American Higher Education and Income Inequality

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I. Introduction

One of the most important developments in the U.S. economy going forward that will affect higher education is the aggregate growth of real incomes. During the last decade, the real incomes of families across the income distribution suffered. (See Saez, 2013.) This has been a major cause of the downward pressure on tuition increases and the increasing need for financial aid at many non-profit institutions of higher education.[1] And, in the public sector, slower income growth has affected tax revenues and commitments to public higher education. Constrained appropriations to public institutions have led to higher tuition, as schools attempt to protect quality. Going forward, if real income growth picks up, so will the ability of some institutions to increase tuition in both the private non-profit and the public sectors, as families would be able to afford higher expenditures on education. The need for financial aid would moderate, and the possibility of renewed public support through state budgets would also improve.[2]

In addition to the aggregate growth rate of income, the distribution of income across families also matters for colleges and universities. Income inequality has increased in the United States over the last several decades, with the share of income earned by the top 10% of the income distribution increasing from about 33% of total income in the 1970s to a little over 48% in 2011.[3] This has resulted in large part because the increase in demand for skilled labor resulting from skill biased technological change has exceeded the increase in supply of skilled labor (See Goldin and Katz, 2008.) Greater investment in human capital, through increased access to higher education, would help moderate the increase in income inequality. But, increasing income inequality itself is in fact exacerbating the challenges facing

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[1] Kevin Kiley, "Price of a Bad Economy," May 7, 2013, Inside Higher Education on the NACUBO 2012 Tuition Discounting survey of private colleges and universities.
[2] There is some automatic adjustment to higher education institutions' costs if real income growth slows. When real wages for skilled labor go down across the economy, putting downward pressure on tuition increases, this also puts downward pressure on compensation for skilled workers at colleges and universities. This adjustment can be painful, however, and slow given traditions of shared governance.

[3] Saez, 2013. Much of this shift is explained by changes in the incomes of the top 1% of families.

colleges and universities and making it more difficult for institutions of higher education to contribute to greater income equality.

Real income growth that is skewed toward higher income families creates challenges for higher education because the highest income families are willing and able to pay the full sticker price. And schools compete for these students, supplying the services that they desire, pushing up costs. At the same time, many schools have been committed to recruiting and educating a socioeconomically diverse student body, contributing to greater income equality over time.[4] But, lower income families' incomes have lagged even further behind the top groups, because of increased income inequality, increasing the need for financial aid. If the income distribution were less skewed, the demand for services at one end of the income distribution on the part of higher income families and the need for financial aid at the other end on the part of lower income families would both moderate, reducing the financial challenges facing many colleges and universities.

Over the last decade or so, there is been an increasing refrain that the financial model of American higher education is broken and not sustainable. This mainly refers to the high tuition institutions that have been experiencing rising costs, rising tuition, and rising claims on financial aid. While this clearly applies to much of the non-profit sector, in particular the selective non-profits, it is also relevant to many institutions in the public sector as well, which have become increasingly less reliant on state appropriations by necessity.[5] These phenomena are in part a result of the increasing income inequality in America. Ironically, some of the proposed "solutions" to make higher education finances sustainable would actually contribute to increasing future income inequality, rather than address the trends in income inequality that are in part creating the financial challenges for institutions in the first place.[6] Rising income inequality in America is part of the challenge, and higher education institutions cannot address the causes of this on their own. The government is in a much better position to address this issue, either directly through the tax system or through the incentives that it creates for both private, non-profit and public colleges and universities.

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[4] At the private, non-profits this has occurred through financial aid policies, while at the publics, low tuition policies have historically supported access.

[5] As public institutions push up tuition, increase fund raising efforts, and offer greater financial aid, their financial model moves closer to that of the private, non-profits.

[6] For example, calls to slow tuition growth not tied to offsetting expenditure savings can be paid for by reductions in financial aid. We are seeing this in the private, non-profit sector. Lower tuition combined with lower financial aid benefits higher income students, contributing to worsening income inequality in the future.

II. Summary

This paper will show how increasing income equality is contributing to the trends we see in American higher education and to the financial challenges that many colleges and universities are currently facing. It presents a simple model to demonstrate that increased income inequality, given the structure of many American higher education institutions, can contribute to the challenges currently facing the sector. The model is most appropriate for the selective non-profit higher education institutions. Even though they account for only a small share of the aggregate enrolments in higher education, they receive much of the attention in the national press and concerns about sustainability are focused on these schools. Given their commitment to the socioeconomic diversity of their students, the model demonstrates how increasing income inequality leads to higher tuition, higher costs, and higher financial aid than would otherwise be the case. These trends contribute to the stress that colleges and universities have been facing over the last several decades.

A simple numerical example is also presented that estimates how much lower tuition, spending (proxying for costs), and financial aid would have been, if household incomes in the United States had grown by the same aggregate amount between 1971 and 2009, but with no increase in income inequality.[7] It is based on data from a set of selective non-profit colleges and universities, and most appropriate for demonstrating the impact of greater income equality on trends in this sector over time.

The policy insight of these exercises - the model and the numerical example - is that higher education is being held responsible by the press, politicians and the general public for trends that are in large part the result of rising income inequality in America. And, the rising income inequality has many causes and implications, but the government is in the best position to respond to changes in income distribution, through a variety of policies at its disposal. Greater support for higher education is, ironically, one such policy. But the developments in higher education resulting from greater income inequality are being used to criticize it, rather than to argue for increased support from the public sector.

If rising income inequality is a concern, the government can moderate it both through the tax system and by increasing investment in higher education, especially among lower and middle-income families. Increased support for public education and incentives for private, non-profit institutions to increase socioeconomic diversity of their students would work to moderate future income inequality. Absent changes in policies, existing research suggests we will see continued increases in income inequality. (See Altonji, Bharadwaj, and Lange, 2012) This will continue to create challenges for colleges and universities which are committed to

[7] 2009 in used, rather than a more recent year, because of data availability.

attracting talented students from across the income distribution, contributing to social mobility and equal opportunity.

III. The Model

Much of the criticism targeted at American higher education is focused on the non-profit sector, particularly the selective schools with total student charges (the sticker price) above $50,000. While these schools in fact educate a small share of the total number of students going on the higher education, with the entire private, non-profit sector accounting for only about 15% of enrolments, they receive disproportionate attention. This is in part because they are among the most selective and spend the most per student, not unrelated phenomena. This simple model is designed to represent their decision-making in the market in which they operate. Based on Winston (2003), it is assumed that schools make decisions to increase the demand on the part of students and their families for places at their school. Unlike other markets, however, schools do not adjust price to equate supply with demand. In fact, schools attempt to create a queue of student applicants, from which they can admit the most qualified students. The admit rates at schools like Harvard, Yale, Princeton and Stanford are all below 10%, indicating the intensity of the excess demand. This excess demand allows schools to control student quality through the admissions process. In a market where the consumers are also inputs into the educational process (see Rothchild and White, 1995), this contributes to the quality of the education offered. It is also assumed that schools ("part church" and "part car dealer", see Winston (2000)), also care about socioeconomic diversity. This has increasingly been stated as an explicit objective of schools over the last forty years.[8] So, schools make decisions in order to increase the demand for their school on the part of talented students, but also want to attract students from lower income families as an additional objective.

The objective function of a simplified, representative school is to maximize the demand on the part of both high income and low income student applicants, from which the school will decide who to admit. For simplicity, assume there are just two types of students, high-income and low-income, whose demands are represented by D^H and D^L. For simplicity, it is also assumed that the school has decided on the quantity of each type of student, high and low income, that it wants in the class, Q^H and Q^L. It then makes decisions to increase the demand on the part of both groups, so that it can select the highest quality class from the two pools of applicants. The major decision variables under the school's control are the amount it spends (E) on programs and the prices it charges the high and low-income students. T, for tuition, is the price that the high income students are asked to pay, and NP, for net price, is

[8] See Bowen, Kurzweil, and Tobin, 2006, for a discussion of the commitment to socioeconomic diversity on the part of colleges and universities. This work, and others, including Hill, Van Atta, Gambhir, and Winston (2011) and Carnevale and Rose (2004) discuss the extent to which this stated objective has been accomplished.

the price that the low income students are asked to pay and equals the tuition price that the high income students pay minus financial aid.[9] The demand on the part of high income students depends on E and T, while that of low income students depends on E and NP. The school is subject to a budget constraint, which depends on its decisions about prices and expenditures, the number of high income and low income students it matriculates, as well as its assets, A. It is assumed that schools spend a fixed percent each year, r, from their assets. A more complicated spending rule, and current gifts and other sources of current revenue could easily be included in the model.

The demand on the part of students and their families also depends on their incomes. The higher their incomes, the greater the demand (willingness and ability to pay) for education for their children. Y^H, Y^L refer to the incomes of the high and low income families.

The constrained optimization problem facing a representative school then becomes:

Maximize $D^H(E,T,Y^H) + D^L(E,NP,Y^L)$ subject to $T*Q^H+NP*Q^L + rA - E=0$

Or,

$$\text{Max } L= D^H(E,T,Y^H) + D^L(E,NP,Y^L) + \lambda(T*Q^H+NP*Q^L + rA - E)$$

Where D^H, D^L is the demand on the part of high (low) income students

E is the school's expenditure on program, which can be equally accessed by both high income and low income students.

T is the full sticker price, paid by the high income students

NP is the net price paid by the lower income students

Q^H, Q^L are the fixed numbers of high and low income students that the school desires for socioeconomic diversity

Y^H, Y^L are the incomes of the high and low income families

rA refers to the earnings on the school's endowment, which contributes to the amount that the school can spend each year.

The school faces given Y^L, Y^H, and rA and has made decisions about Q^H and Q^L. It then decides on E, T, and NP to maximize the demand on the part of high and low income students, to generate the queues from which the school will pick the most qualified students. This is a highly simplified description of how the selective, non-profit schools behave, but is useful for modeling some of the important decisions that schools must make. Given the incomes of their applicant pools and the school's budget constraint, they decide how much to spend, what to charge full pay students

[9] The distinction between tuition and total student charges is ignored here. T could more accurately be defined as total student charges. For simplicity, I am ignoring this distinction.

and how much financial aid to offer, to maximize the quality of their student bodies subject to their objectives for socioeconomic diversity.[10]

First order conditions

Differentiating the Lagrangian with respect to E, T, NP and λ and setting the results equal to 0 yields the following:

$$\frac{\partial L}{\partial \lambda} = rA + TQ^H + NPQ^L - E = 0$$

$$\frac{\partial L}{\partial T} = \frac{\partial D^H}{\partial T} + \lambda Q^H = 0$$

$$\frac{\partial L}{\partial NP} = \frac{\partial D^L}{\partial NP} + \lambda Q^L = 0$$

$$\frac{\partial L}{\partial E} = \frac{\partial D^H}{\partial E} + \frac{\partial D^L}{\partial E} - \lambda = 0$$

or,

$$\frac{\partial D^H}{\partial E} + \frac{\partial D^L}{\partial E} = -\frac{\partial D^H}{\partial T} = -\frac{\partial D^L}{\partial NP}$$

assuming $Q^H = Q^L = 1$ for simplicity.

The first order conditions demonstrate how schools behave. They allocate their resources on the margin to increase the demand on the part of the two types of students they desire to recruit. Those students care about how much the school spends on their education, and it is assumed that schools cannot target specific expenditures to particular types of students. (This could be relaxed and overstates the extent to which expenditures are available equally to all students. Some

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[10] One could model this in different ways. Schools could face a continuous distribution of students by both talent and income and seek to maximize the quality of their students at the least cost. The model as presented is designed to both simplify the presentation, and to demonstrate the pressures that schools will face when they care about attracting both a talented and a socioeconomically diverse student body. The model as presented assumes there is talent in both pools of students, high income and low income, but that the school is not indifferent between these students. It desires students from both groups, so as to meet its objectives of contributing to social mobility in the U.S. and to learning by bringing together students with different life experiences.

expenditures probably benefit, or are used by, different types of students. Examples might include expenditures on the sailing club versus a variety of support services that might be targeted at first-generation, lower income students.) They also care about the price they are asked to pay. In equilibrium, the school will have made decisions about how much to spend and how much to charge each group such that an additional dollar of expenditure generates the same amount of extra demand on the part of the two groups of students as would result if that dollar were used instead to reduce the prices faced by both groups, and the price reductions in T and NP would be such that, on the margin, they generate equal changes in demand on the part of the two types of students.

These decisions about how much to spend and what to charge different students are among the most important decisions that schools make. Schools decide how much to spend and on what, to supply as high a quality education as possible, captured in the model as generating a queue of talented students who want access to that education.[11] But, students and families also care about the price they have to pay. Schools, on the margin, are deciding whether an additional dollar would be better spent on program or on reducing price for the students it is trying to attract. Prices are higher for high income students, because they are willing and able to pay more and would rather do so than attend a school that spent less on their education. (Such a school is in fact in their choice set, in the form of less selective alternatives, with less spending per student and a lower price.) Lower income families are less willing or able to pay for education for their children, so on the margin face a different trade-off between spending and price. The level of expenditure and prices set by schools reflect this.[12]

IV. Extensions to the model

Several simplifying assumptions have been made that could be relaxed. It is assumed that schools have made commitments to attract fixed numbers both high income and low income students. The share of high income and low income students could instead be determined by the model, given the characteristics of these students. The model, as formulated, assumes that the school has already done this independently, and decided on the ratio of students in these two groups given their desirability (based on their talents and their socioeconomic diversity, given the school's objectives), and then makes decisions to increase the queues of both students from which it chooses the fixed number from each group.

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[11] Whether the views of families and students on a quality education and that of the school are the same is ignored for now. The model could certainly help explain why schools spend on amenities that they perhaps do not believe add fundamentally to the quality of the education offered, if those expenditures still increase the demand on the part of talented students to attend the school.

[12] This model could easily be extended to incorporate merit aid.

It would also be possible to allow expenditures to be targeted toward each of the type of students. In general, however, most expenditures are not or cannot be targeted in this way. The logic of the model would suggest that, if this were relaxed, schools would allocate expenditures to generate the most demand on the part of the two groups, equating on the margin the impact on demand of expenditures targeted to each group.

The budget constraint could also be made more complicated. As written, the intertemporal decisions that face institutions has been simplified by assuming that schools spend a fixed share of their endowments each year, modeled as a very simplistic spending rule. A more complicated two period version of the model could be used to examine the decisions that schools have to make about spending resources today versus saving them for the future. A more complicated objective function that included the impact of decisions today on the demand of students tomorrow, for example through reputation effects or rankings, would allow an extension of the model to be used to address a different set of questions.

Finally, each school is assumed to take the behavior of other schools as given. Changes in other schools' behavior could be included as exogenous variables in the model as presented. Essentially, schools are assumed to be small in the higher education market place.

V. Comparative statics

By totally differentiating the first order conditions, the comparative static results can be used to examine the effects of changes in exogenous variable on the decisions of a school on spending and prices. For example, an exogenous change in a school's assets relaxes the budget constraint facing the school. This could result from a gift or unexpected appreciation of the endowment or an exogenous change in spending rule, for example increasing r in the simplified model.

Assuming that the second order conditions for a maximum are met and that some of the second derivatives equal zero (see the appendix), it is possible to demonstrate that:

$$\frac{dE}{dA} > 0 \text{ while } \frac{dT}{dA}, \frac{dNP}{dA} < 0.$$

The effect on expenditure seems straightforward. Relaxing the budget constraint increases spending. The results on price may seem less intuitive to any observer of higher education, when price increase have been persistent year in and year out. But, all else constant, greater resources on the part of schools lead them to make decisions on the margin between increasing spending and reducing price (or increasing it by less, given other changes it faces) so as to increase demand on the part of applicants. Increased spending on financial aid, reducing NP, is more

intuitive, in response to increased wealth and is certainly consistent with observed behavior on the part of many colleges and universities in the 2000s, before the financial market crisis of 2008/09.

It is also possible to look at the effects of a change in income on the part of high income or low income families. Totally differentiating the first order conditions with respect to Y^H and Y^L and rearranging (see the appendix) yields:

$$\frac{dE}{dY^H} > 0 \quad \frac{dT}{dY^H} > 0 \text{ and } \frac{dNP}{dY^H} < \frac{dT}{dY^H}$$

and

$$\frac{dE}{dY^L} > 0 \quad \frac{dNP}{dY^L} > 0 \text{ and } \frac{dNP}{dY^L} > \frac{dT}{dY^L}$$

The intuition of these comparative static results for an increase in high income families' incomes is as follows. When high income families' incomes increase, their demand for education increases. Schools see an increase in demand for their services on the part of these families. This pushes their decisions about spending and pricing out of equilibrium, with greater than expected demand on the part of high income families on the margin. They respond to the increase in demand by increasing the price charged the higher income students, T, which relaxes the school's budget constraint, allowing an increase in expenditure. This increase in expenditure increases the demand on the part of low-income students, allowing an increase in net price, NP. But, tuition (T) increases by more than net price (NP), resulting in an increase in financial aid. These changes restore equilibrium. Summarizing, an increase in income on the part of high income families leads to an increase in tuition, in spending (costs) and financial aid.

The intuition for a change in low-income family income is of course similar. Greater incomes on the part of low income families would lead to increased spending, increases in net price greater than tuition, and therefore moderation in financial aid.

VI. The Impact of Increasing Income Inequality in the United States on Higher Education

a. The model

Given this simple model, it is possible to examine the impact on the equilibrium levels of expenditures, prices and net prices of a change in income distribution between the high and low income families. This is demonstrated by looking at the effects on E, T, and NP of a change in Y^H and Y^L, such that the increase in high income is offset by a reduction in low income. This represents an unchanged aggregate income, but increased income inequality.

$dY^H = -dY^L$

The comparative static results can be used to show that expenditures would go up, tuition would go up, and financial aid would go up, as a result of the increase in tuition and the fall in incomes of the lower income families. (See appendix.) This result depends on there being differences between high income and low income families in their demand for education. If they were exactly the same, of course, a change in the distribution of income would have no impact. An assumption sufficient to guarantee this result is that lower income families are more price sensitive than higher income families. This is consistent with the existing empirical evidence.[13] In this case, as higher income families' incomes go up, they demand more education, while lower income families' incomes decline, reducing their demand. These effects lead to a larger increase in tuition for higher income families than reduction in net price for low income families to restore equilibrium, given the different price sensitivities. The new equilibrium, with the same total income but greater income inequality, will involve higher tuition, financial aid, and spending (because the tuition increase is greater than the fall in net price, leading to an increase in net revenue and a relaxation of the budget constraint).

b. Numerical example

A simple numerical example can also demonstrate the impact of rising income inequality in the United States on the private, non-profit segment of the higher education sector. Using household incomes in 1971 and 2009, it is possible to estimate what household incomes would have been if household incomes had grown at the same rate across the income distribution as in the aggregate. This would have left the income distribution unchanged at its 1971 distribution, rather than growing more unequal with income growing more rapidly among higher income households.

Table 1 shows the income bounds by income quintile and for the top 5% of the income distribution for household income for 1971 and 2009 (in current dollars). The ratio of these two numbers across the income distribution for 2009 is one way of seeing the increased income inequality that has taken place in the United States. The lower bound of the top 20% of the income distribution and that of the top 5% have gone up relative to the other income quintile boundaries, by 6.6 and 7.5 fold compared to 5.4, 5.3 and 5.8 for the top boundaries of the first, second and third quintiles respectively. Table 1 also estimates what those bounds would have been in 2009 had the distribution of income remained unchanged since 1971, assuming aggregate income still grew by the same amount.[14]

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[13] See Schapiro ( ) and Kane ( ).

[14] If everyone's income grew at the aggregate rate, then the boundaries would have grown at this rate and income distribution would have remained unchanged.

Hill, Van Atta, Gambhir, and Winston (2011) reports data for a set of 30 highly selective colleges and universities for 2008/09, including sticker prices, net prices by income quintile, as well as the shares of students in these schools by income quintile. We can use these data to explore the impact of increasing income inequality on the selective non-profit institutions. First, as shown in the simple model above, if the incomes of higher income families had increased by less, it is quite likely that tuition increases would have been more moderate. Hill et. al. find that 69% of students at this group of schools come from the top 20% of the income distribution, and that 51% pay the full sticker price. There are two simpe ways to estimate what might have happened to tuition growth had income growth among the top income families been more moderate. First, assuming that the sticker price would have remained at the same ratio of the income level of families at the top 5% of the income distribution, the sticker price in 2009 would have been $30,788 rather than $35,070. Alternatively, we could assume that these high income families would have been willing to allocate the same share of the (smaller) increase in their incomes to tuition increases as they did with the actual growth of their incomes. This leads to a very similar number of $30,537. (See Archibald and Feldman (2011) who use this as a definition of affordability.) It is also possible to estimate what schools would have spent on financial aid and how much they would have had available through net revenues to spend on their educational programs under a more equal income distribution. Again, using the data from Hill et. al., assume that the share of students from each income quintile remained unchanged at the actual levels in 2009. (See Table 2.) We can either assume that the net price that they were asked to pay remained the same relative to the sticker price paid by the full pay students, or the same relative to their quintile's median income. Financial aid would have fallen respectively by 12 or 22% under these two assumptions. Financial aid falls by more under the assumption that the net price depends on quintile median income because with more equal income distribution assumed, quintile median incomes are higher, resulting in a higher net price than in the scenario assuming that the net price remains at the same ratio of the original sticker price. We can also calculate the impact on net revenues. Tuition revenues from full pay students fall as a result of the smaller increase in tuition growth rates as a result of less income inequality, but financial aid also declines, because of both the slower increase in tuition and the higher incomes assumed on the part of lower income families. Taking these together, however, net revenues decline, leaving schools with fewer resources to push up expenditures and cost. Under the two alternative assumptions about what happens to net prices for financial aid students, net revenues would have fallen by 13% and 9% respectively.

This simple example suggests that many of the troubling trends facing this sector of American higher education result in part from the increasing income inequality in America. It is not just the growth of aggregate income that matters to these schools, but its distribution across families. This results from these schools' commitment to recruiting a socioeconomically diverse student body. As income inequality increases, tuition and spending go up in response to rising incomes for higher

income families, while financial aid rises to continue to attract lower income students.

Because these trends are shown to be the outcome of a school's optimizing decisions, they are by definition sustainable. But, this is because the model takes as given the school's commitment to socioeconomic diversity, assuming the school is committed to attracting given numbers of both high and low income students. As income inequality increases, the cost of attracting a low income student rises relative to the high income student. As a result, schools' commitment to socioeconomic diversity will be tested by increasing income inequality. Increasing income inequality also contributes to increasing skill gaps between high income and low income students over time (see Altonji, et. al.) , making it more difficult to attract talented low income students into the applicant pool. This means that lower income students will increasingly involve a cost not only in terms of the price their families can pay, but in terms of the attributes or level of skills they bring to the student body

VII. Conclusion

The increasing income inequality in the United States can reasonably be demonstrated to have contributed to increasing tuition, increasing spending, and greater financial aid at many colleges and universities that attract both a talented and socioeconomically diverse student body. These developments have been cited as reasons to believe that the financial model facing these institutions is not sustainable. But, rather than being a criticism of these institutions, it is really a result of their response to rising income inequality in the United States, as they continue to try to attract students from across the income distribution. These schools have been criticized for their high tuitions and high spending, but this is the result of the demand for services on the part of high income families, who have done exceptionally well over the last several decades, with increasing income inequality. To ask schools to restrain tuition and spending in the face of this demand is difficult. Students will go to the schools that meet their demands. They are willing and able to pay for the expensive education offered by these schools.[15]

Rising income inequality has contributed to the challenges facing American higher education. If education becomes less accessible for lower income families as a result,

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[15] The fact that some of these expenditures are paid for by the public is important. If public policy makers want to change schools' behavior, it would make sense to implement policies to change the incentive that schools face in setting prices and expenditures.

There is also currently pressure on schools to moderate tuition increases, with some confusion about the impact of this on access issues. If schools compensate for lower tuition revenues by cutting financial aid, socioeconomic diversity will also suffer.

it will reinforce increasing income inequality, rather than help moderate it. The government is in the best position to address rising income inequality directly, which would alleviate some of the pressures facing higher education institutions. At the same time, policy makers could also change the incentives facing higher education, to help insure that the education system contributes to, rather than worsens, future income inequality. But, income inequality is primarily the responsibly of the government and society, and the higher education sector on its own cannot adequately address this problem.

Table 1: Increase in Income inequality in America

Quinitle		Q1	Q2	Q3	Q4	Q5	Top 5%
Upper boundary (current dollars)							
	1971	$3,688	$7,065	$10,276	$14,661	na	$23,175
	2009	$20,453	$38,550	$61,801	$100,000	na	$180,001
	2009/1971	5.4	5.3	5.8	6.6		7.5
	Proj. 2009	$24,878	$47,425	$69,789	$99,512	na	$158,027

Source: U.S. Census Bureau, Historical Income Tables: Households, HO1AR_2011.
Notes: The projected income quintile boundaries are estimated by assuming that they grew at the rate of average household income between 1971 and 2009.

Table 2: Shares of students and net price by quintile: 30 Selective Private Colleges and universities (2008/09)

Quintile	Q1	Q2	Q3	Q4	Q5	Top 5% (Full pay)
Share of students	4.6	6.8	7.8	11.6	18.1	51.2
Net price as % of sticker price	6	8	18	34	60	100
Net prices as % of Quntile median income	17	10	14	18	17	24

Source: Hill, Van Atta, Gambhir,and Winston, 2011.
Note: These data are used to estimate what would have happened to tuition, net prices, and net revenues had income inequality not increased between 1971 and 2009.

Appendix

First order conditions:

$$\frac{\partial L}{\partial \lambda} = rA + TQ^H + NPQ^L - E = 0$$

$$\frac{\partial L}{\partial T} = \frac{\partial D^H}{\partial T} + \lambda Q^H = 0$$

$$\frac{\partial L}{\partial NP} = \frac{\partial D^L}{\partial NP} + \lambda Q^L = 0$$

$$\frac{\partial L}{\partial E} = \frac{\partial D^H}{\partial E} + \frac{\partial D^L}{\partial E} - \lambda = 0$$

or,

$$\frac{\partial D^H}{\partial E} + \frac{\partial D^L}{\partial E} = -\frac{\partial D^H}{\partial T} = -\frac{\partial D^L}{\partial NP}$$

assuming $Q^H = Q^L = 1$ for simplicity.

Second order conditions:

Totally differentiating the four first order conditions yields:

$$rdA + Q^H dT + Q^L dNP - dE = 0$$

$$\frac{\partial^2 D^H}{\partial T \partial E} dE + \frac{\partial^2 D^H}{\partial T^2} dT + \frac{\partial^2 D^H}{\partial T \partial Y^H} dY^H + Q^H d\lambda = 0$$

$$\frac{\partial^2 D^L}{\partial NP \partial E} dE + \frac{\partial^2 D^L}{\partial NP^2} dNP + \frac{\partial^2 D^L}{\partial NP \partial Y^L} dY^L + Q^L d\lambda = 0$$

$$\frac{\partial^2 D^H}{\partial E^2} dE + \frac{\partial^2 D^H}{\partial E \partial T} dT + \frac{\partial^2 D^H}{\partial E \partial Y^H} dY^H - d\lambda + \frac{\partial^2 D^L}{\partial E^2} dE + \frac{\partial^2 D^L}{\partial E \partial NP} dNP + \frac{\partial^2 D^L}{\partial NP \partial Y^L} dY^L = 0$$

Rearranging, yields the following:

$$\begin{vmatrix} 0 & Q^H & Q^L & -1 \\ Q^H & \frac{\partial^2 D^H}{\partial T^2} & 0 & \frac{\partial^2 D^H}{\partial T \partial E} \\ Q^L & 0 & \frac{\partial^2 D^L}{\partial NP^2} & \frac{\partial^2 D^L}{\partial NP \partial E} \\ -1 & \frac{\partial^2 D^H}{\partial E \partial T} & \frac{\partial^2 D^L}{\partial E \partial NP} & \frac{\partial^2 D^H}{\partial E^2} + \frac{\partial^2 D^L}{\partial E^2} \end{vmatrix} \begin{vmatrix} d\lambda \\ dT \\ dNP \\ dE \end{vmatrix} =$$

$$\begin{vmatrix} 0 & 0 & -r & \\ \frac{-\partial^2 D^H}{\partial T \partial Y^H} & 0 & 0 & \\ 0 & \frac{-\partial^2 D^L}{\partial NP \partial Y^L} & 0 & \\ \frac{-\partial^2 D^H}{\partial E \partial Y^H} & \frac{-\partial^2 D^L}{\partial E \partial Y^L} & 0 & \end{vmatrix} = \begin{vmatrix} dY^H \\ dY^L \\ dA \end{vmatrix}$$

The second order conditions for the constrained optimization are satisfied if the d^2z is negative definite subject to dg = 0, where z is the function to be maximized and g is the constraint. Using the 4x4 matrix on the left hand side, this will be the case if $|\overline{H_2}|>0$ and $|\overline{H_3}|<0$, where the former is the 3x3 bordered hessian matrix and the latter is the 4x4 bordered hessian matrix. (See Chiang, 1984, pp. 384-5).

Sufficient conditions for the second order conditions to hold for a constrained maximum are:

$$\frac{\partial^2 D^H}{\partial E^2} + \frac{\partial^2 D^L}{\partial E^2} < 0$$

$$\frac{\partial^2 D^L}{\partial NP^2}, \frac{\partial^2 D^H}{\partial T^2} < 0$$

(This means that increases in price, for both high and low income students, reduce demand by greater absolute amounts as prices increase. In other words, the negative number increases in absolute value as price increases. This is necessary for the 3x3 matrix to be positive, needed for the second order conditions to be satisfied.)

and

$$\frac{\partial^2 D^L}{\partial E \partial NP}, \frac{\partial^2 D^H}{\partial E \partial T} = 0$$

(This condition is not necessary, but makes it possible to unambiguously sign the 4x4 matrix, and is sufficient to make d^2z subject to dg=0 be negative definite.)

The comparative static results can be derived using Cramer's Rule on the above.

In addition to the above assumptions for the second order condition to hold, the following assumptions are made in deriving the results:

$$\frac{\partial^2 D^H}{\partial E \partial Y^H}, \frac{\partial^2 D^L}{\partial E \partial Y^L} > 0$$

$$\frac{\partial^2 D^H}{\partial T \partial Y^H}, \frac{\partial^2 D^L}{\partial NP \partial Y^L} > 0$$

In deriving the effects of increased income inequality on the equilibrium, I assumed the following:

All second derivatives the same for high income and low income families, except:

$\frac{\partial^2 D^L}{\partial NP^2} < \frac{\partial^2 D^H}{\partial T^2}$, or that the effect of an increase in net price for low income families on demand is a bigger absolute value than for high income families.

If the following inequalities hold, the results would remain unchanged:

$$\frac{\partial^2 D^H}{\partial E \partial Y^H} > \frac{\partial^2 D^L}{\partial E \partial Y^L}$$

$$\frac{\partial^2 D^H}{\partial T \partial Y^H} > \frac{\partial^2 D^L}{\partial NP \partial Y^L}$$

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