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

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**Abstract**

University endowments invest on average about 75% of their assets in risky securities. The opportunity cost of this investment in capital markets is foregone expansion through internal projects. We capture this trade-off between internal and external investment by modeling universities as producers of social dividends created by research and teaching. Instead of equity holders, universities have donors and internal stakeholders who exert control. We give universities a realistic objective function that balances the demands of donors for expansion against the desire of internal stakeholders to maximize their lifetime payments from the university. Though internal projects produce cash flows from future donations, internal stakeholders prefer external investments because university expansion dilutes their claim. In this framework, we show that large endowments invested in risky assets signal low productivity marginal internal projects or the dominance of internal stakeholders who do not value expansion. Constraints on maximum endowment payout rates, designed to ameliorate these agency costs, actually cause universities to accumulate larger endowments with riskier asset allocations than they otherwise would choose. The magnitude of the un-produced social dividends due to either the agency costs or the payout constraints ranges upwards of 20% over 50-year horizons.

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# 1 Introduction

Universities produce knowledge through research and disseminate it via teaching. Donors value these social dividends and contribute to support their production. Together with the university's internal stakeholders, such as deans, faculty and students, donors decide how their gifts will be used to expand production today through risky internal investment and support production in the future through the endowment. We show that both the productivity of the marginal internal project available and the relative bargaining power of donors versus internal stakeholders influence this decision. When better marginal projects are available, the university invests more internally and less in risky external projects via the capital markets. Donors and internal stakeholders both want the university to survive, but donors prefer the maximization of social dividends while internal stakeholders prefer the maximization of their lifetime payments from the university. Expansion dilutes the current internal stakeholders' claims to the university cash flows by the addition of new internal stakeholder. Because of this dilution, internal stakeholders resist the expansion demands of donors.

Our paper's innovation comes in two parts. We construct a realistic objective function for the university and its trustees, and we focus on the trade-off between internal and external investment when forming the endowment management policy. The objective function captures how trustees must balance the demands of donors who provide funding and the need to satisfy internal stakeholders who are essential to running the university. Our paper shows that observable university endowment policies – size and asset allocation – provide a window into the university's marginal projects and governance structure.

Universities have accumulated large endowments that on average have a 75% allocation to risky assets. In our framework, this behavior signals that universities face low productivity marginal internal projects, or that their governance is dominated by those who do not value expansion, or that they do not expect any future donations. Externally mandated constraints on endowment spending rates, like those from the Uniform Prudent

Management of Institutional Funds Act (UPMIFA), distort this connection between available internal projects, university governance and endowment decisions. Although designed to lower agency costs and maintain donor intent, we show that these limits on maximum endowment spending rates essentially eliminate highly productive marginal projects. Thus, the constraints have the unintended consequence of causing universities to accumulate larger endowments with riskier allocations than optimal.

We model universities as producers of social dividends: research and teaching. Universities have access to a supply of internal projects, such as hiring new faculty, starting new schools or building libraries, that expand the production of social dividends. These social dividends are non-excludable public goods, such as the cure for cancer, that all members of society consume. That the social dividends cannot be monetized by capital markets is what makes universities distinct from standard firms. Donors such as wealthy former students value the social dividends enough to donate to universities.

A university finances its existing projects and its expansion out of donations and its endowment. Investing internally yields an eventual increase in donations since, as the university expands, so does its pool of donors (former students). This donation growth occurs with a delay because students do not donate immediately upon graduation. Donations rise in good times and fall in bad, making internal projects risky. At any given time, if the university cannot meet the cost needed to sustain its existing projects, then it must shrink, thereby reducing the amount of social dividends produced and alienating donors. Alternatively, the university may take on external projects via the endowment in the capital markets. These external projects do not produce social dividends but do yield a risk premium.

The key intuition of our model is that the opportunity cost of investing the endowment in risky assets is foregone expansion through risky internal projects. The more productive the marginal internal projects are, the more the university invests internally leading to a small endowment with a low allocation to risky assets. When a university receives an unexpectedly large donation, it increases internal investment but does not spend the entire donation immediately due to decreasing marginal returns to internal investment. The university puts the excess temporarily into its endowment and tilts the endowment towards riskier assets. Over time as highly productive projects again arrive, the university spends its endowment down to its smaller steady state value and tilts the endowment allocation back towards safe assets. Universities expecting high productivity marginal projects in the future may temporarily invest in risky assets while they wait, but they eventually return the allocation to safe assets. Only universities with perpetually low productivity marginal projects maintain endowments permanently invested in risky assets.

University governance determines the relative importance placed on expansion. The non-profit nature of universities eliminates explicit residual claimants with control rights. Faculty and administrators have control rights and receive payments from the university through fixed wages (tenure) and perks. When cash is available, internal stakeholders may divert it from expansion towards higher perks, such as higher research budgets or newer athletic facilities.[1] Donors limit this diversion and influence the investment decision through their bargaining power achieved from their donations. We do not comment on the efficiency of this wage contract for internal stakeholders – it may be an efficient way of sharing risk between internal stakeholders and donors – we simply analyze the effect such a wage contract has on optimal endowment management choices.

We model this governance structure by forming the university's objective function as a convex combination of the objectives of internal stakeholders and donors. This objective function allows us to consider universities that range from complete donor control to complete insider control.[2] In our model the university has three choice variables: the total payout from the endowment; the split of this payout between wages, perks and internal

[1]We do not view all perks as inefficient. However, if the payment of perks depends on the financial performance of the university (Brown et al., 2012), then the availability of these perks does change the incentives within the university.

[2]For simplicity, we assume that donors and internal stakeholders have starkly individual and separate objectives (donors like social dividends and internal stakeholders like cashflows), and the university maximizes a weighted average of these objectives. In reality, internal stakeholders such as the faculty do care about social dividends and some donors may dislike expansion because it dilutes their claim as a former student. Such extensions would only change our interpretation of the weighting parameter in the university's objective function and would not change our overall story.

investment; and the asset allocation of the remaining endowment between the risky and risk-free assets.

When donors have most of the control, no perks are paid and there is a high rate of internal investment. However each period, in order to maintain its existing set of internal projects, the university must be able to make a minimum payment in proportion to the available university capital. If this minimum maintenance cost cannot be met out of the new donations and the payout from the endowment, then the university must shrink. Donors dislike shrinking the university because it reduces social dividends and future donations. Therefore to reduce the chances of shrinking, almost all of the risk borne by such a university comes in the form of internal projects and not from risky investments through the endowment, leading to a safe asset allocation policy.

In contrast, internal stakeholders try to divert any endowment payout above the required minimum towards perks and away from internal investment. If internal stakeholders dominate the control of the university's governance, then they do not invest internally into new projects. Doing so dilutes their claim to future cash flows and lowers their ability to pay perks to themselves in the future. Internal stakeholders take on all of the university's risk through external capital markets. The reason is that they bear all the downside risk in the case of both risky internal and risky external investment, but they only capture the full upside of risky external investment. Thus dilution is key to the intuition of the interaction of internal stakeholder and donors.

In addition to the quality of marginal internal projects and the governance of the university, externally mandated maximum endowment payout rates have a large impact on the universities' growth as well as the management of its endowment. For instance, UPMIFA stipulates that a payout rate of more than 7% is imprudent and we show that such a maximum payout constraint leads to a larger and riskier endowment than universities would otherwise hold. The intuition is that the constraint effectively eliminates high positive net present value projects that the university would like to take in order to increase its production of social dividends. 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. However, we show that such universities actually grow at a much slower rate and there is a large social welfare loss due to the unproduced social dividends.

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 production function and investment opportunities and then describe the university's governance and its objective function. 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 finally, we 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 main reason for this is the lack of definition of the university's objective function, something we directly tackle in this paper. However, 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 both sides as they pertain to our research question.

## 2.1 Theoretical Literature

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). Given a fixed level of endowment risk, Tobin develops a basic formula for permanent endowment payout that is based upon the notion of intergenerational fairness. Gilbert and Hrdlicka (2012) develop a framework for the analysis of optimal endowment asset allocation 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) 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 hedge against adverse changes in the investment opportunity set. While Merton refuses to define an objective function for the university, Constantinides (1993) discusses the importance of choosing the correct objective function for a university, something we attempt to do in this paper.

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 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 constituents, namely donors and internal stakeholders (faculty, staff, etc.). This objective function allows us to explicitly solve for endogenous payout and asset allocation policies. In addition, since risk is borne by people and the walls of the university cannot absorb it, 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.

## 2.2 Empirical Literature

The empirical literature on university operations and governance is small (Winston, 1999; Ehrenberg, 1999; Clotfelter, 1999) and mainly highlights the differences between higher education and other nonprofits.[3] Brown et al. (2011) analyze the endowment investment and advisory committee of U.S. universities and document some significant correlations between the characteristics of the universities and the committees' composition. We focus on the joint university governance of donors and internal stakeholders, taking the contract between the regents and the endowment manager as given.

Brown et al. (2012) investigate the effects of endowment shocks on university operations. They find that, following negative return shocks, universities consume less out their endowments than specified by their payout rule, whereas they do not significantly deviate from the rule following positive shocks.[4] To make up for the reduced endowment consumption, universities scale down fundamental parts of their operations and cut perquisites to students, faculty, and staff. By modeling the objective function of the entire university, including the endowment, we are able to explicitly measure the impact of return and donation shocks on the performance of the university.

A number of facts have been documented in terms of the behavior and performance of university endowments. Lerner, Schoar, and Wang (2008) report that universities with large endowments and those with high SAT scores enjoy consistently higher returns than universities with smaller endowments and lower SAT scores. The former universities also invested earlier and more in so-called alternative strategies (hedge funds, etc.) compared to the latter universities. Dimmock (2012) presents evidence that universities whose nonfinancial income (tuition, fees, grants, etc.) is more volatile invest more of their endowment in fixed income assets and reduce their allocation to risky assets. Brown et al. (2010) report evidence of skill in security selection on the part of university endowment managers. Barber and Wang (2011) show that the average asset allocation of the largest endowment funds

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

[4] Most universities employ a payout rule in which they consume a fixed percentage of the previous few years' average market value of the endowment.

is the most important factor in explaining their superior returns of the last two decades, which suggests that endowment managers do not add alpha. Goetzmann and Oster (2012) document both herding and trend-chasing behavior in university endowments. Rather than focusing solely on a narrow return-maximization objective for the endowment, our paper defines a realistic objective function for the university as a whole, which in turn has direct implications for the management of the endowment.

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. While our model is built with universities in mind, the results apply to all nonprofits that rely partly on donations to fund their operations.

# 3 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.

## 3.1 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 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 investment in 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 $K_t$:

$$SD_t = K_t \times sd. \tag{1}$$

where $sd$ is a scaling parameter.[5] Underlying our framework is the notion of the university as a *stock of capital* such as buildings, faculty, students, etc.

## 3.2 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:

$$K_{t+1} = K_t \times f\left(\frac{IntInv_t}{K_t}\right) \quad \text{where} \quad IntInv_t \geq 0 \tag{2}$$

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

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

functional form for the production function:

$$f(y) = \ln(Ay + 1) \tag{3}$$

where $A$ captures the productivity of the university's marginal project – 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 or it will be forced to shrink its operations. Under the assumption of a balanced university budget (see Section 5), 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:

$$NetMnt_t = NetMnt \times K_t \tag{4}$$

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 $EndPay_t$:

$$K_{t+1} = \frac{EndPay_t}{NetMnt_t} K_t \quad \text{if} \quad EndPay_t < NetMnt_t. \tag{5}$$

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:

$$K_{t+1} = \begin{cases} K_t + K_t f\left(\frac{IntInv_t}{K_t}\right) & \text{if} \quad EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t} K_t & \text{if} \quad EndPay_t < NetMnt_t. \end{cases} \tag{6}$$

Our production function captures only the mean productivity of an internal project, which implies that projects produce a deterministic amount of social dividends. 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. For simplicity, we combine all of the risks of internal projects into their stochastic generation of donations, which is specified in the next subsection.

## 3.3 Donations, Endowment Dynamics and Payouts

Internal projects, besides generating social dividends, also generate a tangible cash flow: donations. Schools and laboratories are often built following a capital campaign aimed at raising funds for the project at hand. But once the 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. 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:

$$I_{t+1} = \begin{cases} \frac{K_t}{K_{t+1}} I_t(1 - vest) + \frac{K_t}{K_{t+1}} f\left(\frac{IntInv_t}{K_t}\right) & \text{if} \quad EndPay_t \geq NetMnt_t \\ I_t(1 - vest) & \text{if} \quad EndPay_t < NetMnt_t \end{cases} \tag{7}$$

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. 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:

$$\hat{K}_t(1 - I_t) \times DS \times \tilde{R}_{t+1} \tag{8}$$

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:

$$\hat{K}_t = \begin{cases} K_t & \text{if} \quad EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t} K_t & \text{if} \quad EndPay_t < NetMnt_t \end{cases} \tag{9}$$

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 therefore as follows:

$$\begin{aligned} End_{t+1} &= (End_t - EndPay_t) \times (\alpha_t \tilde{R}_{t+1} + (1 - \alpha_t) R_f) \\ &\quad + \underbrace{\hat{K}_t(1 - I_t) \times DS \times \tilde{R}_{t+1}}_{\text{Donations}} \end{aligned} \tag{10}$$

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.

One choice the university makes in each time period is 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 $\alpha_t$. We rule out net leverage and shorting by constraining $\alpha_t$ between 0 and 1.

In each period, in addition to its endowment asset allocation $\alpha_t$ 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 (perks) to its internal stakeholders, $Perks_t$ (see Section 4). We assume that the total endowment payout falls on a continuum between 0 and the total value of the endowment, $End_t$, and that this continuum is separated into two regions (see Figure 1). The university must first meet its current net maintenance cost $NetMnt_t$ or it must shrink its operations. If it can meet its net maintenance cost of current operations, then the university can choose to invest internally into new projects and simultaneously pay perks to the internal stakeholders. The university's decision process is described in the next section.

# 4 University Governance

Characterizing the university's optimal trade-off between expansion through risky internal investment and risky external investment in the capital markets via the endowment requires a stance on the university's objective function. We form an objective function that captures a realistic feature of a university: tension between donors who want more social dividends produced over the life of the university and internal stakeholders who want to maximize their lifetime payout from the university.

Summarizing the setup described in Section 3, the choice variables available to the university are:

$$\mathcal{C}_\tau = \{EndPay_t, IntInv_t, \alpha_t\} \tag{11}$$

where $EndPay_t$ is the total endowment payout, $IntInv_t$ is the amount of internal investment, and $\alpha_t$ is the fraction of the endowment allocated to the risky asset.[6] The state variables are denoted as:

$$\theta_\tau = \{K_t, I_t, End_t, X_t\} \tag{12}$$

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.

## 4.1 Donors

Alumni, members of the community, and generous benefactors, among many others, donate to universities because they value the social dividends that are or will be created with the help of their gift. The motivation for these donors may be altruism or the prestige of their name associated with a university that produces good works. There are countless examples of schools being named after a donor who has provided a significant gift. Endowed chairs are also examples of how donors value both applied and fundamental research, as well as its output for society.

We take donations as exogenous and do not model *why* donors donate (Rose-Ackerman, 1996). We only make the weak assumption that donors value at least in part the creation of social dividends. Donors may value other things in addition to the creation of social dividends but the critical assumption is that a donor would rather have her name attached to a university building producing research and teaching than a building sitting empty.

We make several additional assumptions about donations and donors. First, donations are stochastic and correlated with the market: the amount of gift-giving to nonprofits has a significant amount of systematic risk. Second, donations only accrue from *vested* projects. It seems logical that a brand new research or teaching project within the univer-

[6] Optimal choices are denoted with a star.

sity takes time to mature so as to become donation-generating. Third, donors are averse to variations in the production of social dividends.

Donors have expected utility with time discount rate $\delta$ and constant relative risk aversion period utility over social dividends:

$$\sum_{\tau=t}^{\infty} \delta^{\tau-t} E_t[u_D(SD_\tau)] \tag{13}$$

where

$$u_D(SD_\tau) = \frac{SD_\tau^{1-\gamma_D}}{1-\gamma_D} \tag{14}$$

where $\gamma_D$ is the donors' coefficient of relative risk aversion. We rewrite this utility function recursively with the addition of the university's optimal future choice variables, $\mathcal{C}^*$, to express the donors' value function in terms of this period's choice and state variables:

$$V_D(\mathcal{C}_t, \theta_t) = u_D(K_t \times sd) + \delta E_t[V_D(\mathcal{C}_{t+1}^*, \theta_{t+1})]. \tag{15}$$

## 4.2 Internal Stakeholders

Internal stakeholders of the university are the trustees, regents, administrators (president, deans, department chairs), faculty (tenured and nontenured), staff, and the students. These stakeholders, apart from the students, receive wages. Students receive instruction. In addition to these fixed benefits of being current members of the university, all internal stakeholders receive perquisites. Examples of perks are larger research and travel budgets, more department assistants, higher quality student activities, etc. While we do not view all perks as inefficient, their availability does change the incentives within the university, especially if these perks vary according to the economic state of the university. In times of budgetary strain, as is shown by Brown et al. (2012), these perks are quickly eliminated as endowment payouts are cut.

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

We assume that growth through internal projects dilutes the claim of the existing internal 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.

Internal 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. We assume that firings and dismissals occur randomly in proportion to the required shrinkage of the university. Departing internal stakeholders receive their outside option which is likely to be worse than their current expected cash flow: net maintenance (wages) plus perks.

We assume that internal stakeholders have expected utility with time discount rate $\delta$ and constant relative risk aversion period utility over their consumption $c_t$:

$$\sum_{\tau=t}^{\infty} \delta^{\tau-t} E_t[u_S(c_\tau)] \tag{16}$$

where

$$u_S(c_\tau) = \frac{c_\tau^{1-\gamma_S}}{1-\gamma_S}. \tag{17}$$

where $\gamma_S$ is the internal stakeholders' coefficient of relative risk aversion. The internal stakeholders' consumption is their proportional fraction of the total endowment payout in the form of wages (the net maintenance) and $Perks_t$.

We rewrite this utility function recursively with the addition of the university's optimal future choice variables, $\mathcal{C}^*$, to express the internal stakeholders' value function in terms of this period's choice and state variables:

$$V_S(\mathcal{C}_t, \theta_t) = \begin{cases} u_S\left(\frac{EndPay_t - IntInv_t}{K_t}\right) + \delta E_t[V_S(\mathcal{C}^*_{t+1}, \theta_{t+1})] & \text{if } EndPay_t \geq NetMnt_t \\ \frac{EndPay_t}{NetMnt_t}\left[u_S\left(\frac{EndPay_t}{K_{t+1}}\right) + \delta E_t[V_S(\mathcal{C}^*_{t+1}, \theta_{t+1})]\right] & \\ + \left(1 - \frac{EndPay_t}{NetMnt_t}\right) \times [\text{outside option}] & \text{if } EndPay_t < NetMnt_t \end{cases} \tag{18}$$

where the outside option is the utility from an infinite stream of some fraction $wl$ of the internal stakeholders' current wage:

$$\text{outside option} = \sum_{\tau=t}^{\infty} \delta^{\tau-t} u_S(wl \times NetMnt) \tag{19}$$

We do not analyze the source of the contract with internal stakeholders nor the total amount of expected compensation received under the contract. Our focus is on the implications of this contract for investment and endowment decisions. In a competitive market for internal stakeholders, 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 internal stakeholders.

### 4.3 University Objective Function

Universities, being not-for-profit institutions, do not have *explicit* residual claimants. However, they do have *implicit* residual claimants, who exert control without the authority to liquidate the university. These residual claimants are the donors and the internal stakeholders. Donors want the university to invest internally for the creation of social dividends, but they also want to minimize the risk that the university ceases to exist. Internal stakeholders also want to minimize the risk of default, since they would lose their job, but beyond that their interests differ from that of the donors. Internal stakeholders want to maximize the cash flows (wages and perks) they receive while they are members of the university. This claim is diluted among more internal stakeholders as the university invests internally and grows. Both forces cause internal stakeholders to lobby against growth.

We model the competing forces of the different stakeholders – donors and internal stakeholders – as a convex combination of their individual value functions, giving rise to the following value function for the university as a whole:

$$V(\mathcal{C}_t, \theta_t) = (1-\beta) \times V_D(\mathcal{C}_t, \theta_t) + \beta \times V_S(\mathcal{C}_t, \theta_t) \tag{20}$$

where $\beta$ represents the level of control awarded to internal stakeholders. $\beta$ may be thought of as a reduced form measure of bargaining power. These features lead to the university solving the following optimization:

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

where

$$\mathcal{C}_t = \{EndPay_t, IntInv_t, \alpha_t\} \quad \text{and} \quad \theta_t = \{K_t, I_t, E_t, X_t\}.$$

## 4.4 Model Timing Summary and Discussion

Figure 1 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 internal stakeholders ($Perks_t^*$), and how to allocate the remainder of the endowment between safe and risky assets ($\alpha_t^*$).

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 internal 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.

For simplicity, our model ignores the risks inherent in some of the university's budgetary cash flows (see Section 5). For instance, income from tuition and 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.[7]

# 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 and it consists of three key groups: those related to the university's internal projects; those related to the university stakeholders; and those related to the endowment. After defining the budgeting process of the university, we discuss each group of parameters in turn.

[7]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.

## 5.1 University Internal Projects

### 5.1.1 University Budget

At each date (year), the university must balance its budget: its income must be enough to match its costs.[8] The university has multiple sources of income (or revenue):

$$Income_t = Tuition_t + Fees_t + Grants_t + Donations_t + EndPay_t \tag{21}$$

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.[9] $EndPay_t$ 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.[10]

The university's cost structure is:

$$\begin{aligned} Expenditures_t \quad = \quad & \underbrace{Wages_t + Research_t + Instruction_t + Administration_t}_{\text{Gross maintenance cost}} \\ & + Perks_t + IntInv_t \end{aligned} \tag{22}$$

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 internal stakeholders. $IntInv_t$ is the amount of new internal investment that the university undergoes

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

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

[10] 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.

during the year.

We define the net maintenance cost of the university as:

$$\begin{aligned} NetMnt_t &= (Wages_t + Research_t + Instruction_t + Administration_t) \\ &\quad -(Tuition_t + Fees_t + Grants_t) \end{aligned} \tag{23}$$

which represents the net continuing cost of existing projects. By equating the university's revenues and costs (equations (21) and (22)), we therefore have the following budgetary restriction at each point in time:

$$NetMnt_t + Perks_t + IntInv_t = EndPay_t + Donations_t. \tag{24}$$

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.[11] $Grants_t$ (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.

### 5.1.2 Cost of Internal Production and Net Maintenance

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

[11] 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.

initial cost is embodied in our installation cost function (equation (3)). 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.

Having derived the link between the net maintenance cost of the university and the choice variables in our model (equation (24)), the second part of the 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 allows us to calibrate the fraction of the budget that the net maintenance cost represents. 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 (24), 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.

### 5.1.3 Production Function and Social Dividends

We consider three different levels of *productivity* for the university's internal projects. Project productivity enters through equation (3), 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.[12]

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 (see equation (1)). The choice of the proportionality constant $sd$ is a normalization that affects the interpretation of $\beta$, the bargaining power parameter. We normalize $sd$ such that near the steady state, the marginal utility of donors from an additional unit of university capital and the marginal utility of internal 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.

### 5.1.4 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.[13] This delay between when a project is undertaken and when it begins pro-

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

[13]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.

ducing 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' net present value (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 (8)) 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 $DS = 0.47$.[14]

## 5.2 University Stakeholders

We assume that donors and internal stakeholders both have coefficients of relative risk aversion of 5 in their respective CRRA utility functions (Barsky et al., 1997). We also assume that the internal stakeholders' outside option is equal to a perpetuity at their wage rate without perks. Thus in equation (19), the wage loss parameter is $wl = 1$. In one of the model's extensions, we consider a larger wage loss of 30%, making $wl = 0.7$. Lastly, following Campbell and Viceira (1999), we give the stakeholders a time discount rate of $\delta = 0.94$ in annual terms.

## 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

[14]That is, we consider the NPV at investment = 0, 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.

rate of 5%, in line with the empirical evidence highlighted by the National Association of College and University Business Officers (NACUBO) 2011 survey, even though the Uniform Prudent Management of Institutional Funds Act (UPMIFA) sets the "imprudent" maximum payout limit at 7%.

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 A.[15] The unconditional expected log excess return is 5% per year and the annual volatility of the stock return is 14.55%. The log real risk-free rate is 0.28% per year (constant).

# 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 as well as 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 donors' utility function and the internal 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. 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 set to zero.

[15]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. (2011) show that investing in illiquid assets can be suboptimal since consumption must be financed out of liquid assets.

Throughout the analysis of the results, we will vary the three key free parameters in the following way. The governance parameter of the university $\beta$ will take the value of 0 for full donor control, 1 for full internal 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 $A$ will take the value of 1 for the medium production case, 4 for the high production case, and 1/4 for the low production case. The endowment payout will be either unconstrained (100% possible payout) or will be constrained to 5% of the value of the endowment.

## 6.1 Steady State Endowment and University Characteristics

### 6.1.1 The Endowment

**Endowment Asset Allocation.** Panel A of Table 2 shows the endowment's 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 spend 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 of high productivity, then it will take little risk externally and instead focus its attention internally. Everything held equal, a risky endowment is a signal of the low productivity of the university's marginal internal project.

The governance structure of the university also affects the endowment's asset allocation. In a donor-controlled university ($\beta = 0$), the endowment is significantly less invested in the risky asset compared to an internally-controlled university ($\beta = 1$). 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 donors to internal stakeholders. Donors are averse to the risk of the university having to shrink its operations if it is unable to meet its net maintenance cost. Indeed, shrinking leads to a permanent loss of university capital, which in turn leads to a permanent loss in future social dividends and future donations. As a result, donors prefer a safe endowment that minimizes the risk of shrinking. Internal stakeholders exert an opposing force on the asset allocation because they are able to fully capture the upside of risky external investments. Everything held equal, a risky endowment is a signal that the governance of the university is in the hands of internal stakeholders.

Comparing Panels A.1 and A.2 of Table 2 shows 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 payout constraints effectively eliminate 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 it became large enough.

**Endowment Size.** Panel B of Table 2 shows the 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 unity, 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 donors to internal stakeholders, and as 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 net present value 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 internal stakeholders, who aim to capture the full upside of risky external investments, the size of the endowment rises with the allocation to the risky asset. The effect of imposing a payout constraint is particularly strong, as the size of the endowment increases by a factor of 22 for the case of $\beta = 1/2$ at the medium production. 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.

**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 internal stakeholders' perks (Panel D).[16] 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.[17]

The endowment payout reflects both the equilibrium asset allocation and endowment size shown in Table 2. As the governance of the university shifts from donors to internal stakeholders, the endowment becomes riskier and larger. As a result, the payout is larger, as

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

[17]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.

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 donor-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. The opposite happens for the internally-controlled university, which relies solely on the endowment for funding, therefore leading to a larger payout.

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 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 even though highly productive universities are likely to be larger than less productive ones.

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. As such the constrained donor controlled university grows more slowly.

### 6.1.2 The University

**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 net present value projects. Also, as the governance of the university shifts to internal stakeholders, the growth rate of the university falls since internal stakeholders prioritize perks over internal investments since they do not capture the upside of the risky internal projects. When the university is under complete control of internal 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 subtle role on the growth rate of the university. If the university is donor-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 donors and internal 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 4 shows the university growth rate via Monte Carlo simulations. By taking 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 growth rate (4.4%) is actually higher than the constrained growth rate (3.9%) in the $\beta = 0$ case. Moreover, the simulations highlight the fact that in the constrained case, the growth rate is significantly more volatile in the $\beta = 1/2$ case.

Summarizing, it appears as though the maximum endowment payout constraint may be fixing the agency problem created by the internal stakeholders not investing internally. However, aside from Jensen's inequality, this occurs in cases where the agency costs are low in the first place, i.e., when the productivity of the marginal projects is low. When the productivity of marginal projects is high, and hence the agency costs could be high, the payout constraint makes the university worse off.

**University Size.** Panel B of Table 4 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.

After 100 years, an unconstrained donor-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 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.

**The University's Risk of Shrinking.** At each time period, if the university cannot meet its net maintenance cost, then it must shrink its current operations. Analyzing the 100,000 Monte Carlo simulations, Panel C of Table 4 shows the average time to the first shrinkage point and the average time between two shrinkage points, as well as the number of simulations that cross these thresholds. As the governance of the university shifts from donors to internal stakeholders, and as the endowment payout constraint is applied, both the average time to the first shrinkage point and the average time between shrinkage points significantly decrease. This result reiterates the above point that the payout constraint and the increased control of the internal stakeholders implicitly render the university riskier.

## 6.2 Loss 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.[18] By comparing this sum across models, we can then estimate the loss (or gain) of social dividends imposed by a shift in governance or the presence of a payout constraint.

The first row of Table 5 shows the amount of social dividends produced in the baseline case of an unconstrained donor-controlled ($\beta = 0$) university over three different horizons, both at the stochastic steady state solutions and using Monte Carlo simulations. The remaining rows of the table show the percentage loss in social dividends of each model compared to the baseline case.

As the governance of the university is shifted away from donors and toward internal stakeholders ($\beta = 1/2$ or 1), the loss of social dividends increases quite dramatically compared to the donor-controlled university. Over a 50-year horizon, an unconstrained but internally-controlled produces 54% less social dividends. This is consistent with prior results showing that the growth rate of the university falls as the control shifts to internal stakeholders, who prioritize perks over internal investments. Loosely speaking, we can say that the quality of the internally-controlled university in terms of its production of research and teaching is 50% worse than its equivalent donor-controlled university.

Even if the governance of the university is solely in the hands of donors ($\beta = 0$), the introduction of a maximum payout constraint leads to a loss of social dividends of almost 20% over 20 years. In the case of split governance ($\beta = 1/2$), it appears as though the introduction of the constraint actually leads to a gain in social dividends, i.e., the loss in social dividends is lower in the constrained case compared to the unconstrained

[18] We discount future sizes at the rate of time preference $\delta$.

case. This is also consistent with prior results showing that the growth rate is higher in this constrained case compared to the unconstrained one. As a result, it seems that the constraint fixes the agency problem, leading to higher internal investment, higher growth rate, and hence a smaller loss in social dividends. But this fix 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.

## 6.3 Impulse Response Functions

We further analyze the behavior of universities and their endowments by subjecting their 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 2 and 3.

### 6.3.1 The Role of the University's Governance

Figure 2 shows IRFs for two unconstrained models with medium production ($A = 1$): one where the donors are in control of the university ($\beta = 0$, darker blue lines) and one where the internal stakeholders are in control ($\beta = 1$, lighter purple lines). The steady states are the continuous lines and the IRFs are the dashed lines.

We first focus on how a donor-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 governed by the internal 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 internal stakeholders "use" the endowment to smooth their consumption (via perks).[19]

### 6.3.2 The Role of the Productivity of the Marginal Internal Project

Figure 3 shows IRFs for two unconstrained models with donor 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 because of its low productivity. It spends its endowment to a level below its steady state

[19]For the sake of tractability, we do not model the internal stakeholders' personal consumption and savings behavior, which would require an additional maximization. As a result, we implicitly assume that the internal stakeholders can use the endowment as they would use their personal savings account.

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 observed behavior of endowments.

# 7 Model Extensions

## 7.1 Absence of Donations

In Table 6, we show the steady state results of our model *without* any donations. More 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 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 whoever is in control of the university (donors and/or internal stakeholders) do care about social dividends, 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 controlling stakeholders' minds. Phrased more strongly, it is as if internal investment in research and teaching is not viewed as an investment but rather as a cost.

### 7.2 Lower Outside Option of Internal Stakeholders

In our baseline model, the outside option of the internal stakeholders is defined by their loss of perks: If the university shrink 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 internal stakeholders by imposing a 30% permanent wage loss if they are fired ($wl = 0.7$). Table 7 shows the steady state results of the unconstrained models with this decreased outside option.

We see that as their outside option decreases, the internal stakeholders somewhat reduce their exposure to risky assets in the endowment. The effect is small though, from 49.9% to 37.5% in the $\beta = 1/2$ case, and has only a minor effect on the endowment size and the growth rate of the university. This finding suggests that our previous results – a large and risky endowment is driven by concessions to the internal stakeholders – are not due to the internal stakeholders using the endowment as a hedge against the risk of being fired.

## 8 Conclusion

In this paper, we attempt to explain why university endowments have the propensity to hold a large fraction of their assets in risky securities. To the best of our knowledge, we are the first to explicitly take a stand on the objective function of universities. Specifically, we model universities as producers of social dividends – knowledge creation and dissemination via research and teaching – which are non-marketable public goods. Donors want the university to invest their donations in risky internal projects to produce social dividends, now and forever. However, internal university stakeholders, such as faculty, staff, and students, prefer risk to be taken through the endowment in the capital markets because expansion through internal projects dilutes their claim to the university. In equilibrium, the university must balance these two forces when it decides how much of its endowment to pay out, where to spend it, and how to invest the remainder.

By observing a university's endowment decisions – size and asset allocation – we can infer information about its governance structure as well as its marginal internal projects. Even when donors are in control, the productivity of the marginal projects available to the university affect the endowment investment decision. When the university faces high productivity marginal projects, the university chooses a small endowment invested in relatively safe assets. When the productivity of the marginal projects is low, the university chooses a larger endowment tilted toward riskier assets. If the control of the university is shifted to internal stakeholders, internal investment is further reduced in favor of additional risk-taking in the endowment. Externally mandated constraints on endowment spending rates interfere with the university's optimal choices. Though aimed at reducing the agency costs, these maximum spending constraints cause universities to hold larger endowments allocated toward riskier assets than they otherwise would choose. Thus the regulatory thinking on what constitutes prudent endowment management should be reexamined.

Our analysis suggests that the current behavior of universities – building large endowments heavily invested in risky assets and spending a small fixed percentage of the endowment in perpetuity – is puzzling if the sole objective is to maximize the production of social dividends. We show several ways this puzzle may be explained. Universities may have few new productive internal projects in need of funding. The incentive contract of internal stakeholders may encourage them to prefer risky returns in financial markets instead of internal expansion, which dilutes their claim to the university. University trustees may fail to account for future donations generated by new internal investment today. Or legal constraints on maximum endowment payout rates may distort university decisions, unintendedly forcing endowments to take more risk.

We do not advocate the complete avoidance of risky assets. Instead, we highlight that risk-taking in financial markets comes at the cost of internal risk-taking. Taking risks by pursuing new ideas and teaching more students is the primary mission of the university – producing knowledge today so that others can stand on the shoulders of giants in the future, though some giants might not end up so tall!

# A 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

$$r_{t+1} - E_t\left[r_{t+1}\right] = u_{t+1} \tag{25}$$

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

$$E_t\left[r_{t+1}\right] - r_f + \frac{\sigma_u^2}{2} = x_t \tag{26}$$

The state variable is modeled as an AR(1) process with mean $\mu$ and persistence $\phi$

$$x_{t+1} = \mu + \phi(x_t - \mu) + \eta_{t+1} \tag{27}$$

where the innovation $\eta_{t+1}$ is normally distributed with mean zero and variance $\sigma_\eta^2$.

The model's key assumption is the covariance between the two innovations, $\eta_{t+1}$ and $u_{t+1}$, which is labeled as $\sigma_{\eta\mu}$. This covariance generates intertemporal 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 $(d_t - p_t)$, 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

$$\begin{pmatrix} r_{1,t+1} - r_f \\ d_{t+1} - p_{t+1} \end{pmatrix} = \begin{pmatrix} \theta_0 \\ \beta_0 \end{pmatrix} + \begin{pmatrix} \theta_1 \\ \beta_1 \end{pmatrix} (d_t - p_t) + \begin{pmatrix} \varepsilon_{1,t+1} \\ \varepsilon_{1,t+1} \end{pmatrix} \tag{28}$$

where the innovations are normally distributed with mean zero and covariance matrix $\Omega$. From the estimated coefficients of the VAR(1) model, the coefficients in equations (25), (26) and (27) 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 $\mu$ is estimated to be 5% per year and the log real risk-free rate $r_f$ is 0.28% per year. The persistence parameter $\phi$ of the state variable process is 0.957 and the correlation between the $\eta$ and $u$ innovations is -0.737. The annual volatility of the stock return $\sigma_u$ is 14.55% and the annual volatility of the state variable $\sigma_\eta$ 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., Papanikolaou, D., Westerfield, M., 2011. Portfolio choice with illiquid assets. Columbia University Working Paper.

Barber, B. M., Wang, G., 2011. 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.

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., 2012. How university endowments respond to financial market shocks: Evidence and implications. NBER Working Paper 15861.

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.

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

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.

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

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.

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.

Goetzmann, W. N., Oster, S., 2012. Competition among university endowments. NBER Working Paper 18173.

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.

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.

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

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.

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 fixed costs (wages, research, instruction, administration) and its fixed revenues (tuition, fees, grants). 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 donors and internal 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 outside option of the internal stakeholders is the present value of their wage or a partial fraction thereof. 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 |
| Donors Coefficient of Relative Risk Aversion ($\gamma_D$) | 5 |
| Internal Stakeholders Coefficient of Relative Risk Aversion ($\gamma_s$) | 5 |
| Wage Loss of Internal Stakeholders ($1 - wl$) | 0% or 30% |
| Annual Rate of Time Preference ($\delta$) | 0.94 |
| Endowment Payout Constraint | 100% or 5% |
| Annual Expected Excess Stock Return | 5.00% |
| Annual Standard Deviation of Excess Returns | 14.55% |
| Annual Risk-Free Real Rate of Return ($R_f$) | 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. All models are run to 200 years.

Panel A: Endowment Allocation to Risky Asset

A.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 43.2% | 0% | 0% |
| $\beta = 1/2$ | 63.2% | 49.9% | 44.0% |
| Internal ($\beta = 1$) | 100% | 100% | 100% |

A.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 100% | 54.8% | 39.8% |
| $\beta = 1/2$ | 100% | 92.0% | 86.2% |
| Internal ($\beta = 1$) | 100% | 100% | 100% |

Panel B: Endowment Size

B.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 0.31 | 0.27 | 0.25 |
| $\beta = 1/2$ | 0.39 | 0.33 | 0.31 |
| Internal ($\beta = 1$) | 0.63 | 0.63 | 0.63 |

B.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 6.77 | 4.71 | 4.18 |
| $\beta = 1/2$ | 9.51 | 7.20 | 6.48 |
| Internal ($\beta = 1$) | 26.82 | 26.82 | 26.82 |

Panel C: University Growth Rate

C.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 2.7% | 4.5% | 5.7% |
| $\beta = 1/2$ | 1.3% | 2.4% | 3.3% |
| Internal ($\beta = 1$) | 0% | 0% | 0% |

C.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 3.4% | 3.5% | 3.6% |
| $\beta = 1/2$ | 2.5% | 3.0% | 3.2% |
| Internal ($\beta = 1$) | 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 internal stakeholders' 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

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 35.4% | 17.3% | 5.9% |
| $\beta = 1/2$ | 47.8% | 37.5% | 28.6% |
| Internal ($\beta = 1$) | 47.2% | 47.2% | 47.2% |

A.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 2.0% | 0.8% | 0.2% |
| $\beta = 1/2$ | 2.9% | 2.2% | 1.9% |
| Internal ($\beta = 1$) | 4.3% | 4.3% | 4.3% |

Panel B: Discretionary Payout as Percentage of Budget

B.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 11.6% | 4.8% | 1.5% |
| $\beta = 1/2$ | 19.4% | 13.2% | 9.3% |
| Internal ($\beta = 1$) | 31.2% | 31.2% | 31.2% |

B.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 14.6% | 3.7% | 1.0% |
| $\beta = 1/2$ | 29.0% | 16.8% | 13.1% |
| Internal ($\beta = 1$) | 120% | 120% | 120% |

Panel C: Percentage of Discretionary Payout for Internal Investments

C.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 100% | 100% | 100% |
| $\beta = 1/2$ | 28.2% | 19.1% | 9.3% |
| Internal ($\beta = 1$) | 0% | 0% | 0% |

C.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 100% | 100% | 100% |
| $\beta = 1/2$ | 37.2% | 19.3% | 6.5% |
| Internal ($\beta = 1$) | 0% | 0% | 0% |

Panel D: Percentage of Discretionary Payout for Perks

D.1: Unconstrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 0% | 0% | 0% |
| $\beta = 1/2$ | 71.8% | 80.9% | 90.7% |
| Internal ($\beta = 1$) | 100% | 100% | 100% |

D.2: Constrained

| | Production Function | | |
|---|---|---|---|
| Governance | Low | Medium | High |
| Donors ($\beta = 0$) | 0% | 0% | 0% |
| $\beta = 1/2$ | 62.8% | 80.7% | 93.5% |
| Internal ($\beta = 1$) | 100% | 100% | 100% |

**Table IV**
**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 |

Panel C: University Shrinking Times

| | Unconstrained | | | Constrained | | |
|---|---|---|---|---|---|---|
| | $\beta = 0$ | $\beta = 1/2$ | $\beta = 1$ | $\beta = 0$ | $\beta = 1/2$ | $\beta = 1$ |
| % of universities that shrink $\geq 1$ | 91.1% | 65.5% | 100% | 92.0% | 50.0% | 100% |
| Average time to first shrinking | 32 years | 47 years | 8 years | 28 years | 45 years | 7 years |
| % of universities that shrink $\geq 2$ | 69.0% | 38.3% | 100% | 80.2% | 30.9% | 100% |
| Average time between shrinking | 22 years | 15 years | 6 years | 13 years | 9 years | 2 years |

**Table V**
**Loss 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 (at the steady state or via simulations) over the given horizon, discounting at the rate of time preference $\delta$. 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. All models are at the medium production function ($A = 1$).

| | | Steady State | | | Simulations | | |
|---|---|---|---|---|---|---|---|
| | | 10-year | 20-year | 50-year | 10-year | 20-year | 50-year |
| Baseline Total Production of Social Dividends: | | | | | | | |
| $\beta = 0$ | Unconstrained | 9.1 | 16.7 | 32.8 | 9.1 | 16.7 | 32.8 |
| Loss of Social Dividends Relative to Baseline: | | | | | | | |
| $\beta = 1/2$ | Unconstrained | 10.3% | 18.0% | 33.7% | 9.8% | 16.9% | 32.9% |
| $\beta = 1$ | Unconstrained | 20.4% | 33.3% | 54.4% | 20.6% | 33.5% | 54.4% |
| $\beta = 0$ | Constrained | 5.0% | 9.0% | 18.4% | 4.6% | 7.1% | 11.5% |
| $\beta = 1/2$ | Constrained | 7.2% | 12.8% | 25.2% | 5.9% | 9.7% | 19.1% |
| $\beta = 1$ | Constrained | 20.4% | 33.3% | 54.4% | 20.6% | 33.5% | 54.4% |

**Table VI**
**Absence of Donations**

This table shows the stochastic steady state endowment size (Panel A), endowment allocation to the risky asset (Panel B) and university annual growth rate (Panel C) for an unconstrained university that receives no further donations, i.e., $DS = 0$. 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. All models are run to 200 years.

Panel A: Endowment Allocation to Risky Asset

| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 76.5% |

Panel B: Endowment Size

| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 7.34 |

Panel C: University Growth Rate

| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 0.5% |

**Table VII**
**Lower Outside Option of Internal Stakeholders**

This table shows the stochastic steady state endowment size (Panel A), endowment allocation to the risky asset (Panel B) and university annual growth rate (Panel C) for an unconstrained university whose internal stakeholders' outside option includes a permanent 30% wage loss. 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. All models are run to 200 years.

Panel A: Endowment Allocation to Risky Asset

| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 0% |
| $\beta = 1/2$ | 37.5% |
| Internal ($\beta = 1$) | 100% |

Panel B: Endowment Size

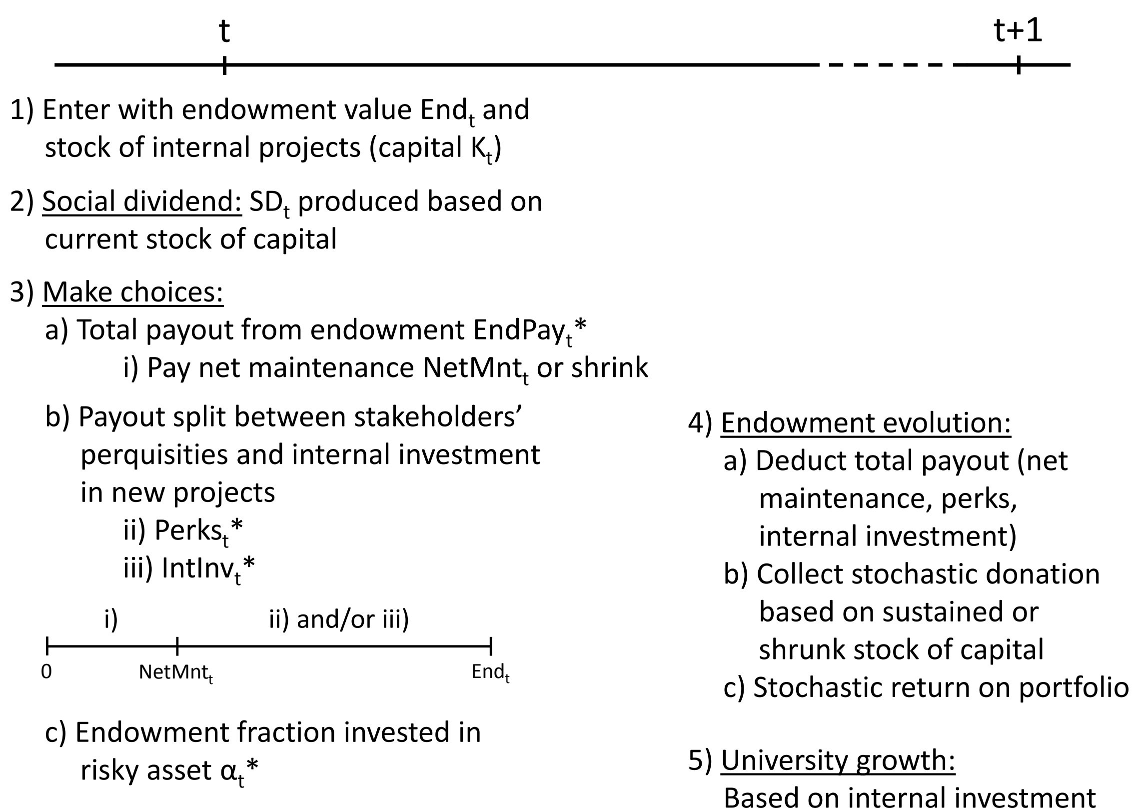
| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 0.27 |
| $\beta = 1/2$ | 0.34 |
| Internal ($\beta = 1$) | 0.63 |

Panel C: University Growth Rate

| Governance | Production Function Medium |
|---|---|
| Donors ($\beta = 0$) | 4.5% |
| $\beta = 1/2$ | 2.4% |
| Internal ($\beta = 1$) | 0% |

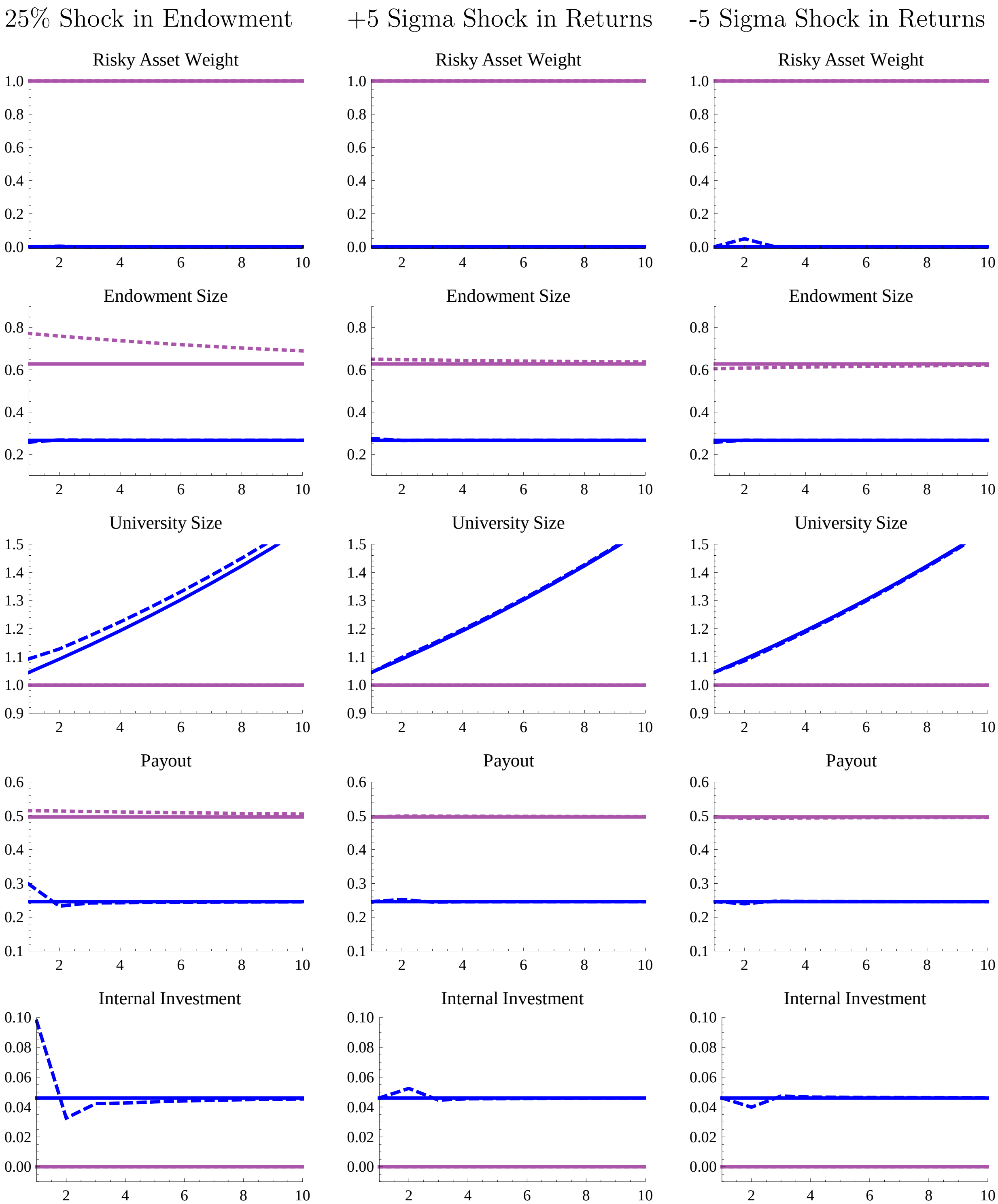
## Figure 1
## Timeline of Production Model

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 internal 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.



## Figure 2
## Impulse Response Functions for Varying University Control

Each graph shows the steady state (solid lines) and the impulse response functions (dashed or dotted lines) over 10 years for various characteristics of the university. The blue (darker) lines are for the case with full donor control ($\beta = 0$) and the purple (lighter) lines are for the case with full internal stakeholder control ($\beta = 1$). 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.



## Figure 3
## Impulse Response Functions for Varying Production Function

Each graph shows the steady state (solid lines) and the impulse response functions (dashed or dotted lines) over 10 years for various characteristics of the university. The blue (darker) lines are for the high production function ($A = 4$) and the purple (lighter) lines are for the low production function ($A = 0.25$). All lines are for the unconstrained case with full donor 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.