Why Do University Endowments Invest So Much In Risky Assets?*

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Abstract

Maintaining a large endowment invested in risky securities requires a university to forego expansion through internal projects. We capture this trade-off by defining a university objective function that balances the demands of altruistic stakeholders to expand against those of self-interested stakeholders to maximize their lifetime payments. We show that a risky and large endowment signals a combination of three university characteristics: low productivity marginal internal projects; self-interested stakeholders resisting productive expansion; or binding constraints on maximum endowment payouts. Our model demonstrates that endowments offer a window into university fundamentals, and it helps explain the empirical heterogeneity in asset allocations and sizes.

1 Introduction

Universities produce and disseminate knowledge, a key input to production through both labor and physical capital. We label this output of universities as *social dividends* to emphasize its public good nature. A significant and increasing portion of university social dividend production is funded by endowments, which in aggregate have nearly half a trillion dollars in assets. These endowments invest on average about 75% of their assets in risky securities such as equities, hedge funds, real estate, private equity and other alternative assets. However, these numbers mask a substantial heterogeneity in both endowment asset allocation and size across universities. At one end of the spectrum is Harvard University with an endowment seven times its operating budget allocated 90% to risky assets. At the other end of the spectrum is Chapman University whose endowment is only three-quarters the size of its annual operating budget and is allocated 60% in risky investments. The full distribution of this heterogeneity can be seen in Figure 1.

We seek to understand the university characteristics that drive endowment spending and investment choices. We build a positive model of university endowments based on two ideas. First, the opportunity cost of maintaining an extra dollar in the endowment is delaying internal investments that increases the production of social dividends. Second, a university has no objective of its own. Instead a university is governed by stakeholders who each have their own objective functions. The action taken by the university is a function of the bargaining outcome of these stakeholders and what they value.

Our model shows that the marginal productivity of a university's internal investment projects and the agency frictions within the university drive endowment decisions. Varying the marginal productivity of the university or the extent of the agency frictions allows us to match a broad range of the heterogeneity observed in endowment asset allocations and sizes. Moreover our model allows us to analyze the ability of an external constraints on endowment payouts such as that imposed by the Uniform Prudent Management of Institutional Funds Act to alleviate these agency problems.

Our main innovation comes in the construction of a realistic objective function for the university and its trustees. The addition of agency frictions moves beyond the standard view of liability hedging and return maximization as a means of understanding university endowment management. Our objective function gives the flexibility to match the empirical moments while being concrete enough to give insights into what drives university decisions. The objective function captures how trustees must trade off the demands of different university stakeholders, such as the donors, the faculty, the administration and the students. We reduce these stakeholders to two categories: *altruistic* stakeholders who value the production of social dividends (a public good) and *self-interested* stakeholders who value personal payments from the university (a private good). These labels are not judgmental but reflective of utility types in the spirit of Becker (1976). We model the bargaining game between these two sets of stakeholders in reduced by defining the university's objective function as a convex combination of the objective functions of each set of stakeholders.

To fix ideas, one may think of donors who support the university and the faculty who value the university's expansion regardless of department as the altruistic stakeholders. They are altruistic because they gain utility from the increased production of social dividends. The self-interested may be thought of as administrators who value their salaries, students who value only their personal learning, or faculty who value increases to their own research budgets more than increases to their colleagues' budgets. The assignment to a particular category will of course depend on an individual donor, faculty member, administrator or student. The precise assignment of the university's various constituents to the two categories of stakeholders is not crucial for our theory and only affects the interpretation of the bargaining power between the altruistic and self-interested stakeholders.

Without the agency conflict, the altruistic stakeholders completely control the university, and only the university's marginal productivity on internal investment matters for deciding the endowment's payout and asset allocations. When better marginal internal projects are available, the opportunity cost of investing the endowment in risky assets rises.

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Thus a higher marginal productivity university invests more internally and less in risky external projects via the capital markets. These decisions lead to a small endowment with a low allocation to risky assets. We are not making a statement about the productivity of the university's existing capital stock – this result is only about the productivity of the next available new project. Nevertheless many universities with high allocations to risky assets such as Harvard, Yale or Stanford may not seem to have low marginal productivity.

Adding the agency conflict helps explain universities with high marginal productivity that still invest their endowments heavily in risky assets. When self-interested stakeholders exert control, they push the university toward policies that maximize their personal payments. Internal expansion of the university adds new self-interested stakeholders who dilute the current self-interested stakeholders' claims to the university's cash flows. The dilution of their claim lowers the value of their future personal payments, making current self-interested stakeholders resist university expansion. Without expansion the only way to generate higher cash flows is to take risk in the endowment via capital markets.

Externally mandated constraints on endowment spending rates, like the 7% maximum payout rate from the Uniform Prudent Management of Institutional Funds Act aim to alleviate such agency problems and maintain donor intent. However, we show that these constraints actually distort the connection between available marginal internal projects, university governance and endowment decisions. We show that the constraints accomplish their goal of reducing agency costs and increasing the production of social dividends only in some cases: those of low marginal productivity universities with severe agency costs. In the cases of high marginal productivity universities, the constraints actually lower the production of social dividends. The constraints come with the additional unintended consequence of causing the universities to accumulate larger endowments with riskier allocations than they otherwise would. The intuition is that the constraint effectively eliminates high marginal productivity projects that a university would like to undertake. As a result, the university takes risk in the endowment, thereby growing its size, so as to attempt to undo the payout constraint in dollar terms.

We extend our basic model in two ways. In the first extension, we consider the impact of ignoring future donations generated by today's expansion of the university. Disregarding future donations may arise for two reasons. Donors, assuming that they are the stakeholders in control, may ignore future donations because they value university expansion from their gift only (which has their name attached to it) and not future expansion driven by other current or future donations. Alternatively the administration, if they are the stakeholders in control, may not internalize the fact that current internal investment leads to future donations. In either case, the university's marginal productivity as viewed by those in control is lowered and the university therefore holds a larger and riskier endowment.

In the second extension, we consider the notion that the altruistic stakeholders (donors) may value immortality, having an infinite horizon, while the self-interested stakeholders (faculty, administration, and students) have a finite horizon. When the self-interested stakeholders have less time within the university to extract personal payments, they prefer the faster payoff from risk taken in the capital markets compared to the slower return from internal investment. This preference also pushes the endowment toward a riskier asset allocation.

It is important to note that our theory is positive in nature, and we are not making any normative statements about what universities should or should not do with their endowment. Moreover we do not make any statements about whether universities in general or any particular university are following sub-optimal or misguided endowment investment policies. Also, we do not model competition between universities but rather focus on the governance and productive features of a single university. We leave the competitive aspect of university behavior for future research.

Our model provides a quantitative theoretical framework that connects endowment asset allocation and size to the university's fundamental characteristics: the marginal productivity of internal investment, agency frictions within the university, and external constraints on endowment payouts.[1] The flexibility of our model generates heterogeneity in

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[1]Our theory can also be applied to other endowed not-for-profit organizations.

endowment allocations and sizes similar to that observed in the data. More generally, we show that an endowment can be a window into a university to help us observe otherwise hard to measure fundamental characteristics. For example, in our framework, a risky and large endowment signals either low marginal productivity internal projects, or agency frictions within the university, or severely binding external constraints on the endowment's payout.

We organize the rest of the paper as follows. In Section 2 we review the literature. We build our model in Sections 3 and 4, where we first specify the university's objective function and governance and then describe the university's production function and investment opportunities. We calibrate the model in Section 5 and present the results of that calibration in Section 6. We provide extensions of our model in Section 7 and conclude in Section 8.

2 Literature Review

The theoretical literature on governance, incentives, and optimal investment and portfolio choices with a focus on universities is small. The empirical literature on university endowments has grown in recent years, due to the interest created by the extraordinary endowment gains and losses of the Ivy League schools. We review the theoretical literature in this section. We review the literature's empirical results throughout the paper as they pertain to our model's assumptions and predictions.

The chief investment officer of the Yale University endowment, Swensen (2009), states that endowment managers have two primary, and conflicting, goals: provide stable (predictable) cash flows to the operating budget of the university as well as maintain the purchasing power of the endowed gifts. Swensen relies heavily on Tobin (1974). Tobin develops a formula for the permanent endowment payout taking the level of risk the endowment takes and expected return that comes with that risk as exogenous. Tobin's model is based upon the notion of inter-generational fairness. Gilbert and Hrdlicka (2012) de-

velop a framework to endogenize the optimal endowment asset allocation (risk level) and spending when the university or nonprofit has a preference for fairness across generations.

Merton (1993) maps his earlier work on optimal portfolio choice (Merton, 1969, 1971, 1973) onto a university endowment framework, redefining consumption in his standard model as expenditure on internal projects. Merton's conclusions on asset allocation remain unchanged in this setting: The endowment should be viewed as a portfolio made up of a liability-hedging component and an investment component and it should hedge against adverse changes in the investment opportunity set that should include all of the university's assets (real estate, donors, etc.). While Merton refuses to define an objective function for the university, Constantinides (1993) discusses the importance of both choosing the correct objective function for a university and allowing for heterogeneity across universities, something we explicitly do in this paper.[2]

Building on Merton's work, Dybvig (1995, 1999) builds a model where the spending rule and asset allocation are linked in order to preserve spending power. However, like Merton, Dybvig does not define an objective function for the university and therefore is not able to take the preferences of the stakeholders into account. All of the above theories, as well as mean-variance analysis and the notion of stocks for the long-run (Siegel, 2008) for instance, do not allow for an explicit link between the endowment and the mission and goals of the university as established by its stakeholders. Our positive theory breaks this notion of the endowment is mostly viewed as a stand-alone portfolio and quantitatively analyzes the impact of the university's objective function for the management of the endowment.

Black (1976) denounces as ungrounded the typical argument that because of their very long horizon, universities can afford to take more risk. Since risk must eventually be borne by individuals, such risky asset allocations unfairly punish some generations for the benefit of other ones. Hansmann (1990) expresses a skeptical viewpoint on the reasons for the existence of endowments. He argues that, beyond motives of creating a savings buffer

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[2]Hoxby (2012) qualitatively discusses a possible venture-capital based objective function but abstracts from the individual stakeholders of the university nor does she provide any quantitative implications.

against bad times, all other arguments for the existence of endowments are unpersuasive. While we do not question the reasons endowments exist, we do explicitly model Black's intuition that risk is borne by the various stakeholders of the university who jointly exert control over the university operations as well as the management of the endowment.

Our paper is also related to the literature on corporate control and agency problems in not-for-profit institutions (Alchian and Demsetz, 1972; Hansmann, 1980, 2000; Fama and Jensen, 1983a, 1983b, 1985; Glaeser and Shleifer, 2001; Fisman and Hubbard, 2005). However, little is written on the actual objective function of universities and nonprofits, something we explicitly focus on.

To the best of our knowledge, we are the first to take a stand on the objective function of universities or, to be more precise, of their stakeholders. This objective function allows us to explicitly solve for endogenous payout, investment and asset allocation policies. Since risk is borne by people – the walls of the university cannot absorb risk – we focus our model on the joint optimization of the various stakeholders in the university, who ultimately have to pay the cost, and receive the benefit, of their decisions.

3   University Objective Function and Stakeholders

Characterizing a university's optimal trade-off between expanding the production of social dividends through risky internal investment and expanding the endowment through risky external investment in the capital markets requires a stance on the university's objective function. The objective function we study captures a realistic feature of the university: the tension and ensuing agency conflict between its different stakeholders.

3.1   Objective Function

As a not-for-profit institution, a university lacks explicit residual claimants with control rights. Nevertheless a university has sets of individuals who exert control and have the ability to gain from their actions. We call these individuals with a controlling interest stake-

holders. We divide these stakeholders into two sets, the self-interested and the altruistic, based on how they gain from their actions[3]. The self-interested stakeholders gain when the university increases personal payments to them via wages and perquisites. These payments are private goods that are diluted as the number of stakeholders increase. This dilution makes the self-interested dislike university growth. Altruistic stakeholders gain when the university expands its production of social dividends: research and teaching. These social dividends are a public good; so the altruistic suffer no dilution as the university expands. Hence the altruistic prefer university growth.

Both sets of stakeholders suffer when the university receives a bad shock and is forced to reduce its scope of operations. The self-interested only receive payments during their association with the university. When the university shrinks they face the risk of firing and the termination of all future payments. The altruistic suffer from the reduced production of social dividends. Thus both sets of stakeholders dislike risk.

We model the bargaining between stakeholders in reduced form as a convex combination of their individual value functions with a bargaining power parameter β. This gives rise to the following value function V that the university as a whole maximizes:

$$V(\mathcal{C}_t, \theta_t) = (1 - \beta) \times V_A(\mathcal{C}_t, \theta_t) + \beta \times V_S(\mathcal{C}_t, \theta_t) \tag{1}$$

where V_A is the value function of the altruistic stakeholders, V_S is the value function of the self-interested stakeholders and β represents the level of control the self-interested stakeholders exert. $\mathcal{C}_t$ is the set of choice variables available to the university each period:

$$\mathcal{C}_t = \{EndPay_t, IntInv_t, \alpha_t\}. \tag{2}$$

$EndPay_t$ is the total endowment payout, $IntInv_t$ is the amount of internal investment, and α_t is the fraction of the endowment allocated to the risky asset.[4] The set of state

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[3]We are not making any statements about whether these labels are "good" or "bad". Instead we are simply categorizing the preferences of each set of stakeholders in the spirit of Becker (1976).

[4]Optimal choices are denoted with a star.

variables each period is

$$\theta_t = \{K_t, I_t, End_t, X_t\} \tag{3}$$

where K_t is the university capital, I_t is the fraction of unvested projects, End_t is the size of the university's endowment, and X_t is the conditional expected return of the risky asset. We explain how the choice and state variables interact in Section 4.

3.2 Altruistic Stakeholders

We label one set of university stakeholders as *altruistic* because they have a preference for the production of social dividends. Plausible member of this set are alumni, members of the community, and generous benefactors who, among many others, donate to universities because they value the social dividends that are or will be created with the help of their gift.[5]

In addition to donors, a significant fraction of the faculty and the administration may be placed in this altruistic set because they value the university's expansion. Researchers want more colleagues to interact with and deans want more professors since they value the prestige of the university as it increases its production of social dividends.[6] For public universities, taxpayers (the state) are also part of this set in that they support a low-cost access to education for in-state students. It is important to keep in mind that the labeling of particular stakeholders as altruistic, or self-interested, is not crucial for our theory – it only affects the interpretation of the bargaining power between the two sets.

We take donations as exogenous and do not model why donors donate or why altruism is a significant part of these stakeholders' preferences. We take as given the findings of Fehr and Fischbacher (2003) who show the importance of both altruism and selfishness in the organization of human societies. In the U.S. in particular, individuals and organizations

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[5]One could view the social dividend more narrowly as something only benefiting a subset of society of which the altruistic stakeholders are a member.

[6]In our setting, the empire-building desires of university administrators can be mapped to the altruistic set of stakeholders. This mapping holds because the desire for more productive university capital is equivalent the desire for the production of more social dividends in our model. This mapping breaks down if the empire building goals are focused on the size of the university endowment.

donate large amounts every year to not-for-profit organizations (Rose-Ackerman, 1996). Numerous papers show that alumni donate to their alma mater in order to further the institution's educational quality (Baade and Sundberg, 1996; Clotfelter, 2003; Ehrenberg and Smith, 2003). There are countless examples of schools being named after a donor who has provided a significant gift, such as Vanderbilt and Carnegie-Mellon, or on a smaller scale scale buildings on a university campus. The altruistic stakeholders may value other things in addition to the creation of social dividends. Indeed, donors may value the prestige and immortality associated with their gift, but we make the critical assumption that they would rather see a university or building bearing their name producing research and teaching than sitting idle.[7]

Following this assumption altruistic stakeholders have expected utility u_A with time discount rate δ and constant relative risk aversion period utility over social dividends SD:

$$\sum_{\tau=t}^{\infty} \delta^{\tau-t} E_t[u_A(SD_\tau)] \tag{4}$$

where

$$u_A(SD_\tau) = \frac{SD_\tau^{1-\gamma_A}}{1-\gamma_A} \tag{5}$$

where γ_A is the stakeholders' coefficient of relative risk aversion. The infinitely-lived altruistic stakeholders therefore want to maximize the production of social dividends but they are averse to variations in this production.

3.3   Self-Interested Stakeholders

We label a second set of university stakeholders as *self-interested* because they want to maximize their personal lifetime payments from the university. These payments come in the form of fixed benefits (wages) as well as the variable consumption of perquisities. While a significant fraction of the university's faculty and administration may be altruistic, it is clear that a significant fraction may be self-interested. The self-interested faculty

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[7]We return to this assumption in Section 7 and consider the impact of weakening it.

want larger personal research budgets, larger personal travel budgets, more research and teaching assistants for themselves. These types of spending can clearly increase research and teaching output. Thus altruistic faculty value these types of spending as well, but they desire the spending go to the most productive part of the university. This distinction may be made at the department level with departments valuing spending only on their members but not on member of other departments. Self interest at the administration level is exemplified by the desire for more staff or new buildings with larger offices and state-of-the-art technology all run by themselves not another administrator in a potentially more productive part of the university. Students may be placed in this set of self-interested stakeholders: they receive a fixed benefit (instruction) but want to maximize the amount and quality of scholarships, student activities, dorms, and athletic facilities they personally receive during their time within the university.

We are not the first to posit agency costs within non-profits. Winston (1999), Ehrenberg (1999), and Clotfelter (1999) document agency problems between the different stakeholders and power brokers within universities.[8] Moreover, even donors can have self-interested motives, as documented by Meer and Rosen (2009). New York University provides a current example of self-interested stakeholders resisting expansion: The faculty held a no confidence vote against the university president to oppose expansion of the university abroad and even its expansion within New York City.[9]

Compared to the standard corporate finance setting where CEO compensation is the subject of much scrutiny, our focus is not on the compensation of university presidents or football coaches, but instead pequisities consumed widely throughout the university structure. We do not assume that perquisites consumption is completely inefficient. For instance, a larger research budget does benefit the production of social dividends even though it leads to overseas trips to conferences that get combined with personal vacation. As such, perquisities consumption can be a tax efficient way of providing compensation,

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[8]See Glaeser (2003) for a comprehensive analysis of the governance structure of nonprofit institutions.

[9]`www.nytimes.com/2013/03/10/nyregion/john-sexton-is-tested-by-nyu-faculty.html?smid=pl-share`

and the co-variation between perquisities consumption and the university's financial health may even be an efficient way of sharing risk among the stakeholders who otherwise have inflexible contracts.

Our focus is also not on whether there is over-consumption of perks. Instead we seek to understand how the availability of perks changes incentives (Jensen and Meckling, 1976), leading to an agency conflict within the university between the altruistic and the self-interested stakeholders.[10] In the context of university endowments, the fact that perks co-vary positively with the state of the overall university makes them particularly important to include in our model.[11]

For tractability, we reduce all the benefits received by the self-interested stakeholders from the university to one-dimensional consumption. This consumption is a cash flow formed as the sum of a semi-fixed component and the more variable perks component. We will refer to this semi-fixed component as wages or net maintenance, which is reduced only if the university shrinks.

An important assumption of our setup is that growth through internal projects dilutes the claim of the existing self-interested stakeholders to the university resources. Everything held constant, hiring a new faculty member or creating a new school, such as the school of music, increases the number of stakeholders while the size of the available surplus, the accumulated endowment, stays constant.

Following these assumptions, self-interested stakeholders have expected utility u_S with time discount rate δ and constant relative risk aversion period utility over their consumption c_t:

$$\sum_{\tau=t}^{\infty} \delta^{\tau-t} E_t[u_S(c_\tau)] \tag{6}$$

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[10]Core et al. (2006) show that excess endowments in nonprofit firms are associated with greater agency problems: institutions with excess endowments do not grow faster, they invest less internally in their charitable good, and they have higher executive compensation. Using not-for-profit hospitals, Adelino et al. (2012) document significant sensitivity of capital expenditures to endowment shocks, particularly in U.S. states with poor regulatory oversight.

[11]Brown et al. (2012a) show that various perks are quickly eliminated as endowment payouts are cut in times of budgetary strain.

where

$$u_S(c_\tau) = \frac{c_\tau^{1-\gamma_S}}{1-\gamma_S} \tag{7}$$

where γ_S is the self-interested stakeholders' coefficient of relative risk aversion. Like the altruistic stakeholders, the self-interested stakeholders are infinitely lived, an assumption we relax in Section 7. Their consumption is a proportional fraction of the total endowment payout in the form of wages and perks, which is explained in the next section.

4 The University as Producer of Social Dividends

In this section, we explain how the production of social dividends distinguishes a university from a standard firm. We define the university's production function, its investment in internal university capital, and how the endowment evolves due to capital market returns and donations.

4.1 Social Dividends

Universities organize and implement investment projects that have large positive value for society, but which cannot be completely captured and charged for in the private markets. Famous examples of university production are the development of the laws of motion by Isaac Newton, the discovery of penicillin by Alexander Fleming, and the invention of the Black-Scholes-Merton options pricing model by Fisher Black, Robert Merton, and Myron Scholes. Large research laboratories are built within universities to allow researchers the freedom to push the frontier of science. These research projects may produce capturable externalities (or economies of scope) when combined with teaching. For example learning about a new technology from its inventor provides a head start in the market place when trying to implement the new technology.

We focus on the funding of the portion of university production that is a public good. These public goods range from the huge benefit of a university professor discovering

the cure for cancer to the smaller, but still important, value of a well-informed citizen gained when a student works to complete a bachelor's degree. We define this output of the university's production as *social dividends*. These social dividends are non-monetary and non-capturable public goods, mainly stemming from research and teaching.

In our model, the social dividends SD_t are produced each period in proportion to the university's stock of internal capital K_t:

$$SD_t = K_t \times sd \tag{8}$$

where sd is a scaling parameter.[12] Underlying our framework is the notion of the university as a *stock of capital* such as buildings, faculty, students, etc., and that this capital leads to the production of social dividends in a deterministic way. Indeed, research and teaching are both cumulative and exploratory in nature, where every marginal unit of capital leads to a marginal increase in output. Large advances occur on a periodic basis but usually knowledge is built slowly by standing on the knowledge of others.

4.2 Investment in University Capital

Universities invest funds in *internal projects* to generate new university capital K_t. For a given positive internal investment $IntInv_t$, the university obtains the following increase in capital:

$$K_{t+1} - K_t = K_t \times f\left(\frac{IntInv_t}{K_t}\right) \quad \text{where} \quad IntInv_t \geq 0 \tag{9}$$

where f is the production function of the university that transforms (dollar) funds, possibly from the endowment or donations, into new university capital. We assume the following functional form for the production function:

$$f(y) = \ln(Ay + 1) \tag{10}$$

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[12]The calibration of all parameters is discussed in Section 5.

where A captures the productivity of the university's marginal project – new higher productivity projects produce more university capital per unit invested. Projects have decreasing returns to scale for a fixed university capital stock, but linear returns to scale as the university's capital stock grows. This specification implies that increasing the size of the university by 100% in one period costs more than twice as much as increasing the university size by 50%. But a university twice as large may install twice as much capital at (only) twice the cost. As soon as internal investment occurs and new capital is added to the existing stock, the new capital is able to produce social dividends such as research and graduates.

In each period, the university must meet the cost of maintaining and operating its current stock of internal capital, which includes paying wages to its employees, or it will be forced to shrink its operations. There are countless examples of universities shrinking, failing, and entering bankruptcy. The University of Chicago is one example of bankruptcy. An earlier University of Chicago (now known as the Old University of Chicago) founded in 1857 closed due to bankruptcy in 1886. The current University of Chicago was incorporated with a new donation from Rockefeller in 1890. The university's emblem of a phoenix rising from fire is a representation of this rebirth.[13] A more recent example of a university shrinking is when New York University sold off its engineering school located at the University Heights campus in 1973 due to financial difficulties.[14] At the height of the recent financial crisis, Harvard dramatically shrunk new projects because of financial duress driven by the endowment's losses (Ang, 2011).

Under the assumption of a balanced university budget (see Appendix A), we define this minimum amount that must be paid from the endowment and potential donations in each period as the *net* maintenance cost $NetMnt_t$ of the university:

$$NetMnt_t = NetMnt \times K_t \tag{11}$$

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[13] secretary.uchicago.edu/page/emblems
[14] www.nyu.edu/library/bobst/research/arch/thenandnow/

where $NetMnt$ is a scaling variable. If this net maintenance cost cannot be met, then the university capital shrinks immediately to the fraction that the university can support from this period's endowment payout defined as $EndPay_t$:

$$K_{t+1} = \frac{EndPay_t}{NetMnt_t} K_t \quad \text{if} \quad EndPay_t < NetMnt_t. \tag{12}$$

We assume that the university may not shrink and invest simultaneously, but rather that the net maintenance cost must be met before any new internal investments can be made. Thus we have the following capital evolution equation:

$$K_{t+1} = \begin{cases} K_t + K_t f\left(\frac{IntInv_t}{K_t}\right) & \text{if} \quad EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t} K_t & \text{if} \quad EndPay_t < NetMnt_t. \end{cases} \tag{13}$$

Our production function captures only the mean productivity of an internal project, which implies that projects produce a deterministic amount of social dividends so long as the net maintenance cost is paid. Thus we do not directly model the fact that university projects themselves may produce different amounts of social dividends: some research agendas fail and some students do not graduate.[15] For simplicity, we combine all of the risks of internal projects into their stochastic generation of donations, which is specified in the next subsection.

4.3 Donations, Endowment Dynamics and Payouts

Internal projects, besides generating social dividends, also generate a cash flow: donations. Schools and laboratories are often built following a capital campaign aimed at raising funds for the project at hand. But once a project is built, once faculty members are hired to fulfill their research and teaching goals, and once students start graduating, new donations arise. If a professor makes a discovery, an endowed chair will probably be created for him or her.

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[15]To the extent that the type of risk we ignore is idiosyncratic, it will have only a small effect on university endowment asset allocation decisions. Moreover the directional effect of this ignored idiosyncratic risk would be to push the university toward a safer endowment so as to reduce the risk of shrinking.

Successful students tend to give back to their alma maters many years after graduation.

We assume that projects take some time to mature or vest after the initial internal investment. A new business school takes some time to build. It takes two years to generate the first MBA students and four years to generate the first business majors. In addition, even more time may elapse before these students are able and willing to give back to their alma mater. As a result, donations only accrue from projects that have vested. We keep track of a state variable, I_t, which denotes the fraction of current university capital that is unvested and hence not yet generating donations. The evolution equation of this state variable is:

$$I_{t+1} = \begin{cases} \frac{K_t}{K_{t+1}} I_t (1 - vest) + \frac{K_t}{K_{t+1}} f\left(\frac{IntInv_t}{K_t}\right) & \text{if} \quad EndPay_t \geq NetMnt_t \\ I_t (1 - vest) & \text{if} \quad EndPay_t < NetMnt_t \end{cases} \tag{14}$$

where $vest$ is the fraction of unvested projects that vest each period. If the university shrinks, capital is destroyed in equal proportions across the vested and unvested projects.

We assume that donations are stochastic and follow the same process as the risky asset traded in the capital markets, i.e., donations are cyclical, rising and falling with the overall economy. This assumption is consistent with the findings of Brown et al. (2012b). In our model, this donation risk is the sole source of risk that affects the university's internal projects. At the end of each period, the university receives the following donations from its vested projects:

$$\hat{K}_t (1 - I_t) \times DS \times \tilde{R}_{t+1} \tag{15}$$

where DS is a scaling parameter and $\tilde{R}_{t+1}$ is the return of the risky asset. $\hat{K}_t$ is the amount of university capital at the end of each period when donations accrue, and it is defined as:

$$\hat{K}_t = \begin{cases} K_t & \text{if} \quad EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t} K_t & \text{if} \quad EndPay_t < NetMnt_t. \end{cases} \tag{16}$$

We do not endogenize the type of donation that any one donor might choose (e.g. current-use versus endowment capital). Endogenizing this division would require a full model of the bargaining game between donors and the university and such a model is beyond the scope of this work. Our simplification complicates the interpretation of our model's endowment size and payout rate, issues we revisit in Section 6. Our simplification does not affect the interpretation of the endowment asset allocation between risky and risk-free assets.

Donations go into the endowment at the end of each time period. At the beginning of each period, the university funds itself out of the endowment and the remaining endowment is then allocated between a risky asset and a risk-free asset. The endowment evolution equation is as follows:

$$
\begin{aligned}
End_{t+1} &= (End_t - EndPay_t) \times (\alpha_t \tilde{R}_{t+1} + (1 - \alpha_t)R_f) \\
&\quad + \underbrace{\hat{K}_t(1 - I_t) \times DS \times \tilde{R}_{t+1}}_{\text{Donations}}
\end{aligned} \tag{17}
$$

where End_t is the value of the endowment at time t, $\tilde{R}_{t+1}$ is the return of the risky asset between time t and time $t+1$, and R_f is the constant risk-free rate of return. In this setup, the university cannot use this period's donations to pay for current expenditures.[16]

Each period the university chooses its asset allocation. The university invests the endowment assets, net of $EndPay_t$, in a risky stock and a risk-free bond, and the proportion of the endowment invested in the risky asset is labeled as α_t. We rule out net leverage and shorting by constraining α_t between 0 and 1.

In each period, in addition to its endowment asset allocation α_t and the total payout from the endowment $EndPay_t$, the university must choose how to split the endowment payout between new investment in internal projects, $IntInv_t$, and payment of perquisites to its self-interested stakeholders, $Perks_t$ (see Section 3). The total endowment payout falls on a continuum between 0 and the total value of the endowment, End_t. This continuum is

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[16]Donations occur at the end of each period whereas expenditures must be paid at the beginning of each period.

separated into two regions (see Figure 2). In the first region, the university fails to meet its current net maintenance cost $NetMnt_t$ and shrinks its operations. At the division between the two regions the university exactly meets it net maintenance cost of current operations and neither shrinks nor grows. In the second region, the university chooses to split the endowment payout above the net maintenance costs between internal investment into new projects and the payment of perks to the self-interested stakeholders. The university's decision process is described in the next subsection.

4.4 Model Timing, Summary and Discussion

4.4.1 Model Timing

Figure 2 shows the sequence of events taking place at each time period in the model. The university enters the period with a particular endowment size End_t and a particular stock of projects, K_t, of which fraction I_t are unvested (non-donation producing). The amount of social dividends produced SD_t is a function of this current stock of projects. In period t, the university makes three choices: how much to invest internally in new projects ($IntInv_t^*$), how much to pay to self-interested stakeholders ($Perks_t^*$), and how to allocate the remainder of the endowment between safe and risky assets (α_t^*).

The total endowment payout($EndPay_t^*$) can be any value between 0 and the total value of the endowment. However, when deciding how much to pay out, the university follows a payout continuum: it must first either cover its net maintenance cost or shrink; only if it does not shrink can it then choose to pay perquisites to its self-interested stakeholders and simultaneously choose to invest and thereby grow internally.

The university must also decide how much of the remaining endowment should be invested in the risky asset. The endowment evolution from t to $t+1$ then takes place where the endowment grows based on its stochastic return and the new donations. The university capital stock grows based on its internal investment, and a fraction ($vest$) of the previously unvested projects vest and begin producing donations.

4.4.2 Maximization Summary

Summarizing our model, the university solves the following optimization:

$$\max_{\{\mathcal{C}_t\}} \quad (1-\beta) \times V_A(\mathcal{C}_t, \theta_t) + \beta \times V_S(\mathcal{C}_t, \theta_t) \tag{18}$$

by choosing a total endowment payout, the split of the payout between new internal investments and perks (after having paid the net maintenance cost), as well as the asset allocation of the remainder of the endowment. β is the governance parameter that characterize the balance of control between the altruistic and self-interested stakeholders. Given the university's production function and the model's timing, we can write the utility function of the altruistic stakeholders recursively with the addition of the university's optimal future choice variables, $\mathcal{C}^*$, to express their value function in terms of this period's choice and state variables:

$$V_A(\mathcal{C}_t, \theta_t) = u_A(K_t \times sd) + \delta E_t[V_A(\mathcal{C}^*_{t+1}, \theta_{t+1})] \tag{19}$$

where the production of social dividend SD is proportional to the university's capital K. Similarly, we can write the utility function of the self-interested stakeholders as:

$$V_S(\mathcal{C}_t, \theta_t) = \begin{cases} u_S\left(\frac{EndPay_t - IntInv_t}{K_t}\right) + \delta E_t[V_S(\mathcal{C}^*_{t+1}, \theta_{t+1})] & \text{if } EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t}\left[u_S\left(\frac{EndPay_t}{K_{t+1}}\right) + \delta E_t[V_S(\mathcal{C}^*_{t+1}, \theta_{t+1})]\right] & \\ \quad + \left(1 - \frac{EndPay_t}{NetMnt_t}\right) \times [\text{outside option}] & \text{if } EndPay_t < NetMnt_t \end{cases} \tag{20}$$

where the self-interested stakeholders' outside option is the utility from an infinite stream of their current wage, i.e., when fired, they lose the ability to earn perks:

$$\text{outside option} = \sum_{\tau=t}^{\infty} \delta^{\tau-t} u_S(NetMnt). \tag{21}$$

In Section 7, we relax this assumption by allowing the stakeholders to lose some fraction of their current wage in addition to the ability to earn perks. We see in equation (20) why self-interested stakeholders are averse to variations in donations as well as variations in the payout from the endowment. This aversion occurs because bad outcomes have two important effects. First, perks are withdrawn if the university barely has enough cash on hand to pay the continuing net maintenance costs of existing projects. Second, if far left-tail events occur, faculty and staff can be fired, students dismissed, and alumni programs reduced, which leads to a permanent loss of perks.

4.4.3 Discussion

We do not analyze the source of the contract with university employees, including the contract with the endowment's investment staff and chief investment officer, nor the total amount of expected compensation received under the contract.[17] Our focus is on the implications of this contract for investment and endowment decisions. In a competitive labor market, it could be reasonable to assume that the total level of expected compensation through wages and perks is efficient. This contract may even be an efficient way of sharing risk between donors and employees.

However, we are assuming that the university labor market is not frictionless. One clear friction is that changing universities is costly. Professors accumulate a significant amount of university-specific knowledge and, together with their families, they consume significant amounts of location-specific rents, such as the weather in California. Another friction is the difficulty of monitoring research production (effort). When monitoring costs are high one would expect no rents ex-ante but rents ex-post to maintain incentives. Those faculty earning ex-post rents then become tied to their particular university as described in our model.

For simplicity, our model ignores the risks inherent in some of the university's budgetary cash flows (see Section 5 and Appendix A). For instance, income from tuition and

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[17]See Brown et al. (2011) for an analysis of the endowment investment and advisory committees of U.S. universities.

grants is clearly stochastic but we choose to make both of them known and scaling linearly with the size of the university's internal capital. This assumption has two effects. First, it makes the internal projects appear safer than they really are. As a result, given a limited risk-bearing capacity, the university will have an incentive to take risk in external projects (the capital markets). Second, since the internal projects appear safer, then for a given expected return, the university will have an added incentive to invest internally.[18]

Another aspect of the university that we do not model is the stochastic nature of the internal projects' arrival rate. If positive net present value (NPV) projects are expected to arrive on a steady basis, then it is likely optimal for the university to maintain a relatively safe and liquid endowment that allows flexibility in its internal investment policy. However, if high positive-NPV projects are few and far between, then it may be optimal for the university to take risk externally while waiting for the next great research area to become clear (such as nanotechnology). We leave these extensions for future research.

5   Calibration

In this section we discuss the calibration of our model's parameters. The full list of our parameter choices is in Table 1. We divide the parameters into three groups: those related to the university's internal projects; those related to the university stakeholders; and those related to the endowment. As a reference, in Appendix A, we establish the budgeting process of the university and define the notion of net maintenance cost.

5.1   University Internal Projects

5.1.1   Cost of Internal Production and Net Maintenance

We calibrate the cost of internal production relative to the size of the endowment. The calibration involves the ratio of initial cost of investment to the total continuing cost of an

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[18]Dimmock (2012) presents evidence that universities whose non-financial income (tuition, fees, grants, etc.) is more volatile invest more of their endowment in fixed income assets and reduce their allocation to risky assets.

internal project. When a university chooses to expand it must pay an initial cost to create and install the capital – building a library and purchasing the initial books. This initial cost is embodied in our installation cost function (equation (10)). In each subsequent period the university must pay a continuing cost. This gross maintenance cost can be thought of as the payment to buy new books, replace ones that are destroyed and paying staff to run the library. In the case of a library the ratio of initial costs to per period continuing costs is greater than 1. For other university projects such as creating a new faculty line this ratio is likely less than 1, for the recruiting costs are surely less than the continued salary cost.

The ratio of initial to continuing costs affects the riskiness of internal projects because it affects the cost of replacing capital after the university shrinks. A higher ratio makes internal projects riskier. Without strong guidance on this ratio, we set it to 1. The main reason for this choice is that it makes the risk of internal projects closer to that of the external risky asset and eases our approximate pricing of internal projects.

The second part of this calibration involves calculating the fraction of the university budget that is supported out of the endowment and donations compared to support from other sources such as tuition, fees and grants. This then allows us to calibrate the fraction of the budget that the net maintenance cost represents. In Appendix A, we define both the gross and net maintenance cost of the university and we establish the link between the net maintenance cost of the university and the choice variables in our model:

$$NetMnt_t + Perks_t + IntInv_t = EndPay_t + Donations_t. \qquad (22)$$

Table 2.2 on page 21 in Swensen (2009), based on a report from Moody's Investors Service, shows that the average university receives 75% of its annual revenue stream from tuition, fees, and grants. Of the remaining 25%, 10% comes from donations and 15% from investment income out of the endowment. Under the balanced budget assumption of equation (22), this implies that $NetMnt_t + Perks_t + IntInv_t$ must be equal to 25% of the total

budget.

We make the assumption the net maintenance is 20% of the annual budget, which implies that perks and internal investment average 5% of the university budget. Under the assumption that the ratio of fixed investment costs to per period continuing cost is 1, we get that our $NetMnt$ parameter equals 0.20. Hence 1 unit of endowment is equivalent to 5 years worth of net maintenance payments or 1 years' worth of the entire university's budget.

5.1.2 Production Function and Social Dividends

We consider three different levels of *productivity* for the university's internal projects. Project productivity enters through equation (10), which defines the amount of university capital produced for each dollar of internal investment. The A parameter controls the derivative of capital production with respect to dollars invested. When $A = 1$ which we label as *medium* productivity marginal projects, this derivative is 1 for the initial marginal investment each period. When $A = 1/4$, labeled *low* productivity marginal projects, the derivative is $1/4$ and when $A = 4$, labeled *high* productivity marginal projects the derivative is 4.[19]

Regardless of the productivity of the marginal projects available, all universities have a uniform social dividend production function that produces social dividends in proportion to university capital (equation (8)). The choice of the proportionality constant sd is a normalization that affects the interpretation of β, the bargaining power parameter between the altruistic and self-interested stakeholders. We normalize sd such that the marginal utility of altruistic stakeholders from an additional unit of university capital and the marginal utility of self-interested stakeholders from an additional unit of income are approximately equal. We obtain a value of $sd = 0.27$ and this normalization makes $\beta = \frac{1}{2}$ approximately equal to the case of even bargaining power.

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[19]Furman and Stern (2011) empirically show that effective research institutions are able to amplify the cumulative impact of individual scientific discoveries.

5.1.3 Internal Project Vesting and Donations

Internal university projects produce not just social dividends but donations as well, even though the projects take time before they begin producing donations (vest). We assume that 5% of projects vest each year, which means that the half-life of unvested projects is about 14 years.[20] This delay between when a project is undertaken and when it begins producing donations means the university must finance the maintenance cost of new projects out of the endowment for many years. Thus, slow project vesting creates another motive for having an endowment.

The rate at which internal projects generate donations is a critical component of the projects' NPV. A university that has a low donation rate has lower NPV projects all else equal than a university with a high donation rate. We focus our variation in project NPV on the installation cost of capital rather than through variation in donation rates. Thus we set a constant donation rate per unit of university capital (DS in equation (15)) across all cases we consider. We do not want the internal projects to have an unreasonably high NPV and bias our analysis toward internal projects. Thus we choose this constant donation rate DS such that the initial marginal investment of a university with medium productivity ($A = 1$) has an NPV of zero, leading to $DS = 0.47$.[21]

5.2 University Stakeholders

We assume that both the altruistic and self-interested stakeholders have coefficients of relative risk aversion of 5 in their respective CRRA utility functions. This moderate level of risk aversion is in line with the large-sample survey evidence from Barsky et al. (1997). Following Campbell and Viceira (1999) and the evidence in Barsky et al. (1997), we give

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[20]Phrased differently, half of the new projects will generate donations after 14 years. 75% of the new projects will generate donations after 28 years. And nearly 90% of the new projects will generate donations after 42 years.

[21]That is, we consider the NPV for the first marginal unit of internal investment. This is where each university has the highest productivity projects each period. For all higher investment values, the internal projects have negative NPV. Because donations have the same stochastic properties as the risky asset, we use the unconditional risky asset return as the discount rate for calculating the NPV of internal projects.

both sets of stakeholders a time discount rate of $\delta = 0.94$ in annual terms, implying moderate levels of patience. In Section 7, we analyze how changes in these parameters affect the optimal asset allocation and investment policies.

5.3 Endowment and Return Process

The endowment's annual payout can be either unconstrained, i.e., 100% of the endowment can be paid out, or constrained to a maximum payout rate. We use a maximum payout rate of 5%, in line with the empirical average documented by the most recent National Association of College and University Business Officers (NACUBO) survey. The Uniform Prudent Management of Institutional Funds Act (UPMIFA) sets the "imprudent" maximum payout limit at 7%, which does not lead to any qualitative difference in our findings.

It is well known that stocks outperform bonds over the long-run (Siegel, 2008) and that it is optimal for long-horizon investors to take more risk in their portfolio compared to one-period investors (Campbell and Viceira, 2002). In order to capture this crucial feature of universities as probably the longest-horizon investors in the market, we assume that the risky asset's expected excess returns follow a highly persistent mean-reverting process: if realized returns are high today then expected returns are likely to be low tomorrow, and vice versa. The setup and parameter choices for the risky asset's return process are taken directly from Campbell and Viceira (1999) and are explained in Appendix B.[22] The unconditional expected log excess return is 5% per year and the annual volatility of the stock return is 14.55%. The log risk-free rate is 0.28% per year (constant). Our return parameters are all in real terms, making inflation a non-issue in our setup.

Our model also assumes that endowment investments in risky assets do not generate alpha. Alpha seems be present for a small set of elite universities and top-performing endowments as noted by Brown et al. (2010), who report some evidence of skill in security

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[22]Even though university endowments invest significant amounts in more illiquid assets than the equity markets, such as private equity and hedge funds, we bundle all risky assets into one. Ang et al. (2012) show that investing in illiquid assets can be suboptimal since consumption must be financed out of liquid assets.

selection on the part of university endowment managers. However, Barber and Wang (2012) show that the average endowment earns no alpha and that, for the largest endowment funds, their average asset allocation is the most important factor in explaining their superior returns of the last two decades.

6   Results and Analysis

The form of our model does not allow closed-form analytical solutions for the optimal investment and payout policies. We therefore use numerical solutions. We proceed via standard methods of value function iteration combined with linear interpolation over a discretized state space. We use Gaussian quadrature to approximate the normal distribution of the innovations of the random shocks in the return process (Judd, 1998). Our only departure from standard practice lies in the fact that we iterate over two value functions: the altruistic stakeholders' utility function and the self-interested stakeholders' utility function. This feature produces no complications other than to slow the computations. All value functions are well behaved and convergence is achieved within a few hundred iterations.[23] Once the value functions have converged, we calculate the model's stochastic steady state as the point in the state space where the agents would choose to remain were all realized shocks in the return process equal to zero.

Throughout the analysis of the results, we vary the three key free parameters in the following way. The governance parameter of the university β takes the value of 0 for full altruistic stakeholder control, 1 for full self-interested stakeholder control, and 1/2 for the intermediate case where control of the university is shared between the two sets of stakeholders. The slope of the production function A takes the value of 1 for the medium productivity case, 4 for the high productivity case, and 1/4 for the low productivity case. The endowment payout is either unconstrained (100% possible payout) or constrained to 5% of the value of the endowment.

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[23] All results are shown at 250 iterations, which is equivalent to 250 years.

6.1 Steady State Endowment Characteristics

Endowment Asset Allocation. Panel A of Table 2 shows the endowment's stochastic steady state asset allocation to the risky asset across the different governance, production, and constraint parameters. For any level of governance and payout constraint, the allocation to the risky asset increases as the productivity of the university's marginal project decreases. For instance, for the $\beta = 1/2$ case, the allocation increases from 44% to 63% in the unconstrained case and from 86% to 100% in the constrained case as the productivity of the marginal project falls from high to low. The university has a limited risk-bearing capacity and it must choose whether to take this risk internally via new projects or externally in the capital markets via the endowment. This result shows that, as the productivity of its marginal internal project falls, the university takes more risk externally. Similarly, if the university's marginal project is highly productive, then it takes little risk externally instead focusing its attention internally. Everything held equal, a risky endowment is a signal of the low productivity of the university's marginal internal project.

Labeling universities with the riskiest endowments as the universities with the least productive marginal projects is obviously a provocative statement. It is highly unlikely that Harvard, Yale, Princeton, and Stanford have no good marginal projects to invest in. However, the model in the first row of Panel A is the most streamlined model of universities: the stakeholders in control have a preference solely for the production of social dividends. Absent any other friction, if, in stochastic steady state, the altruistic stakeholders have no good marginal projects to invest in within the university, they will build a large endowment composed of risky investments. This result may explain the behavior of some universities, but it seems likely that other frictions are at play.

The governance structure of the university also affects the endowment's asset allocation in a significant way. In an altruistic stakeholder-controlled university ($\beta = 0$), the endowment is significantly less invested in the risky asset compared to a similarly productive university controlled by self-interested stakeholders($\beta = 1$). For the unconstrained case at the medium production function, the allocation to the risky asset rises from 0% to

100% as the governance shifts from altruistic to self-interested stakeholders. Everything held equal, a risky endowment is a signal that the governance of the university is in the hands of self-interested stakeholders.

The self-interested stockholder's preference for external risk-taking is driven by the way the downside and upside of risk are borne. Both sets of stakeholders are risk averse and suffer when a lack of resources causes the university to shrink, leading to the destruction of valuable university capital. Altruistic stakeholders suffer the permanent loss of all future social dividends that the destroyed capital would have produced. Some self-interested stakeholders are fired, losing any surplus they gain from their association with the university. However, both sets stakeholders gain differently from the upside of risk depending upon its source. The risk of internal projects benefits altruists through the increased production of social dividends but harms the self-interested ones. Indeed, new internal projects bring with them new self-interested stakeholders who dilute the claims of the current stakeholders to the university surplus (the accumulated endowment). Thus self-interested stakeholders bear all the downside risk of internal projects but only a fraction of the upside. In contrast, the risk of external investment in the capital markets via the endowment does not come with this dilution, so if risk is to be taken, self-interested stakeholders prefer external investment.

Absent any difference in the productivity of marginal projects, two universities may have very different endowment allocations to risky assets because of a difference in outcome of the agency conflict between altruistic and self-interested stakeholders. In this simple model where governance is the only friction at play, a university with a risky endowment is a university that is governed by stakeholders who resist expansion. These could be donors who want to maximize the prestige of their degree and expansion dilutes the university's brand value. In a business school, these could be students from a given degree program who do not want resources taken away from them and spent on a new degree program. These could be faculty members who want to maximize their research budgets and minimize the hiring of new colleagues because those colleagues, though appealing from an intellectual

standpoint, do take away a share of the resources. These could be the members of a given school (humanities) who are pushing back against the extension of another, perhaps more profitable, school (business). While it seems clear that such agency conflicts and dilution are real effects in universities, externally imposed frictions could magnify these effects.

Comparing Panels A.1 and A.2 of Table 2, one sees the effect of imposing maximum endowment payout constraints, such as the 7% level labeled as imprudent in UPMIFA. Imposing such a constraint significantly raises the endowment's allocation to the risky asset for all cases of governance and production. For example, for $\beta = 1/2$ at medium production, the constraint almost doubles the allocation to the risky asset from 50% to 92%. The reason for such a drastic effect is that the payout constraint effectively eliminates internal investment opportunities in new teaching or research projects. As a result, the university takes an increasing amount of its risk externally via the endowment, in the hope of increasing the size of the endowment, which could effectively undo the constraint in dollar terms if the endowment became large enough.

The prudent man rule embedded in UPMIFA is not a fixed and absolute rule. While the average payout rate across U.S. universities is about 5%, some endowments do have payout rates of more than 7%. The issue at hand is that there exists external forces, such as UPMIFA or the will of donors, which implicitly keep the university from spending "too much" of its endowment. Similar to the free cash flow problem in for-profit corporations, these payout limits have the goal of minimizing agency conflicts and maintaining donor intent. While most universities have payout rules that use a rolling window in order to determine the actual payout rate in any given year (Swensen, 2009), the payout can be relatively easily adjusted if the circumstances dictate it. For instance, in 2009, following the financial crisis, all endowments dramatically cut their payout – a signal that universities do not view the endowment as a precautionary savings vehicle. Our result highlights the novel insight that these payout constraints may actually be pushing endowments to dramatically increase their holdings of risky assets.

Endowment Size.   Panel B of Table 2 shows the stochastic steady state endowment size for the same set of governance, production, and constraint parameters. The university's size and hence its annual budget is rescaled to one, so an endowment of 0.33 means that the university holds an endowment equal to 33% of its annual budget. Mirroring the results of the asset allocation to the risky asset, we observe an increase in the endowment's size as the productivity of the university's marginal internal project falls; as the governance structure shifts from altruistic to self-interested stakeholders; and as the a maximum payout constraint binds.

In equilibrium, the size of the endowment and its asset allocation are inherently tied. If the university faces low-productivity marginal projects, then it is better off keeping its assets in the endowment rather than spending them on potentially negative NPV internal projects. At the same time, in this case, the university shifts its risk from internal projects to external projects via the endowment, increasing its optimal allocation to the risky asset. Together, both effects lead to an increasing endowment size in equilibrium. Similarly, as the governance shifts to self-interested stakeholders, who capture the full upside of risky external investments but not internal investments, the size of the endowment rises with the allocation to the risky asset. The effect of imposing a payout constraint is particularly strong: the size of the endowment increases by a factor of 22 for the case of $\beta = 1/2$ at the medium productivity. In order to circumvent the payout constraint in dollar terms, both the size of the endowment and the allocation to the risky asset rise together.

In our stochastic steady state results, the endowment size may appear low compared to the average but it does match the low end of the empirical data, as shown in Panel B of Figure 1. The main reason why this is sustainable is that new internal investments do lead to future donations and the stakeholders in control understand this. While there is a delay after the building of a new department, it will over time yield significant donations, reducing the need for a large endowment. American colleges and universities are well-known as phenomenal fund-raising machines. The evidence in Brown et al. (2012b) shows that, on average, universities raise about 50% more in donations than they pay out of their

endowment every year.[24] This behavior is consistent with our model but also suggests that one of the above frictions, or a combination thereof, has to be at play in order to explain why some universities are holding risky and large endowments.

Endowment Payout. Table 3 shows the steady state discretionary endowment payout as a percentage of the endowment (Panel A), the discretionary payout as a percentage of the annual (non-discretionary) budget (Panel B), as well as the percentage split of that discretionary payout across internal investments (Panel C) and self-interested stakeholders' perks (Panel D).[25] The discretionary payout is the total endowment payout net of the amount spent on net maintenance (20% of the annual budget), i.e., the payout dedicated solely to internal investment and perks.[26]

The endowment payout reflects both the equilibrium asset allocation and endowment size shown in Table 2. As the governance of the university shifts from altruistic to self-interested stakeholders, the endowment becomes riskier and larger. As a result, the payout is larger relative to the university budget, as shown on Panels A and B of Table 3, and is solely spent on perks rather than new internal projects, as shown on Panels C and D of Table 3. Additionally, the altruistic stakeholder-controlled university invests solely in new internal investments and as a result relies much more on donations for future funding rather than on returns from the endowment, leading to a lower payout relative to the budget. The opposite happens for the self-interested stakeholder-controlled university, which relies solely on the endowment for funding, therefore leading to a larger payout relative to the budget.

The university with the low production function faces a higher cost of university capital compared to the high productivity university. It must therefore spend more out of

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[24]At our home institution, the approximately \$2 billion endowment pays out about \$100 million each year while we raise about \$300 million in donations each year.

[25]In our calibration, the non-discretionary budget (excluding internal investments and perks) is 95% of the total budget.

[26]For tractability reasons, our model does not include the endogenous choice that donors face when allocating their donations between the endowment (future spending) and current operating use (net maintenance). As a result, at any time t, some donations flow into the endowment but are immediately spent at time $t + 1$ on the university's net maintenance cost, rendering the total payout a somewhat different construct than the value commonly empirically measured.

the endowment to buy the same amount of capital. Table 3 shows that the low productivity university actually has a higher payout percentage than the high productivity one. But despite this higher percentage payout, it buys less capital and hence grows more slowly. When mapping our results to the data, it is important to keep in mind that we rescale all universities to the same size. So interpreting empirical data requires the additional step of adjusting for the larger size of highly productive or altruistic stakeholder-controlled universities.

The introduction of a maximum payout constraint makes the asset allocation of the endowment riskier and the endowment larger. In equilibrium, the payout is therefore larger since the university relies more on funding from the capital markets (endowment) rather than from donations since it is constrained in its capacity to invest internally and thereby generate future donations. As such the constrained altruistic stakeholder-controlled university grows more slowly. Moreover we see that the constraint only solves the agency problem, reducing the fraction of payout diverted toward perks, in the case of the low marginal productivity university. In the case of the medium marginal productivity university the fraction of the endowment payout devoted to perks is almost unchanged.

Current Use Versus Endowment Donations. Our model does not make a distinction between donations made for current use versus donations that are intended for the endowment. Our model considers the endowment very broadly. All donations sit in the endowment between when they are donated and spent. This broad view does not affect the interpretation of the asset allocation choice variable, because only donations held for at least one period are invested and influence the asset allocation.[27]

The endowment size and payout rate however are affected. In our model donations that are nearly immediately spent such as current use donations show up in both the endowment size and endowment payout rate. This flow of current use donations through

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[27]Donations come at the end of each period while the payout occurs at the beginning of each period. Since asset allocation decisions are made over the remainder of the endowment (after payout), only donations that are not immediately spent are invested and allocated between risk-free and risky assets.

the endowment has the effect of overstating the size of the endowment by the amount of current use donations. The payout rate is simultaneously overstated by the amount of current use donation as they leave the endowment where they temporarily sat. This overstatement is merely an accounting one and it does not change the dynamics or choices within the model.

The distinction between current use and endowment donations matters only when we impose the external constraint on the endowment spending rate. Our lack of distinction between these two types of donations makes current use donations subject to the constraint. With this in mind, one can interpret the recent increase of current use donations at U.S. universities as a way of circumventing the constraint on endowment spending by never putting a set of donations in the endowment.

6.2   Summary and Empirical Moments

Table 4 shows a summary of the empirical moments (mean, 10th and 90th percentile) depicted in Figure 1 for the endowment allocation to risky assets and endowment size relative to total university budget. In order to summarize our findings, we report the stochastic steady state results of our model for different choices of our three key parameters: productivity, governance, and constraint.

In Panel A we show three sets of parameter choices that get us close to the empirical averages in the data, namely an allocation of 77% to risky assets and an endowment that is 2.2 times the university's annual budget. We obtain model moments close to the empirical moments with a university run by altruistic stakeholders ($\beta = 0$) that has a medium level of marginal productivity ($A = 1$) but faces a payout constraint on its endowment. Lowering the marginal productivity slightly would improve the match.[28] An unconstrained university run by altruistic and self-interested stakeholders ($\beta = 1/2$) but with low marginal productivity comes close as well. Again lowering the productivity slightly or tilting the

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[28]We do not run alternative specifications aimed at matching the empirical moments exactly due to computational time involved.

bargaining power toward the self-interested stakeholder would improve the match. Finally we show that a highly productive university ($A = 4$) with equal bargaining power ($\beta = 1/2$) faced with a constrained payout can match the empirical moments as well. In all three cases we do a better job of matching the risky allocation than the size of the endowment and we see that the presence of the constrained payout is important for getting a large endowment, as observed in the data.

In Panel B we show how various combinations of our model parameters are able to replicate a substantial amount of the heterogeneity we observe in the data. At the 10th percentile universities have an endowment 40% the size of their annual budget and they allocate 66.8% of their endowment to risky assets. At the 90th percentile, university endowments are nearly five times their annual budget with 86% allocated to risky assets.

Turning off the agency channel ($\beta = 0$), a low marginal productivity university ($A = 1/4$) facing an unconstrained payout comes close to matching the moments of the 10th percentile. Lowering the marginal productivity would improve the match. Alternatively adding the agency channel with an equal split of bargaining power ($\beta = 1/2$) matches the empirical moment almost exactly both on asset allocation and endowment size.

Adding the payout constraint helps our model match the 90th percentile moments. A constrained university without agency costs ($\beta = 0$) but low marginal productivity matches the empirical moments though raising the productivity slightly would help improve the match. Alternatively a constrained high marginal productivity ($A = 4$) university with equal bargaining power across the two sets of stakeholders ($\beta = 1/2$) matches the empirical moments well.

Although we highlight only some particular sets of parameter choices, there are other combinations that can match the empirical moments as well. More generally, our framework shows how the university endowment can serve as a window into the university to infer key characteristics such as marginal productivity, the extent of agency costs, and whether payout constraints bind. We leave our framework to provide guidance for empiricists working to understand the key features that drive university endowment and investment decisions.

The closest existing empirical work seeking to understand the variation in endowments is Lerner et al. (2008) which finds selectivity to be a key predictor of endowment returns and asset allocations, and Dimmock (2012) which finds background risk of universities is a key driver of allocation decisions.

6.3 Steady State University Characteristics

University Growth Rate. Panel C of Table 2 shows the per-period (annual) growth rate of the university for the different sets of governance, production, and constraint parameters. As the productivity of the marginal internal project decreases, the university grows at a slower pace, consistent with the notion that the university will invest less in lower NPV projects. Also, as the governance of the university shifts to self-interested stakeholders, the growth rate of the university falls since they prioritize perks over internal investments – they do not capture the upside of the risky internal projects. When the university is under complete control of self-interested stakeholders ($\beta = 1$), the university neither shrinks nor grows since there is no new internal investments and only payments of perks.

Introducing an endowment payout constraint plays a non-uniform role in the growth rate of the university. If the university is altruistic stakeholder-controlled with medium or high production function, constraining the payout significantly lowers the growth rate of the university. However, if the university has a low production function or if the governance is shared between altruistic and self-interested stakeholders, then the constraint appears to lead to a higher growth rate. But this finding is partly obscured by Jensen's inequality. Panel A of Table 5 shows the university growth rate via Monte Carlo simulations where we take the average annualized growth rate over 100,000 university paths, as opposed to the growth rate of the average university done in the stochastic steady state calculations. We see that the unconstrained average growth rate (2.5%) is actually higher than the constrained average growth rate (2.1%) in the $\beta = 1/2$ case while the average university size is smaller in the constrained case. This highlights the fact that, in the constrained

case, the growth rate comes with significantly more volatility in the cases where it causes faster growth.

Since the maximum endowment payout constraint does lead to higher growth in some cases, it appears as though the constraint may be fixing the agency problem created by the self-interested stakeholders who under-invest internally. However, the benefits of this constraint occur in cases with less overall benefit to society: universities with low productivity marginal projects. Agency costs are more severe in these universities because the cost of indulging in them is small. In contrast, the costs of the maximum payout constraint arise in cases where the benefits to society are large: limiting the internal investments of universities with highly productive marginal projects. Agency costs in these universities are already under control because the cost of indulging in them is high. Thus it is not clear that imposing maximum payout constraints on endowments is a sensible overall solution to limiting agency problems and increasing university production.

University Size. Panel B of Table 5 shows the average university size, the volatility of the university's size, as well as the minimum and maximum size over 100,000 Monte Carlo simulations of various models for 100 years at their stochastic steady states. For any level of governance ($\beta = 0$ or $1/2$), the main result is that the introduction of a maximum payout constraint dramatically increases the volatility of the university's size.[29]

After 100 years, an unconstrained altruistic stakeholder-controlled university ($\beta = 0$) is on average 43% bigger than a similar constrained university. However, the volatility of university size in the constrained case is five times larger than in the unconstrained case. In the case of a mixed-governance university ($\beta = 1/2$), the average size appears higher in the constrained case than in the unconstrained case, but this result is obscured by Jensen's inequality, as explained above. The main effect of the constraint is the increased volatility of the university's size: compared to the unconstrained case, a constrained university could become 20 times larger, but also runs a significant risk of going bankrupt, something that

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[29]At each time period, if the university cannot meet its net maintenance cost, then it must shrink its current operations and hence its size can go down.

does not happen in the unconstrained case.

Overall, the regulatory maximum payout rule introduces a lot of risk in universities. It increases the endowment's allocation to the risky asset and simultaneously leads to a significant increase in the endowment's size. At the same time, the riskiness of the endowment indirectly makes the growth path of the university much more volatile. So even though it is not the intention of the regulation, such maximum payout constraints have the unintended consequence of raising the riskiness of the growth of the average university.

6.4   Production of Social Dividends

In our model, the production of social dividends via research and teaching scales with the amount of university capital, i.e., the size of the university. So if the university invests internally and adds one unit of capital to the university, this will add one unit of social dividend produced in the next period. As a result, in order to compute the amount of social dividend produced over a given time period, one can integrate the growth path of the university's size over that time frame.[30] By comparing this sum across models, we can then estimate the loss (or gain) of social dividends imposed by a shift in marginal productivity, governance or the presence of a payout constraint.

In each panel of Table 6, the first row shows the amount of social dividends produced in the baseline case of an unconstrained altruistic stakeholder-controlled ($\beta = 0$) university over three different horizons.[31] The remaining rows of the table show the percentage loss in social dividends of each model compared to the baseline case.

Comparing the first line across the three panels (low, medium, and high productivity of marginal projects), we see that the university with higher productivity marginal projects does produce more social dividends, which is consistent with the finding that such

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[30]We discount future sizes at the rate of time preference δ.

[31]The calculation of university size and hence the production of social dividends can be done at the stochastic steady state solutions or using Monte Carlo simulations, with no qualitative differences in the result. We report the stochastic steady state analysis.

university has a higher growth rate. The second and third rows of each panel show the impact of shifting the governance of the university towards the self-interested stakeholders with an unconstrained payout rate. Since they invest less in new internal projects, such university has a lower growth rate, and there is a significant loss in social dividends as β increases to $1/2$ and 1. Moreover, this loss increases as the productivity of the marginal projects increases. For instance, a university with shared governance ($\beta = 1/2$) and highly productive marginal projects will produce 40% less social dividends over 50 years.

The bottom three lines of each panel show the percentage loss in social dividends compared to the baseline as we introduce a maximum payout constraint. In the case of highly productive marginal projects, the constraint leads to an increased loss of social dividends compared to the unconstrained university across all levels of governance. However, in the case of split governance ($\beta = 1/2$), it appears as though, in the case of low and medium productivity, the introduction of the constraint also leads to a gain in social dividends, i.e., the loss in social dividends is lower in the constrained case compared to the unconstrained case. Moreover, for $\beta = 0$ in the low productivity case, the constraint actually leads to an increase in the production of social dividends.

The impact of the payout constraint on the production of social dividends is consistent with prior results showing that the growth rate is higher in these constrained cases compared to the unconstrained one. As a result, it seems that the constraint can fix the agency problem, leading to higher internal investment, higher growth rate, and hence a smaller loss in social dividends. But this fix only works in the least important cases (low productivity) and it comes at the cost of high risk: the volatilities of the growth rate and of the resulting size of the university are very high, potentially leading to bankrupt universities as well as very large ones. In addition, the fix also comes at the cost of restricting the growth of the universities with the most productive marginal projects.

6.5 Impulse Response Functions

We analyze the dynamic behavior of universities and their endowments by subjecting their stochastic steady states with either a 25% unexpected increase in the endowment, potentially coming from one large donation, or a five standard deviation shock (positive or negative) in returns. The Impulse Response Functions (IRF) of five aspects of the university (asset allocation, endowment size, university size, endowment payout, and internal investment) over 10 years following the shocks are presented in Figures 3 and 4.

6.5.1 The Role of the University's Governance

Figure 3 shows IRFs for three unconstrained models with medium production ($A = 1$): one where the altruistic stakeholders are in control of the university ($\beta = 0$, darker thick blue lines), one where the self-interested stakeholders are in control ($\beta = 1$, lighter thick purple lines), and one with shared governance ($\beta = 1/2$, black thin lines). The stochastic steady states are the continuous lines and the IRFs are the dashed lines.

We first focus on how an altruistic stakeholder-governed institution responds to shocks. The asset allocation does not change in any significant way, apart from a marginal increase after a negative return shock which is driven by an increase in expected returns. Similarly, the endowment size changes very little, which suggests that any unexpected influx of dollars is quickly spent. Indeed, looking at the payout IRFs, we see that the payout from the endowment is immediately, and temporarily, increased (decreased) following a positive (negative) shock. This increased payout is spent on new internal projects, which permanently increases the size of the university. Notice that following the sharp increase in spending on new internal projects, the spending falls below the steady-state level. This is driven by the fact that the university now has a new set of unvested projects that it needs to support until they become donation-generating. As a result, it will temporarily invest less internally until the steady state is recovered.

If the university is under split governance, the endowment shifts its allocation dramatically towards the risky asset following a large donation. The allocation remains high

for a couple of years as the university increases its spending on both new internal projects and perks. However, the endowment then shifts to a safer asset allocation for a number of years after that. This shift is due to the fact there are many new internal unvested that need to be supported without increased donations, and the self-interested stakeholders want to minimize the increased risk of default due to the increased net maintenance cost.

If the university is governed by the self-interested stakeholders, there is no change in asset allocation, mainly because it is already 100% invested in the risky asset. However, the endowment size, and the payout, increase (decrease) quite significantly and over a long period following positive (negative) shocks, even though there is no change in internal investment and therefore no change in university size. This effect is driven by the fact that the self-interested stakeholders "use" the endowment as their own savings account and smooth their consumption (via perks).[32]

6.5.2 The Role of the Productivity of the Marginal Internal Project

Figure 4 shows IRFs for two unconstrained models with altruistic stakeholder control ($\beta = 0$): one with the high production function ($A = 4$, darker blue lines) and one with the low production function ($A = 1/4$, lighter purple lines). The steady states are the continuous lines and the IRFs are the dashed lines.

The highly productive university's endowment asset allocation does not change following shocks and its endowment size marginally increases (decreases) following positive (negative) shocks. The payout from the endowment temporarily increases (decreases) and the surplus is spent on new internal investments, leading to an increase (decrease) in university size.

The university with low quality marginal projects dramatically decreases its allocation to the risky asset and its endowment size falls following an unexpected increase in the endowment. At the same time, it significantly increases its payout (spent on new internal projects) – an effect driven by the fact that it must invest more in absolute terms

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[32]For the sake of tractability, we do not model the self-interested stakeholders' personal consumption and savings behavior, which would require an additional maximization.

because of its low productivity. It spends its endowment to a level below its steady state and, to limit the risk of shrinking following such a large internal investment, it shifts its endowment towards the risk-free asset until the new projects become donation-generating. The university size also increases permanently in this case, although less than in the high production case.

Taken together, these IRF results show that the effect of significant positive shocks on the university (25% increase in the endowment or a five standard deviation positive shock in returns) mostly lead to a rapid increase in spending on new internal projects, leading to a permanent growth of the university. A negative shock to returns leads to a small decrease in payout and a temporary shift in asset allocation. Interestingly, the change in payout is small and symmetric between positive and negative return shocks, contrary to the empirically observed behavior of endowments (Brown et al., 2012a).

7   Model Extensions

In this section, we provide a number of extensions to our baseline model. For brevity, all results are discussed in the text and are therefore untabulated.

7.1   Differences in Parameters

Increasing the coefficient of relative risk aversion of either or both sets of stakeholders from our moderate baseline of five has a clear impact on the endowment: safer asset allocation. Increasingly risk-averse stakeholders will simultaneously take less risk internally via new projects and also take less risk externally via the endowment, leading to lower university growth and a safer endowment. Decreasing risk aversion will obviously lead to the opposite effect. While it is often said that universities have low risk aversion, the university's constituents and not its walls bear the risk of internal and external investments. As a result, it seems unlikely that they have an average aversion to risk that is significantly lower than the average population surveyed in Barsky et al. (1997).

At the same time, donors may have low elasticity of inter-temporal substitution since they prefer a flat spending path from their gift. In our power utility setup, this is equivalent to a high level of risk aversion, which decreases the endowment's allocation to the risky asset. In addition, Campbell and Viceira (1999) show that changes in inter-temporal substitution have little effect on the portfolio choice of an investor with Epstein-Zin preferences and that this coefficient only plays a role on the consumption choice.

In our baseline model, the outside option of the self-interested stakeholders is defined by their loss of perks: If the university shrinks and a professor is fired, he loses the ability to receive perks but earns his standard wage in perpetuity. In this extension, we consider the impact of lowering the outside option of the self-interested stakeholders by imposing a 30% permanent wage loss if they are fired. The impact of such decreased outside option is relatively small and it decreases the endowment allocation to the risky asset: In the unconstrained case with shared governance ($\beta = 1/2$) with medium productivity marginal projects, the asset allocation to the risky asset falls by about 10% as the self-interested stakeholders want to decrease the likelihood of the university having to shrink.

7.2   Absence of Future Donations

An alternative hypothesis is that the altruistic stakeholders are in control of the university, but they do not account for the fact that investing internally today will lead to donations in the future: The partial derivative of future donations to current internal investment is equal to zero in the administration's mind. Phrased more strongly, it is as if internal investment in research and teaching is not viewed as an investment but rather as a cost. This notion can also be explained by donors who do not internalize the total value of the university's productive spending but rather only value the productive nature of their own gift, i.e., they value only their "immortality" through their endowed gift.

Specifically, we run the unconstrained case where the donors are in control of the university ($\beta = 0$) but where the donation scaling DS is set to zero. This means that investing internally in new university capital will never generate any donations, even though

social dividends are still being produced. On a cash flow basis, the internal projects now have negative net present value. Even in the absence of future donations, a donor-controlled university does invest internally, although the growth rate of the university is significantly smaller than before (0.05% versus 4.5%). As a result, in order to sustain this growth and limit the shrinkage risk of the university, the endowment is both large (7.34 versus 0.27) and heavily invested in the risky asset (76.5% versus 0%).

Interestingly, these moments closely match the empirical moments observed with Ivy League schools who have endowments equal to 4-10 times their annual budget and heavily invested in risky assets. This suggests that one way to rationalize the observed empirical facts is that altruistic stakeholders are in control (no agency problems) but that they do not internalize the notion that internal investment yields future donations, i.e., they believe that new investments will have to be funded in the future out of current budgets.

7.3   Short Horizon of Self-Interested Stakeholders

Donations from internal projects come far in the future, because alumni take time to accumulate their wealth to the level where they make substantial donations. Though far in the future, these donations represent the majority of the present value of the cash flows generated by new internal projects. In contrast, the faculty, the administration, and the students' average horizon is far shorter than the duration of these cash flows, because they only retain their claim while employed.[33] Because of this horizon mismatch, for a given amount of risk, self-interested stakeholders may prefer taking on external projects in capital markets where returns are realized immediately.

Keeping the infinite horizon of the altruistic stakeholders, we assume a 10-year horizon for the self-interested stakeholders and run the unconstrained model with shared governance ($\beta = 1/2$) and medium productivity of marginal projects ($A = 1$). In this case, the steady-

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[33]The average age of university faculty members is around 50, which means that the average horizon is at most 20 years. Deans and presidents have significantly shorter horizons as they work to improve the university's standing while they hold the top job, and not after they retire. Similarly, regents and members of endowment management committees also have short horizons since they have an explicit goal of obtaining high returns during their tenure.

state endowment allocation to the risky asset rises from 49.9% to 81.9% and the endowment size increases by 25% to 0.41. The intuition behind these results is that the self-interested stakeholders want to maximize their consumption of perks within a shortened time as members of the university and the capital markets is the only way to achieve this since internal projects yield new donations only with a lag. As a result, the university's growth rate falls by more than half to 1.1%.

An alternative hypothesis behind this extension is that the university's administration can be blamed much more directly for the failure of a large new internal project such as a new research laboratory in space exploration compared to a significant fall in the stock market. A university president cannot be held accountable for an economic recession but he or she can be held accountable for a bad capital budgeting decision. Therefore, short-horizon self-interested stakeholders may have a preference for risk-taking in the capital markets rather than internally.

8   Conclusion

We expand the standard hedging model of university endowments to one that includes internal investment and agency frictions. First, the opportunity cost of an extra dollar in the endowment is foregoing a dollar of internal university investment today that expands the production of social dividends such as the creation of knowledge through research and its dissemination through teaching. Second, being a non-profit eliminates explicit residual claimants on the university but does not solve the underlying conflict that those in control devote resources toward what they value. We define a university's objective function that moderates the trade-off between internal investment and endowment investment as a reduced form bargaining game between two sets of stakeholders: altruistic ones and self-interested ones.

Our model has the flexibility to match the average endowment size and allocation to risky assets as well as the large variation in these moments observed across universi-

ties in the data. More generally, our model provides a framework for understanding this heterogeneity. It shows that an endowment can serve as window into the university to help us assess more difficult-to-observe fundamentals: the marginal productivity of internal projects; the agency conflicts and power structure within the university; and the extent to which external constraints bind the university's actions.

Our model also shows that well intentioned public policy like UPMIFA that aims to control agency conflicts within non-profits by constraining endowment payouts is effective in some cases. For instance, the universities with low or moderate marginal productivity suffering from agency conflicts have higher growth rates in the production of social dividends with a payout constraint than without one. However the policy comes with costs. The growth in social dividend production of highly productive universities, even ones suffering from agency problems, is reduced. The constraint has an additional subtler cost. Across all universities, imposing the constraint shifts the allocation of the endowment toward risky assets. This shift makes the real outcomes for the universities much more volatile, which leads to some extremely large and productive universities but also to more bankrupt universities. Payout constraints in a world where endowments are free to take risk can lead to unintended consequences and must be re-evaluated.

A   Appendix: University Budget

At each date (year), the university must balance its budget: its income must be enough to match its costs.[34] The university has multiple sources of income (or revenue):

$$Income_t = Tuition_t + Fees_t + Grants_t + Donations_t + EndPay_t \qquad \text{(A-1)}$$

where $Tuition_t$ and $Fees_t$ are the proceeds from the educational mission of the university. $Grants_t$ includes research grants (and contracts) from both private and government sources, such as the National Science Foundation and the Department of Defense. $Donations_t$ can be restricted, unrestricted, earmarked for current use or for the endowment.[35] $EndPay_t$ represents the total annual payout from the endowment. While we focus our discussion on private universities, it is easy to add another income variable, namely $StateSupport_t$, which only occurs for public institutions.[36]

The university's cost structure is:

$$
\begin{aligned}
Expenditures_t \quad = \quad & \underbrace{Wages_t + Research_t + Instruction_t + Administration_t}_{\text{Gross maintenance cost}} \\
& + Perks_t + IntInv_t \qquad\qquad\qquad\qquad\qquad\qquad\quad \text{(A-2)}
\end{aligned}
$$

where $Wages_t$, $Research_t$, $Instruction_t$, and $Administration_t$ represent the gross maintenance cost of the university, including wages, student aid, utilities, research budgets, etc. $Perks_t$ is the amount of perquisites that the university chooses to pay to its self-interested stakeholders. $IntInv_t$ is the amount of new internal investment that the university undergoes during the year.

We define the net maintenance cost of the university as:

$$
\begin{aligned}
NetMnt_t \quad = \quad & (Wages_t + Research_t + Instruction_t + Administration_t) \\
& -(Tuition_t + Fees_t + Grants_t) \qquad\qquad\qquad\qquad\quad \text{(A-3)}
\end{aligned}
$$

which represents the net continuing cost of existing projects. By equating the university's revenues and costs (equations (A-1) and (A-2)), we therefore have the following budgetary

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[34]Massy (1976), Hopkins and Massy (1977), and Grinold et al. (1978) build dynamic models for university budget planning.

[35]The split between these types of donations is part of the tension between donors and advancement offices, which we do not explicitly model.

[36]Historically, the distinction between public and private institutions has been less clear. Early "private" universities received regular appropriations from state governments to support their livelihood (Rudolph, 1962). Though over time these appropriations faded much in the same way state support for today's public universities is fading.

restriction at each point in time:

$$NetMnt_t + Perks_t + IntInv_t = EndPay_t + Donations_t. \tag{A-4}$$

We view all sources of expenditures, $Wages_t$, $Research_t$, $Instruction_t$, $Administration_t$, $Perks_t$, and $IntInv_t$, as scaling linearly over time with the size of the university. For instance, if university A is twice as large as university B, then it can invest twice as much capital internally in new projects for twice the cost. We also view the two teaching-related sources of income, $Tuition_t$ and $Fees_t$, as scaling linearly with the size of the university, i.e. they have constant returns to scale.[37] $Grants_t$ (including contracts) are also assumed to grow linearly with the university. As a result, we are basically assuming that $NetMnt_t$ grows linearly with the university size.

B Appendix: Predictability in Expected Returns

In this appendix, we summarize the model of expected returns of Campbell and Viceira (1999). The log return of the risky asset is defined as

$$r_{t+1} - E_t[r_{t+1}] = u_{t+1} \tag{B-1}$$

where u_{t+1} is the innovation to the return and is normally distributed with mean zero and variance σ_u^2. The expected excess stock return is a state variable (x_t) and is defined as

$$E_t[r_{t+1}] - r_f + \frac{\sigma_u^2}{2} = x_t \tag{B-2}$$

The state variable is modeled as an AR(1) process with mean μ and persistence ϕ

$$x_{t+1} = \mu + \phi(x_t - \mu) + \eta_{t+1} \tag{B-3}$$

where the innovation η_{t+1} is normally distributed with mean zero and variance σ_η^2.

The model's key assumption is the covariance between the two innovations, η_{t+1} and u_{t+1}, which is labeled as $\sigma_{\eta\mu}$. This covariance generates inter-temporal hedging and x_t represents the investment opportunity set at time t. Expected returns mean-revert when $\sigma_{\eta\mu} < 0$: high returns today are followed by low expected returns tomorrow.

Empirically, the state variable x_t is taken to be the log dividend-price ratio $(d_t - p_t)$,

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[37]Even though we are not explicitly modeling state universities, it would be reasonable to assume that $StateSupport_t$ also scales linearly with the size of the university. If the amount of state support does not scale up with the growth of a public university over the long-term, then there will only be private universities left.

which is known to be a good predictor of stock returns. Using post-war quarterly U.S. financial data, Campbell and Viceira (1999) estimate the following restricted VAR(1) model

$$
\begin{pmatrix} r_{1,t+1} - r_f \\ d_{t+1} - p_{t+1} \end{pmatrix} = \begin{pmatrix} \theta_0 \\ \beta_0 \end{pmatrix} + \begin{pmatrix} \theta_1 \\ \beta_1 \end{pmatrix} (d_t - p_t) + \begin{pmatrix} \varepsilon_{1,t+1} \\ \varepsilon_{1,t+1} \end{pmatrix} \tag{B-4}
$$

where the innovations are normally distributed with mean zero and covariance matrix Ω. From the estimated coefficients of the VAR(1) model, the coefficients in equations (B-1), (B-2) and (B-3) can be recovered.

In our calibration, we use the same assumptions and estimates as in Campbell and Viceira (1999). The unconditional expected log excess return μ is estimated to be 5% per year and the log real risk-free rate r_f is 0.28% per year. The persistence parameter ϕ of the state variable process is 0.957 and the correlation between the η and u innovations is -0.737. The annual volatility of the stock return σ_u is 14.55% and the annual volatility of the state variable σ_η is 0.75%.

References

Adelino, M., Lewellen, K., Sundaram, A., 2012. Investment decisions of not-for-profits: Evidence from hospitals. Dartmouth College Working Paper.

Alchian, A. A., Demsetz, H., 1972. Production, information costs, and economic organization. American Economic Review 62 (5), 777–795.

Ang, A., 2011. Liquidating Harvard. Columbia Business School Case 100312.

Ang, A., Papanikolaou, D., Westerfield, M., 2012. Portfolio choice with illiquid assets. Columbia University Working Paper.

Baade, R. A., Sundberg, J. O., 1996. What determines alumni generosity? Economics of Education Review 15 (1), 75–81.

Barber, B. M., Wang, G., 2012. Do (some) university endowments earn alpha? U.C. Davis Working Paper.

Barsky, R., Juster, F., Kimball, M., Shapiro, M., 1997. Preference parameters and behavioral heterogeneity: An experimental approach in the health and retirement study. Quarterly Journal of Economics 112 (2), 537–579.

Becker, G. S., 1976. Altruism, egoism, and genetic fitness: Economics and sociobiology. Journal of economic Literature 14 (3), 817–826.

Black, F., 1976. The investment policy spectrum: individuals, endowment funds and pension funds. Financial Analysts Journal 32 (1), 23–31.

Brown, J., Dimmock, S. G., Kang, J.-K., Weisbenner, S., 2012a. How university endowments respond to financial market shocks: Evidence and implications. NBER Working Paper 15861.

Brown, J., Dimmock, S. G., Weisbenner, S., 2012b. The supply and demand for charitable donations to higher education. NBER Working Paper 18389.

Brown, J. R., Dimmock, S., Kang, J.-K., Richardson, D., Weisbenner, S., 2011. The governance of university endowments: Insights from a TIAA-CREF institute survey. TIAA-CREF Institute Research Dialogue 102.

Brown, K. C., Garlappi, L., Tiu, C., 2010. Asset allocation and portfolio performance: Evidence from university endowment funds. Journal of Financial Markets 13, 268–294.

Campbell, J. Y., Viceira, L. M., 1999. Consumption and portfolio decisions when expected returns are time varying. Quarterly Journal of Economics 114 (2), 433–495.

Campbell, J. Y., Viceira, L. M., 2002. Strategic asset allocation: Portfolio choice for long-term investors. Oxford University Press, New York, NY.

Clotfelter, C., 1999. The familiar but curious economics of higher education: Introduction to a symposium. Journal of Economic Perspectives 13 (1), 3–12.

Clotfelter, C. T., 2003. Alumni giving to elite private colleges and universities. Economics of Education Review 22 (2), 109–120.

Constantinides, G., 1993. Comment on: Optimal investment strategies for university endowment funds. In Studies of Supply and Demand in Higher Education. Edited by C. T. Clotfelter and M. Rothschild. University of Chicago Press, Chicago, IL.

Core, J., Guay, W., Verdi, R., 2006. Agency problems of excess endowment holdings in not-for-profit firms. Journal of Accounting and Economics 41 (3), 307–333.

Dimmock, S. G., 2012. Background risk and university endowment funds. Review of Economics and Statistics 94 (3), 789–799.

Dybvig, P. H., 1995. Dusenberry's ratcheting of consumption: optimal dynamic consumption and investment given intolerance for any decline in standard of living. Review of Economic Studies 62 (2), 287–313.

Dybvig, P. H., 1999. Using asset allocation to protect spending. Financial Analysts Journal January-February, 49–62.

Ehrenberg, R. G., 1999. Adam Smith goes to college: An economist becomes an academic administrator. Journal of Economic Perspectives 13 (1), 99–116.

Ehrenberg, R. G., Smith, C. L., 2003. The sources and uses of annual giving at selective private research universities and liberal arts colleges. Economics of Education Review 22 (3), 223–235.

Fama, E. F., Jensen, M. C., 1983a. Agency problems and residual claims. Journal of Law and Economics 26, 327–349.

Fama, E. F., Jensen, M. C., 1983b. Separation of ownership and control. Journal of Law and Economics 26, 301–325.

Fama, E. F., Jensen, M. C., 1985. Organizational forms and investment decisions. Journal of Financial Economics 14, 101–119.

Fehr, E., Fischbacher, U., 2003. The nature of human altruism. Nature 425, 785–791.

Fisman, R., Hubbard, G., 2005. Precautionary savings and the governance of nonprofit organizations. Journal of Public Economics 89 (11), 2231–2243.

Furman, J., Stern, S., 2011. Climbing atop the shoulders of giants: The impact of institutions on cumulative research. American Economic Review 101 (5), 1933–1963.

Gilbert, T., Hrdlicka, C., 2012. Fairness and risk-sharing across generations: An application to university and nonprofit endowments. University of Washington Working Paper.

Glaeser, E. L., 2003. The governance of not-for-profit organizations. University of Chicago Press, Chicago, IL.

Glaeser, E. L., Shleifer, A., 2001. Not-for-profit entrepreneurs. Journal of Public Economics 81 (1), 99–115.

Grinold, R., Hopkins, D., Massy, W., 1978. A model for long-range university budget planning under uncertainty. Bell Journal of Economics, 396–420.

Hansmann, H., 1980. The role of nonprofit enterprise. Yale Law Journal 89 (5), 835–901.

Hansmann, H., 1990. Why do universities have endowments? Journal of Legal Studies 19, 3–42.

Hansmann, H., 2000. The ownership of enterprise. Harvard University Press, Cambridge, MA.

Hopkins, D., Massy, W., 1977. A model for planning the transition to equilibrium of a university budget. Management Science, 1161–1168.

Hoxby, C., 2012. Endowment management based on a positive model of the uuniversity. NBER Working Paper 18626.

Jensen, M. C., Meckling, W. H., 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of Financial Economics 3 (4), 305–360.

Judd, K., 1998. Numerical methods in economics. MIT press, Cambridge, MA.

Lerner, J., Schoar, A., Wang, J., 2008. Secrets of the academy: The drivers of university endowment success. Journal of Economic Perspectives 2 (3), 207–222.

Massy, W., 1976. A dynamic equilibrium model for university budget planning. Management Science, 248–256.

Meer, J., Rosen, H. S., 2009. Altruism and the child cycle of alumni donations. American Economic Journal: Economic Policy 1 (1), 258–286.

Merton, R., 1969. Lifetime portfolio selection under uncertainty: The continuous-time case. Review of Economics and Statistics 51 (3), 247–257.

Merton, R., 1971. Optimum consumption and portfolio rules in a continuous-time model. Journal of Economic Theory 3 (4), 373–413.

Merton, R., 1973. An intertemporal capital asset pricing model. Econometrica 41 (5), 867–887.

Merton, R. C., 1993. Optimal investment strategies for university endowment funds. In Studies of Supply and Demand in Higher Education. Edited by C. T. Clotfelter and M. Rothschild. University of Chicago Press, Chicago, IL.

Rose-Ackerman, S., 1996. Altruism, nonprofits, and economic theory. Journal of Economic Literature 34, 701–728.

Rudolph, F., 1962. The American college and university: A history. University of Georgia Press, Athens, GA.

Siegel, J., 2008. Stocks for the Long Run. McGraw-Hill, New York, NY.

Swensen, D. F., 2009. Pioneering portfolio management: An unconventional approach to institutional investment. Free Press, New York, NY.

Tobin, J., 1974. What is permanent endowment income? American Economic Review 64 (2), 427–432.

Winston, G. C., 1999. Subsidies, hierarchy and peers: The awkward economics of higher education. Journal of Economic Perspectives 13 (1), 13–36.

Table I
Model Parameters

Net maintenance is the difference between the university's costs (wages, research, instruction, administration) and its revenues (tuition, fees, grants) that are proportional to the amount of university capital. The university's production function is $f(y) = \ln(Ay + 1)$ where y is a dollar input. The scaling of social dividends is calibrated to equate the marginal utilities of altruistic and self-interested stakeholders. The half-life of unvested internal projects is approximately 14 years. The scaling of donations is calibrated such that the internal projects' net present value is equal to zero. The endowment payout can be either unconstrained or constrained to a fixed percentage of its value. The asset return dynamics and parameters are from Campbell and Viceira (1999).

Percentage of Annual Budget Spent on Net Maintenance ($NetMnt$)	20%
Slope of Production Function (A)	0.25, 1, or 4
Social Dividend Scaling (sd)	0.27
Percentage of Internal Projects Vesting Annually ($vest$)	5%
Donation Scaling (DS)	0.47
Altruistic Stakeholders Coefficient of Relative Risk Aversion (γ_A)	5
Self-Interested Stakeholders Coefficient of Relative Risk Aversion (γ_S)	5
Annual Rate of Time Preference (δ)	0.94
Endowment Payout Constraint	100% or 5%
Annual Unconditional Expected Log Excess Stock Return	5.00%
Annual Standard Deviation of Log Excess Returns	14.55%
Annual Log Risk-Free Real Rate of Return	0.28%

Table II
Steady State Endowment and University Characteristics

This table shows the stochastic steady state endowment size (Panel A), the endowment allocation to the risky asset (Panel B) and the university annual growth rate (Panel C). The left column shows the case with an unconstrained payout rate from the endowment and the right column shows the case with a 5% endowment payout rate constraint. The stochastic steady state is defined as the point in the state space where the agent would choose to remain were all realized shocks set to zero.

Panel A: Endowment Allocation to Risky Asset

A.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	43.2%	0%	0%
$\beta = 1/2$	63.2%	49.9%	44.0%
Self-Int. ($\beta = 1$)	100%	100%	100%

A.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	100%	54.8%	39.8%
$\beta = 1/2$	100%	92.0%	86.2%
Self-Int. ($\beta = 1$)	100%	100%	100%

Panel B: Endowment Size

B.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	0.31	0.27	0.25
$\beta = 1/2$	0.39	0.33	0.31
Self-Int. ($\beta = 1$)	0.63	0.63	0.63

B.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	6.77	4.71	4.18
$\beta = 1/2$	9.51	7.20	6.48
Self-Int. ($\beta = 1$)	26.82	26.82	26.82

Panel C: University Growth Rate

C.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	2.7%	4.5%	5.7%
$\beta = 1/2$	1.3%	2.4%	3.3%
Self-Int. ($\beta = 1$)	0%	0%	0%

C.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	3.4%	3.5%	3.6%
$\beta = 1/2$	2.5%	3.0%	3.2%
Self-Int. ($\beta = 1$)	0%	0%	0%

Table III
Steady State Endowment Payout Characteristics

This table shows the stochastic steady state discretionary payout as a percentage of the endowment (Panel A), the discretionary payout as a percentage of the (non-discretionary) budget (Panel B), the percentage of the discretionary payout spent on new internal investments (Panel C), and the percentage of the discretionary payout spent on perks (Panel D). The left column shows the case with an unconstrained payout rate from the endowment and the right column shows the case with a 5% endowment payout rate constraint. The discretionary payout is defined as the total endowment payout minus the amount spent on net maintenance.

Panel A: Discretionary Payout Rate (Percentage of Endowment)

A.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	35.4%	17.3%	5.9%
$\beta = 1/2$	47.8%	37.5%	28.6%
Self-Int. ($\beta = 1$)	47.2%	47.2%	47.2%

A.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	2.0%	0.8%	0.2%
$\beta = 1/2$	2.9%	2.2%	1.9%
Self-Int. ($\beta = 1$)	4.3%	4.3%	4.3%

Panel B: Discretionary Payout as Percentage of Budget

B.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	11.6%	4.8%	1.5%
$\beta = 1/2$	19.4%	13.2%	9.3%
Self-Int. ($\beta = 1$)	31.2%	31.2%	31.2%

B.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	14.6%	3.7%	1.0%
$\beta = 1/2$	29.0%	16.8%	13.1%
Self-Int. ($\beta = 1$)	120%	120%	120%

Panel C: Percentage of Discretionary Payout for Internal Investments

C.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	100%	100%	100%
$\beta = 1/2$	28.2%	19.1%	9.3%
Self-Int. ($\beta = 1$)	0%	0%	0%

C.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	100%	100%	100%
$\beta = 1/2$	37.2%	19.3%	6.5%
Self-Int. ($\beta = 1$)	0%	0%	0%

Panel D: Percentage of Discretionary Payout for Perks

D.1: Unconstrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	0%	0%	0%
$\beta = 1/2$	71.8%	80.9%	90.7%
Self-Int. ($\beta = 1$)	100%	100%	100%

D.2: Constrained

Governance	Production Function		
	Low	Medium	High
Altruistic ($\beta = 0$)	0%	0%	0%
$\beta = 1/2$	62.8%	80.7%	93.5%
Self-Int. ($\beta = 1$)	100%	100%	100%

Table IV
Empirical Moments and Model Moments

This table shows the empirical moments for endowment asset allocation and endowment size relative to total university budget (see Figure 1). We also show a selection of model parametrization and the moments they generate. In Panel A, we select parametrizations that demonstrate the multiple ways to generate moments close to the empirical mean. In Panel B, we choose parametrizations that demonstrate the heterogeneity in outcomes the model can generate.

Panel A: Matching Empirical Average

	Risky Allocation	Relative Size
Empirical Average	77.0%	2.2
No agency, medium productivity, constrained $\beta = 0$, $A = 1$	54.8%	4.7
Agency, low productivity, unconstrained $\beta = 1/2$, $A = 1/4$	63.2%	0.4
Agency, high productivity, constrained $\beta = 1/2$, $A = 4$	86.2%	6.5

Panel B: Matching Empirical Heterogeneity

	Risky Allocation	Relative Size
Empirical 10th Percentile	66.8%	0.4
No agency, low productivity, unconstrained $\beta = 0$, $A = 1/4$	43.2%	0.3
Agency, low productivity, unconstrained $\beta = 1/2$, $A = 1/4$	63.2%	0.4
Empirical 90th Percentile	86.1%	4.8
No agency, low productivity, constrained $\beta = 0$, $A = 1/4$	100%	6.8
Agency, high productivity, constrained $\beta = 1/2$, $A = 4$	86.2%	6.5

Table V
Monte Carlo Simulations

For each model, we simulate 100,000 random paths of 100 years each, starting at the stochastic steady state solutions and using the optimal policies. All models are at the medium production function ($A = 1$). In all simulations, the initial university size is 1 and the results are shown at 100 years. The university must shrink if it cannot pay its net maintenance cost.

Panel A: University Growth Rate

	Unconstrained			Constrained		
	$\beta = 0$	$\beta = 1/2$	$\beta = 1$	$\beta = 0$	$\beta = 1/2$	$\beta = 1$
Average annual growth rate	4.4%	2.5%	0%	3.9%	2.1%	-0.1%
Standard deviation of growth rate	0.2%	0.1%	0%	0.6%	11.3%	2.3%

Panel B: University Size

	Unconstrained			Constrained		
	$\beta = 0$	$\beta = 1/2$	$\beta = 1$	$\beta = 0$	$\beta = 1/2$	$\beta = 1$
Average size	81.1	11.8	1	56.8	32.3	1
Standard deviation of size	9.1	0.9	0	46.2	26.3	0.1
Minimum size	38.9	9.1	1	10.0	0	0
Maximum size	118.8	15.3	1	756.6	303.3	1

Table VI
Production of Social Dividends

The amount of social dividends produced by the university over a given number of years is calculated as the integral of the university's size path over the given horizon, discounting at the rate of time preference δ. The baseline case is the $\beta = 0$ unconstrained model for which the discounted sum of social dividends produced is reported. For the other models, all positive numbers represent a given model's percentage loss in social dividends with respect to the baseline case.

Panel A: Low Production Function ($A = 1/4$)

		10-year	20-year	50-year
Baseline Total Production of Social Dividends:				
$\beta = 0$	Unconstrained	8.3	14.1	23.1
Loss of Social Dividends Relative to Baseline:				
$\beta = 1/2$	Unconstrained	6.9%	11.9%	21.4%
$\beta = 1$	Unconstrained	12.7%	21.2%	35.4%
$\beta = 0$	Constrained	-3.6%	-6.7%	-13.9%
$\beta = 1/2$	Constrained	0.9%	1.6%	3.2%
$\beta = 1$	Constrained	12.7%	21.2%	35.4%

Panel B: Medium Production Function ($A = 1$)

		10-year	20-year	50-year
$\beta = 0$	Unconstrained (baseline)	9.1	16.7	32.8
$\beta = 1/2$	Unconstrained	10.3%	18.0%	33.7%
$\beta = 1$	Unconstrained	20.4%	33.3%	54.4%
$\beta = 0$	Constrained	5.0%	9.0%	18.4%
$\beta = 1/2$	Constrained	7.2%	12.8%	25.2%
$\beta = 1$	Constrained	20.4%	33.3%	54.4%

Panel C: High Production Function ($A = 4$)

		10-year	20-year	50-year
$\beta = 0$	Unconstrained (baseline)	9.7	18.7	42.8
$\beta = 1/2$	Unconstrained	12.0%	21.0%	40.5%
$\beta = 1$	Unconstrained	25.2%	40.7%	65.1%
$\beta = 0$	Constrained	10.3%	18.2%	36.1%
$\beta = 1/2$	Constrained	12.1%	21.3%	40.9%
$\beta = 1$	Constrained	25.2%	40.7%	65.1%

Figure 1
Histograms of Endowment Characteristics

Endowment data are from the National Association of College and University Business Officers (NACUBO) and Commonfund annual surveys of U.S. college and university endowments. The allocation to risky assets is defined as the sum of all asset classes except for cash, cash equivalents and fixed income (domestic and foreign). Budget data (total operating costs) is from the Integrated Post-secondary Education Data System (IPEDS). We take a time-series average of each variable for each university and keep only the universities that are continuously present in the dataset (total = 339 colleges and universities from 2000 to 2010).

<u>Panel A:</u> Histogram of the allocation to risky assets across university endowments.
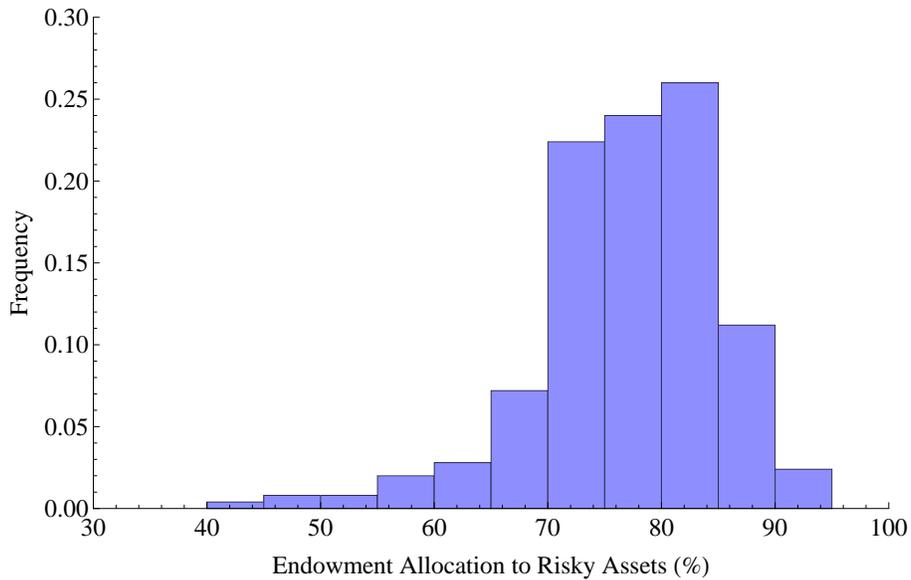
<u>Panel B:</u> Histogram of the endowment size as percentage of budget across universities.
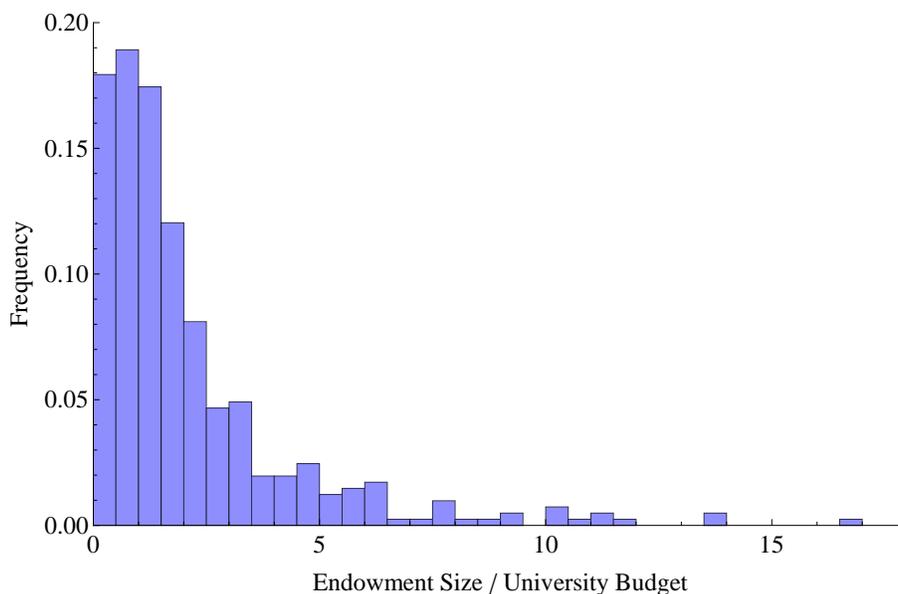
Figure 2
Timeline of Production Model

In each period, the university makes three simultaneous choices. One, it decides how much to pay out of its endowment. Two, it chooses how to split this payout between perks paid to self-interested stakeholders and amount spent on new internal projects. Three, it allocates the rest of the endowment between a risky stock and the risk-free asset. If the starting value of the endowment is not enough to pay its continuing net maintenance cost, then the university must shrink before any investment choices are made. Likewise, if the university chooses to invest internally, then it will grow its stock of internal capital. The amount of social dividend produced each period is deterministically tied to the entering stock of capital. The amount of donations received each period is stochastically tied to the sustained stock of capital.
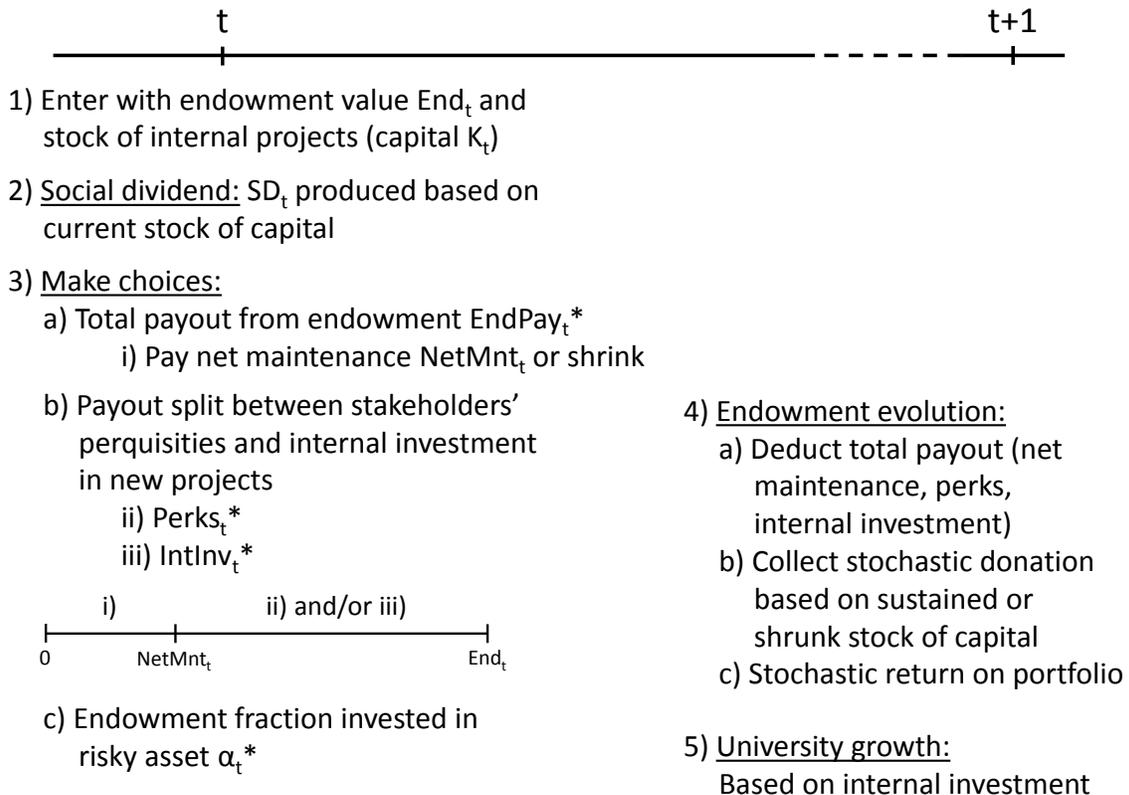
t   t+1

1) Enter with endowment value End_t and stock of internal projects (capital K_t)

2) Social dividend: SD_t produced based on current stock of capital

3) Make choices:
   a) Total payout from endowment $EndPay_t$*
        i) Pay net maintenance $NetMnt_t$ or shrink

   b) Payout split between stakeholders' perquisites and internal investment in new projects
        ii) $Perks_t$*
        iii) $IntInv_t$*

   i)   ii) and/or iii)

   0      $NetMnt_t$ End_t

   c) Endowment fraction invested in risky asset α_t*

4) Endowment evolution:
   a) Deduct total payout (net maintenance, perks, internal investment)
   b) Collect stochastic donation based on sustained or shrunk stock of capital
   c) Stochastic return on portfolio

5) University growth:
   Based on internal investment

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Figure 3
Impulse Response Functions for Varying University Control

Each graph shows the steady state (solid lines) and the IRFs (dashed lines) over 10 years for various characteristics of the university. The thick blue (darker) lines are for the case with full altruistic stakeholder control ($\beta = 0$), the thick purple (lighter) lines are for the case with full self-interested stakeholder control ($\beta = 1$), and the thin (black) lines are for $\beta = 1/2$. All lines are for the unconstrained case with medium production function ($A = 1$). The first column shows IRFs for a 25% increase in the endowment. The second and third columns show IRFs for positive or negative five standard deviation shock in returns, respectively.
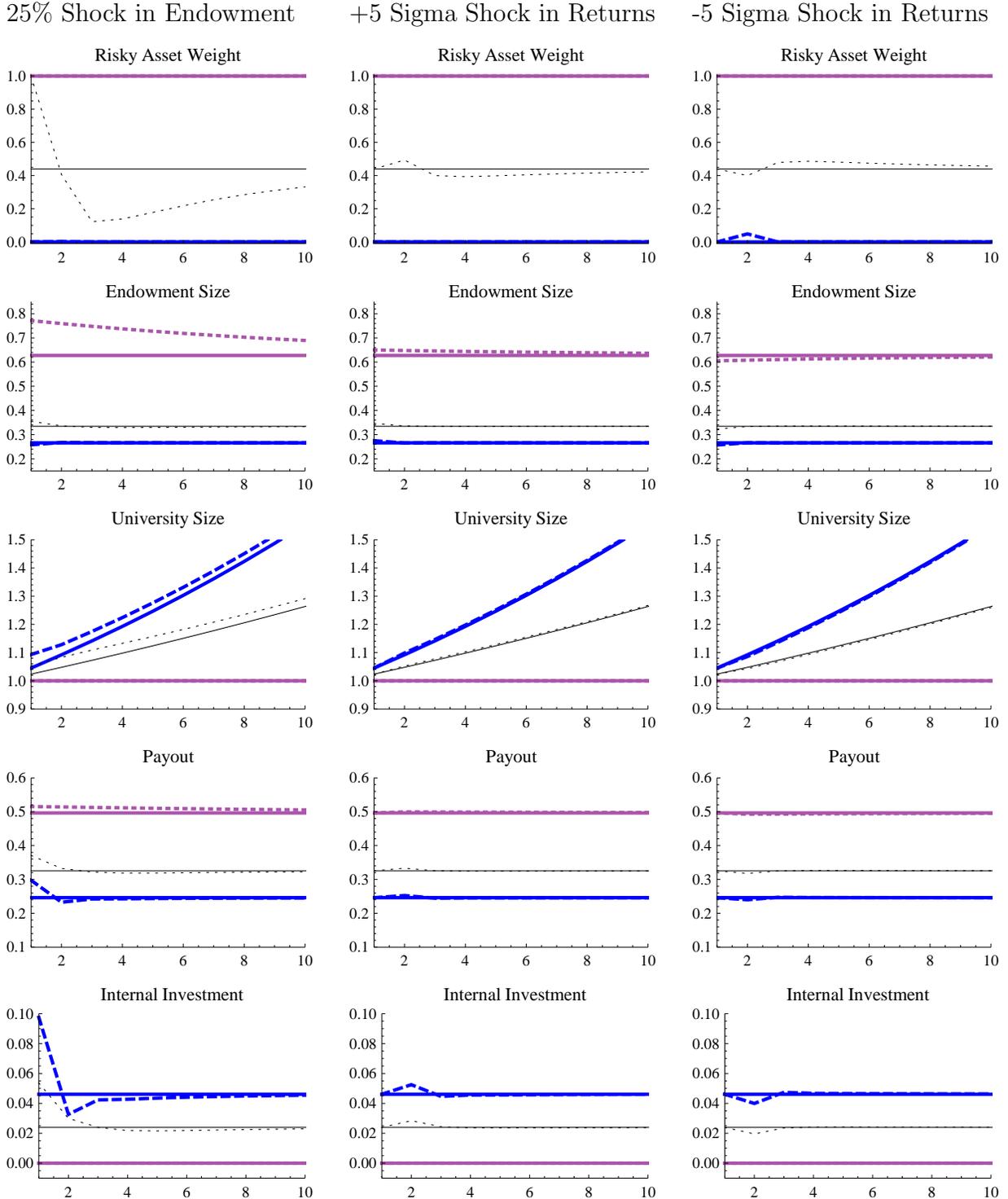

25% Shock in Endowment   +5 Sigma Shock in Returns   -5 Sigma Shock in Returns

Figure 4
Impulse Response Functions for Varying Production Function

Each graph shows the steady state (solid lines) and the IRFs (dashed lines) over 10 years for various characteristics of the university. The thick blue (darker) lines are for the high production function ($A = 4$) and the thick purple (lighter) lines are for the low production function ($A = 0.25$). All lines are for the unconstrained case with full altruistic stakeholder control ($\beta = 0$). The first column shows IRFs for a 25% increase in the endowment. The second and third columns show IRFs for positive or negative five standard deviation shock in returns, respectively.

25% Shock in Endowment   +5 Sigma Shock in Returns   -5 Sigma Shock in Returns