frac{\partial \tau_{i+1}}{\partial r} - \frac{b_i[e_i - e_{i+1}]}{(1-b_i r)^2} \right\}$$

then the dispersion of tuition fees would be increasing in the general return on college education. The above inequality comes from assuming:

$$\frac{\partial \tau_i}{\partial r} > \frac{\partial \tau_{i+1}}{\partial r}$$

Appendix B. Endowments, giving and stock prices

In this appendix I describe a simple model that illustrates the dynamics of endowments when giving is consider. I present evidence of the connection of the stock prices and both giving to higher education and endowments.

B.1. Endowment Dynamics

Suppose the endowment is held in one asset denoted by s which has a price p. At period t the value of the endowment is given by:

$$e_t = p_t s_t$$

The holding of the asset in period t is equal to what is inherited from the previous period and the additions made in the current period or the giving, which is denoted by g_t:

$$s_t = s_{t-1} + g_t$$

If we consider the change in the value of the endowment from $t-1$ to t we have:

$$e_t - e_{t-1} = (p_t - p_{t-1})s_{t-1} + p_t g_t \tag{12}$$

Assume giving is determined by how well people who hold stocks do, through the function g:

$$g_t = g(p_t)$$

with $g > 0$ and $g' > 0$. The function g shall be understood as an equilibrium relationship. The underlying determinants come from colleges' and donors optimization problems, taking into account their tastes, resources and expectations.

Then in times of buoyancy the two terms at the right hand side of equation (12) are positive. When there is a fall in the stock prices, the first term is negative but the second term is still positive.

Suppose the stock price is p in period $\tau - 1$, then rises to p^* in period τ and then goes back down to p in period τ. Then, the change in the value of the endowment between $\tau - 1$ and τ is positive:

$$e_\tau - e_{\tau-1} = (p^* - p)s_{\tau-1} + p^* g(p^*) > 0 \tag{13}$$

The sign of the change between τ and $\tau + 1$ is ambiguous. It depends on the magnitude of the price change and the responsiveness of giving:

$$e_{\tau+1} - e_\tau = (p - p^*)s_\tau + pg(p) \gtrless 0 \tag{14}$$

However, the change in the value of the endowment between $\tau - 1$ and $\tau + 1$ is positive. Adding equations (13) and (14) we get:

$$\begin{aligned} e_{\tau+1} - e_{\tau-1} &= (p^* - p)[s_{\tau-1} - s_\tau] + p^* g(p^*) + pg(p) \\ &= (p - p^*)g(p^*) + p^* g(p^*) + pg(p) \\ &= p[g(p^*) + g(p)] > 0 \end{aligned}$$

Making this simple model more general through the relationship g say to include crowding out of endowment and gifts does not change this basic result, as long as $g > 0$.

Therefore the effect of a bubble in the stock market once it bursts is a net increase in the value of the endowment. This could in principle explain why after 1930 the value of endowments did not fall.

B.2. Evidence of the link between giving and the stock prices

Here I estimate an aggregate function $pg(p)$ using three samples of colleges for which I know the aggregate giving. Data from 51 higher education institutions for 1920-1950 comes from John Price Jones Co. (1952). Data from 1951-1965 comes from 19 major institutions from Bowen (1968). Data from 1969-2005 comes from VSE, considering 170 institutions chosen because they formed a balanced panel in that period.[10]

The first column in Table B.1 shows the results of regressing the amount of giving on the Dow Jones index and two lags, all deflated by the CPI. Dummy variables and interaction terms were used to let the slope and the constant term vary across the three samples. The baseline is the latest sample (1969-2005). The hypothesis of unit root cannot be rejected for the Dow Jones, thus a regression of first differences was run. The results of the first-difference regression are presented in the second column.

B.3. Evidence of the dynamics of endowments and the stock prices

The link between stock prices and endowments can be analyzed using time series covering a period of more than one hundred years. Table B.2 shows a summary of the results of regressing the endowment on the contemporaneous Dow Jones index for one hundred private not-for-profit colleges. The sources are described in section 4. In the first two columns the endowments are regressed on the Dow Jones. The third and fourth columns show the results of regressing the logarithm of endowment on the logarithm of the Dow Jones.

[10] A list of this institutions is available upon request.

In the fifth and sixth columns, the difference in endowments from one year to the next is regressed on the differences in the Dow Jones.

The coefficients on the Dow Jones are positive and significant. Particularly interesting is the logarithmic regression with fixed effects which has an R-square of .8.

Table B.1: Regression of Giving 1920-2005

	Level	First differences
Dow Jones index (level or first difference)		
in t	328,461	-22,712
	(107,721)	(38,847)
in $t-1$	310,181	342,470
	(155,829)	(38,706)
in $t-2$	56,536	110,584
	(100,095)	(38,073)
Constant (millions)	1,920	99.4
	(190)	(36.5)
Obs.	83	80
R-square	.96	.63

Table B.2: Regression of Endowment 1920-2005

	Level		Logarithm of level		First difference	
Endowment $t-1$					.0576	.0438
					(.0025)	(.0203)
Dow Jones in t	86,789	86,407	1.238	1.209	2,187	3,306
	(3,188)	(4,575)	(.0304)	(.0160)	(609)	(1,194)
Constant	-55.3	-53.7	8.051	8.284	-8.1	-8.8
	(1.7)	(1.4)	(.246)	(.133)	(3.0)	(2.7)
College Fixed Effects	No	Yes	No	Yes	No	Yes
Obs.	5,780	5,780	5,767	5,767	5,680	5,680
R-square	.11	.50	.22	.80	.10	.11

Table 1: Correlation coefficients 2004 (Claim 1)

	Endowment per student	
	Level	Logarithm
Endowment per student		
Level	1.000	
Logarithm	.4461	1.000
Verbal SAT		
25th percentile	.6208	.7443
75th percentile	.6002	.7355
Quantitative SAT		
25th percentile	.6050	.7372
75th percentile	.5910	.7158

Table 2: Correlation coefficients 2004 (Claim 2)

	Tuition	
	Before aid	After aid
Tuition		
Before aid	1.000	
After aid	.7895	1.000
Verbal SAT		
25th percentile	.7656	.6500
75th percentile	.6818	.5624
Mathematical SAT		
25th percentile	.7723	.6537
75th percentile	.6964	.5745
Endowment per student		
Level	.4018	.2925
Logarithm	.5805	.4249

Table 3: Regression of tuition (Claim 3)

Variable	OLS			IV		
	A	B	C	D	E	F
Log. of endowment per student	1,486	520	1,651	4,058	4,445	1,708
	(22)	(44)	(2,908)	(359)	(183)	(2,996)
Population 18-22 years old	143.8	96.9	11.7	177.8	209.7	12.3
	(29.8)	(14.2)	(576.1)	(43.6)	(23)	(579.4)
Faculty wages	.4538	.5304	.3560	.2491	.2374	.3525
	(.0107)	(.0062)	(.2547)	(.0324)	(.0158)	(.2592)
Enrollment	.2688	.1079	2.4418	.2342	.3820	2.4704
	(.0079)	(.0265)	(5.4384)	(.0124)	(.0313)	(5.4324)
Pell Grants	3,184	3,957	1,769	2,057	1,892	1,760
	(151)	(102)	(2,298)	(269)	(149)	(2,308)
Stafford unsubsidized loans	1,786	1,957	1,174	1,071	1,033	1,172
	(109)	(43)	(1,423)	(188)	(92)	(1,439)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs.	11,891	812	547	11,891	812	547
R-square	.63	.92	.99	.21	.49	.99

Table 4: Regression of net tuition revenue per student (Claim 3)

Variable	OLS			IV		
	A	B	C	D	E	F
Log. of endowment per student	599	591	1,452	2,910	3,417	1,500
	(21)	(49)	(4,466)	(326)	(173)	(4,924)
Population 18-22 years old	-114.1	-143.3	-193.5	-105.0	-74.2	-195.3
	(29.4)	(16.9)	(904.6)	(40.0)	(23.1)	(902.7)
Faculty wages	.2883	.3006	.2093	.1086	.0906	.2078
	(.0102)	(.0073)	(.3540)	(.0288)	(.0150)	(.3626)
Enrollment	.2915	.1400	2.3187	.2686	.3439	2.3491
	(.0076)	(.0361)	(6.4425)	(.0108)	(.0313)	(6.6602)
Pell Grants	2,348	2,881	799	1,485	1,423	809
	(198)	(154)	(2,433)	(295)	(178)	(2,371)
Stafford unsubsidized loans	537	538	23	-109	-126	18
	(107)	(72)	(3,002)	(172)	(91)	(3,074)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs.	14,109	975	547	14,109	975	547
R-square	.35	.75	.86		.20	.86

Table 5: Regression of tuition (Claim 4)

Variable	OLS			IV		
	A	B	C	D	E	F
Log. of endowment per student	1,465	269	655	1,842	2,315	628
	(22)	(37)	(2,624)	(396)	(208)	(2,673)
College premium	9,289	13,123	7,809	8,433	8,460	7,832
	(717)	(394)	(7,432)	(1,156)	(615)	(7,531)
Population 18-22 years old	191.5	156.4	80.4	192.1	191.5	82.5
	(29.8)	(14.3)	(538.0)	(30.2)	(16.8)	(540.7)
Faculty wages	.2318	.2356	.2680	.2225	.1943	.2683
	(.0202)	(.0111)	(.2303)	(.0227)	(.0118)	(.2310)
Enrollment	.2671	.0388	1.4618	.2622	.2000	1.4388
	(.0078)	(.0241)	(5.2717)	(.0095)	(.0265)	(5.3113)
Pell Grants	2,004	2,456	1,409	1,948	1,960	1,396
	(175)	(110)	(1,962)	(187)	(109)	(1,964)
Stafford unsubsidized loans	1,009	928	900	976	833	915
	(124)	(43)	(1,200)	(130)	(68)	(1,204)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs.	11,891	812	547	11,891	812	547
R-square	.63	.93	.99	.62	.60	.99

Table 6: Regression of net tuition revenue per student (Claim 4)

Variable	OLS			IV		
	A	B	C	D	E	F
Log. of endowment per student	588	458	1,100	2,501	3,157	1,124
	(21)	(47)	(4,359)	(441)	(250)	(4,974)
College premium	6,042	7,760	2,599	1,675	1,111	2,516
	(747)	(426)	(12,049)	(1,375)	(832)	(12,569)
Population 18-22 years old	-103.3	-134.1	-180.1	-103.6	-78.8	-184.4
	(29.4)	(17.0)	(905.2)	(37.0)	(22.8)	(900.9)
Faculty wages	.1463	.1284	.1805	.1008	.0839	.1827
	(.0203)	(.0112)	(.4458)	(.0276)	(.0157)	(.4940)
Enrollment	.2911	.0997	1.9627	.2725	.3207	2.0088
	(.0076)	(.0354)	(6.7140)	(.0104)	(.0348)	(7.0386)
Pell Grants	1,717	2,178	726	1,461	1,447	737
	(212)	(153)	(2,310)	(273)	(174)	(2,276)
Stafford unsubsidized loans	30	-74	-86	-136	-157	-81
	(124)	(79)	(3,204)	(161)	(93)	(3,177)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs. or groups	14,109	975	547	14,109	975	547
R-square	.35	.76	.87	.23	.20	.87

Table 7: Regression of tuition (Claim 5)

Variable	OLS			IV		
	A	B	C	D	E	F
Interaction	948	630	658	1,014	1,095	680
	(13.4)	(25.9)	(546)	(58.2)	(28.4)	(606)
Population 18-22 years old	137.9	107.9	24.7	138.9	127.0	27.0
	(29.2)	(13.7)	(538.0)	(29.3)	(14.5)	(539.9)
Faculty wages	.2400	.3526	.2714	.2168	.1928	.2635
	(.0114)	(.0105)	(.2106)	(.0229)	(.0110)	(.2213)
Enrollment	.2652	.1313	1.9704	.2635	.1753	1.9745
	(.0078)	(.0258)	(5.0360)	(.0079)	(.0186)	(5.0590)
Pell Grants	2,215	3,000	1,620	1,995	2,092	1,581
	(149.4)	(109.8)	(2,070)	(181.5)	(92.1)	(2,050)
Stafford unsubsidized loans	918	1,273	871	829	677	847
	(108.7)	(48.8)	(1,292)	(133.0)	(64.0)	(1,315)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs. or groups	11,891	812	547	11,891	812	547
R-square	.64	.93	.99	.64	.63	.99

Table 8: Regression of net tuition revenue per student (Claim 5)

Variable	OLS			IV		
	A	B	C	D	E	F
Interaction	395	473	390	767	898	471
	(13.0)	(25.6)	(889)	(62.7)	(39.3)	(1,195)
Population 18-22 years old	-128.5	-156.8	-217.3	-139.9	-156.0	-217
	(29.3)	(16.9)	(865.0)	(30.2)	(19.5)	(852)
Faculty wages	.1989	.1838	.1808	.0710	.0395	.1540
	(.0110)	(.0109)	(.3450)	(.0239)	(.0149)	(.3913)
Enrollment	.2904	.1432	1.6955	.2838	.1843	1.6724
	(.0075)	(.0355)	(6.1882)	(.0078)	(.0250)	(6.3790)
Pell Grants	1,985	2,388	855	1,433	1,671	796
	(197.7)	(155.8)	(2,298)	(222.8)	(148.2)	(2,123)
Stafford unsubsidized loans	170.4	72.8	-131	-331.5	-469.6	-232
	(108.2)	(75.4)	(3,288)	(138.7)	(86.5)	(3,681)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
Specific slope	No	No	Yes	No	No	Yes
Obs. or groups	14,109	975	547	14,109	975	547
R-square	.35	.76	.86	.32	.30	.86

Table 9: Regression of scores (Claim 6)

Independent variable	Dependent variable			
	Change in score percentile 1981-2004		Score in 2004	
	SAT	ACT	SAT	ACT
Change in percentile of predicted endowment 1980-2004	.0367	.0123	.3349	.0182
	(.0468)	(.0736)	(.0975)	(.0071)
Score in 1981			.8441	.6689
			(.0375)	(.0632)
R-square	.00	.00	.69	.50
Obs.	269	158	269	158

Table 10: Regression of tuition (Claim 7)

Independent variable	Dependent variable			
	Change in tuition percentile 1980-2004		Tuition in 2004	
	Before aid	After aid	Before aid	After aid
Change in percentile of predicted endowment 1980-2004	.1564	.0995	39.69	26.68
	(.0347)	(.0461)	(5.85)	(7.21)
Tuition in 1980			1.7203	1.5674
			(.0598)	(.0866)
R-square	.05	.01	.71	.47
Obs.	402	425	402	425

Table 11: Regression of tuition pre-1970 (Claim 3)

Variable	OLS			IV		
	A	B	C	D	E	F
Logarithm of endowment	3,112	5,462	6,274	7,813	8,056	7,269
	(55)	(115)	(3,114)	(184)	(104)	(3,264)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
College specific slope	No	No	Yes	No	No	Yes
Obs. or groups	4,408	100	100	4,192	100	100
R-square	.42	.65	.71	.41	.41	.69

Table 12: Regression of tuition pre-1970 (Claim 4)

Variable	OLS			IV		
	A	B	C	D	E	F
Logarithm of endowment	786	-139	-732	-5,712	-4,605	-1,856
	(68)	(146)	(2,685)	(5,979)	(1,827)	(4,714)
College premium	25,084	27,474	26,539	43,565	39,194	29,640
	(479)	(562)	(12,365)	(17,085)	(4,825)	(19,837)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
College specific slope	No	No	Yes	No	No	Yes
R-square	.86	.93	.98	.18	.24	.97

Table 13: Regression of tuition pre-1970 (Claim 5)

Variable	OLS			IV		
	A	B	C	D	E	F
Log. of endowment	1,100	1,172	1,081	1,165	1,172	1,070
× College premium	(19)	(20)	(309)	(22)	(17)	(308)
Fixed college effects	No	Yes	Yes	No	Yes	Yes
College specific slope	No	No	Yes	No	No	Yes
Obs. or groups	652	100	100	652	100	100
R-square	.83	.91	.95	.83	.83	.95

Figure 1: Percentile of tuition fees at private four-year colleges

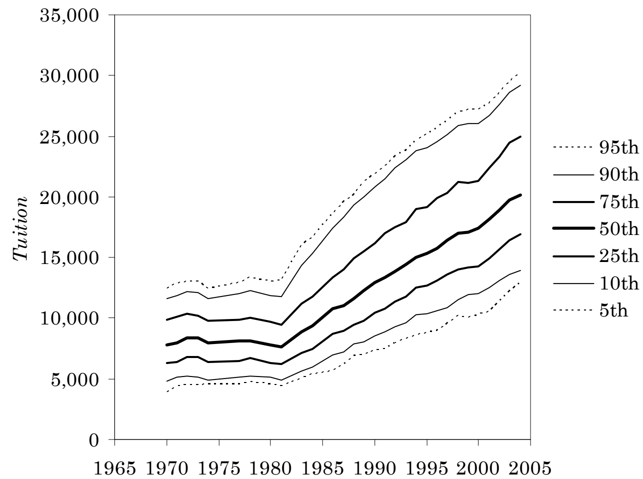

Figure 2: Percentiles of average tuition after aid at private four-year colleges

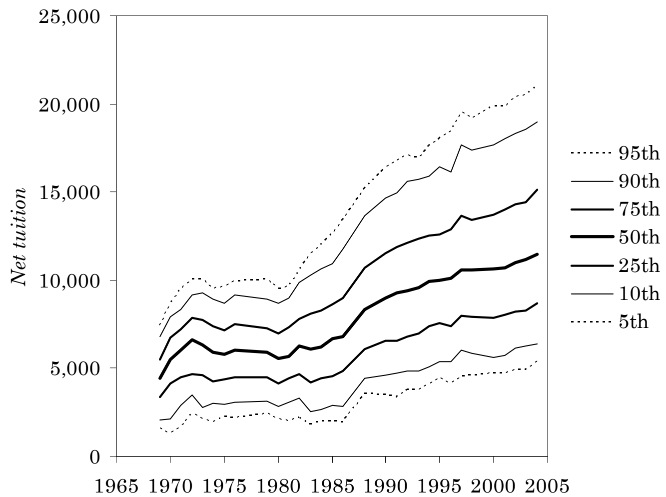

Figure 3: Percentile of endowment per student at private four-year colleges

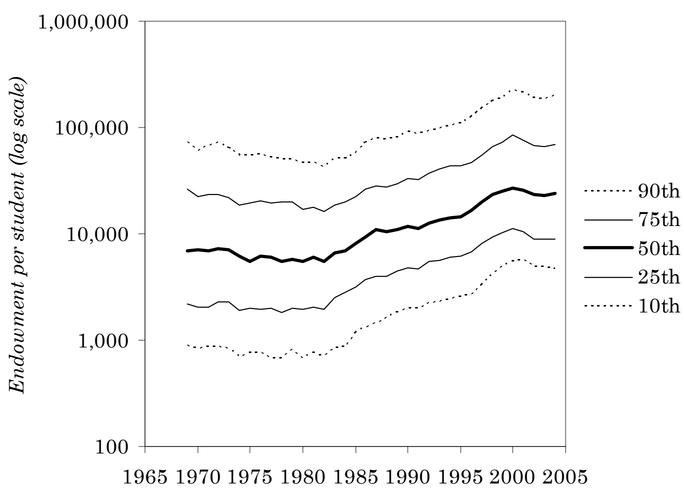

Figure 4: College premium

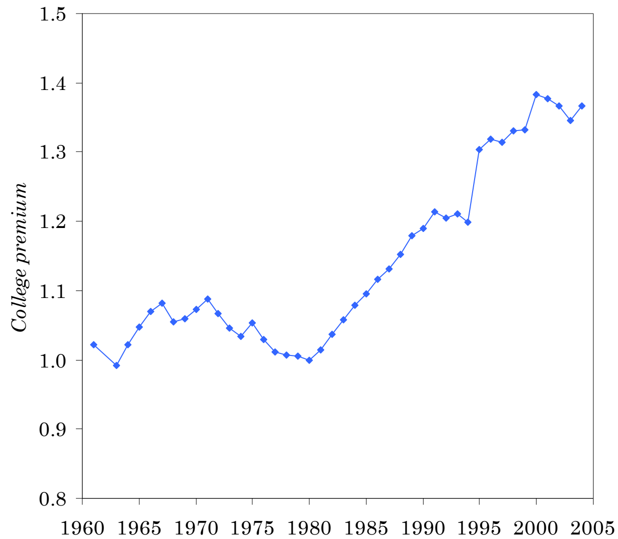

Figure 5: Percentiles of tuition fees 1900-2005

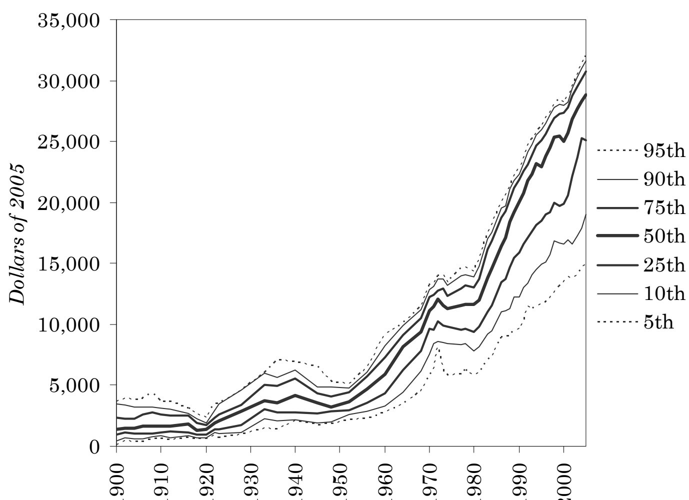

Figure 6: Evolution of endowment 1900-68

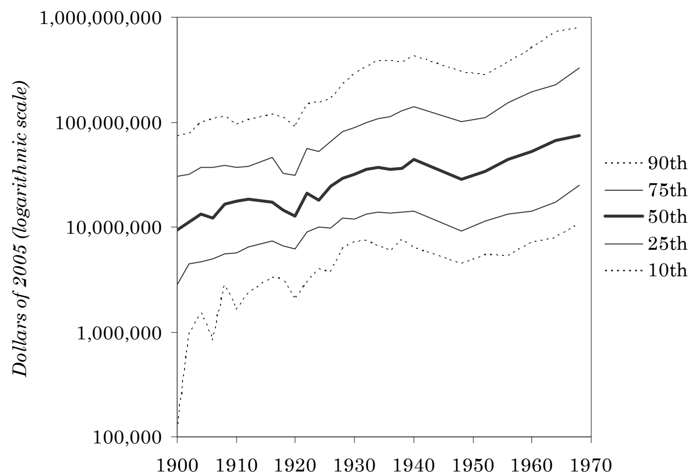

Figure 7: Median tuition fees and median endowment 1900-68

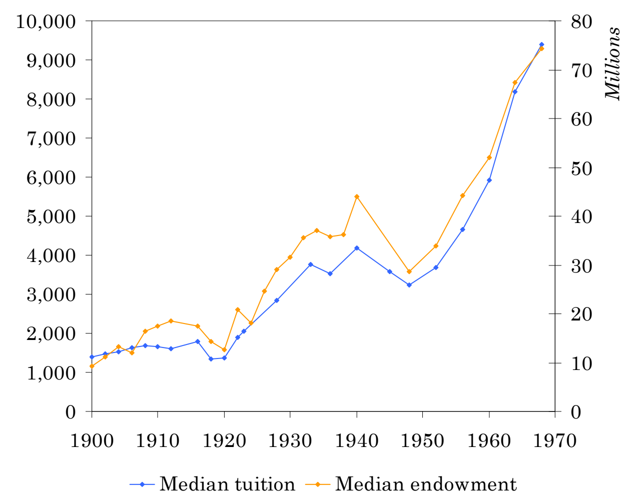

Figure 8: Inter quartile differences of tuition fees and endowment

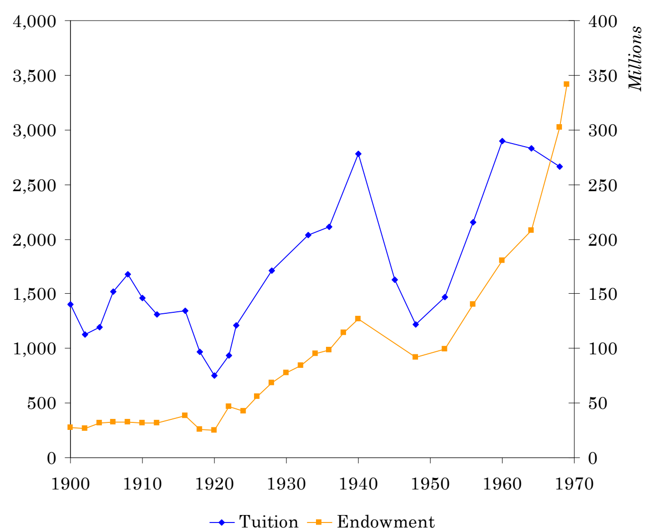

Figure 9: College premium from Census