From:	Jason Gasper
To:	Sen. Pete Kelly; Sen. Anna MacKinnon; Sen. Gary Stevens; Sen. Johnny Ellis; Sen. Peter Micciche; Sen. Click Bishop; Sen. Mike Dunleavy; Sen. Lyman Hoffman; Sen. Donny Olson; Rep. Mark Neuman; Rep. Steve Thompson; Rep. Dan Saddler; Rep. Bryce Edgmon; Rep. Lynn Gattis; Rep. Cathy Munoz; Rep. Lance Pruitt; Rep. Les Gara; Rep. David Guttenberg; Rep. Scott Kawasaki; Rep. Mike Hawker
Subject:	UA proposed budget
Date:	Wednesday, February 24, 2016 9:02:10 PM
Attachments:	Gasper Letter (1).pdf kantor_whalley_spillover_2012.pdf

Greetings,

I figured e-mail is probably the best method to communicate my concerns about the budget put forward by the House Finance Committee.

I am concerned about cuts to the University's research budget and have expressed these concerns in the attached letter. I also provided supplemental documentation to the letter if you feel-inclined to review the source behind the link supplied in my letter.

I appreciate your time and thank you for your service.

Cheers,

Jason Gasper

Greetings,

I am writing out of concern for the proposed UA operating budget.

First, a little of my background and investment in Alaska and the UA system: I have gained much from the UA system. I attended UAS from 1997 to 2002 (Bachelor of Biology- Marine emphasis), UAA (2001-2002), and UAF (2005-2011- PhD Fisheries). I have also attended the University of Washington (School of Marine Affairs- Masters of Marine Affairs-2004). My wife obtained her PhD from UAF (Fisheries) in 2010. I currently work for the National Marine Fisheries Service, Sustainable Fisheries Division.

My education has worked well for me. However, it goes much deeper than pieces of paper; the University system is the key reason I was able to come to Alaska, invest in the State, and call it home. I learned what it means to be an Alaskan through my school-related activities.

In my field, the nearly universal access to research that students currently have sets the UA system apart from other schools. When I was school shopping, I realized the UA system had undergraduate research and graduate research opportunities not available in other parts of the country (or it was highly competitive for few slots). This brought me to UAS. These research programs serve as an apprenticeship program; **employers need graduates who are experienced, not just book smart. Research provides this critical experience for students.**

Cutting these programs, especially during periods when employment is down in other State departments, will reduce the competitiveness of the UA system among students considering whether to stay in Alaska or come to the Great Land for education. UA students will be much less prepared for the "real world" when they leave the system into an already tight job market. Speaking from experience, bridge jobs, such as Fish Tech jobs at ADFG, are important first jobs for many students. These jobs will be fewer due to a declining budget, and more competitive, thus students without research background will be at a significant disadvantage. Students will also have a much harder time completing advanced degrees due to the lack of funding for projects. This will have a long-term effect on who is employed in Alaska; do we want to provide opportunity for Alaskans or hire from outside?

In closing, you have some tough choices to make concerning the budget. I ask that you do not trade short-term budget needs by sending a message that the UA system is not going to provide opportunity for the next generation of Alaskans. We need research programs in place to build and diversify our economy. In fact, I would argue we need well-aligned research money available to attract investment (e.g., http://www.ucmerced.edu/news/2014/research-universities-create-economic-spillover-study-shows).

Thanks for your time.

Jason Gasper
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Knowledge Spillovers from Research Universities:
Evidence from Endowment Value Shocks

(revised May 2012)

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ABSTRACT

We estimate the local spillovers from research university activity in a sample of urban counties. We use the fact that universities tend to follow a rigid endowment spending policy based on the market value of their endowments to identify the causal effect of university activity on labor income in the non-education sector. Our instrument for university expenditures is based on the interaction between each university's lagged endowment level and the variation in stock market shocks over time. We find statistically significant spillover effects from university activity, and the magnitude of the spillover is significantly larger when local universities are more research intensive or when firms are technologically closer to universities, as measured by labor market pooling and patent citations. The findings provide a rationale for place-based university policies, so long as they focus on industry fundamentals. The results also suggest that the longer-term effects that universities have on their local economies may grow over time as the composition of local industries evolve to take advantage of the knowledge spillovers we identify.

We thank the TIAA-CREF Institute Research Grant Program and NSF grant SES-0851788 for financial support. We are grateful to Julie Cullen, Martin Dooley, Enrico Moretti, and three anonymous referees for helpful comments and discussions. Seminar participants at Chapman University, Rensselaer Polytechnic Institute, UC Berkeley, UC Davis, and the University of Hawaii provided many useful suggestions and insights. We also thank Michael Greenstone, Richard Hornbeck and Enrico Moretti for providing their CPS employment transitions data and Ken Redd of the National Association of College and University Business Officers for data on endowment portfolio holdings. Justin Hicks and Nolan Noble provided outstanding research assistance. The views expressed herein are those of the authors and do not necessarily reflect the views of TIAA-CREF or the NSF.

Knowledge Spillovers from Research Universities:
Evidence from Endowment Value Shocks

I. Introduction

The geographic concentration of economic activity is a salient feature of modern economies. There are a number of reasons to suspect that the positive externalities associated with the clustering of labor and capital in urban areas accounts for the dramatic economic density we observe. For example, density allows producers to access suppliers more easily and inexpensively, enables them to reach customers more efficiently, and raises the prospects of hiring high-quality workers in a thick labor market. Furthermore, the thick labor market that a city offers mutually benefits workers who can mitigate their unemployment risk and raise their own chances for a quality employer-match.[1] Economists have also devoted significant attention to understanding the importance that knowledge spillovers play in contributing to the increasing returns of geographic density.[2] According to Marshall (1890, 332), when productive people locate closely, "The mysteries of the trade become no mysteries; but are as it were in the air . . . Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed; if one man starts a

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[1] There is a voluminous and growing literature measuring the determinants and magnitudes of agglomeration spillovers. While not an exhaustive account of the literature, see for example Lucas (1988), Romer (1990), Krugman (1991a,b), Rauch (1993), Audretsch and Feldman (1996, 2004), Ciccone and Hall (1996), Ellison and Glaeser (1997, 1999), Black and Henderson (1999), Glaeser (1999), Glaeser and Mare (2001), Rosenthal and Strange (2001, 2003, 2004, 2008), Dumais, Ellison, and Glaeser (2002), Davis and Weinstein (2003), Henderson (2003), Moretti (2004 a,b,c), Ciccone and Peri (2006), Shapiro (2006), Ellison, Glaeser, and Kerr (2007), Arzaghi and Henderson (2008), Glaeser and Kerr (2009), Iranzo and Peri (2009), and Baum-Snow and Pavan (2012).
[2] For a recent review of this strand of the agglomeration literature, see Henderson (2007).

new idea it is taken up by others and combined with suggestions of their own; and thus becomes the source of yet more new ideas."

While Marshall seems to have emphasized the organic nature in which knowledge is developed and transferred, in this paper we seek to measure the extent and magnitude of such spillovers from a formal institution whose sole mission is the creation and dissemination of knowledge – the research university.[3] In other words, since research universities exist and are heavily subsidized to "spill knowledge," it seems natural to look here first to understand the importance that knowledge spillovers can play in agglomeration economies in general.[4] Despite the prominence of high-profile university-industry partnerships in Silicon Valley and along the Route 128 corridor, there is a relatively small but growing body of empirical research that has attempted to measure the role that universities play in contributing to economic growth at the relatively local level. Following Jaffe (1989; see also Acs, Audretsch, and Feldman 1991) much of the research has explored the spillover effects of academic research on such outcomes as patents, innovations, business start-ups, or employment changes.[5] While the prior research has

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[3] Of course, more recently research universities have been engaged in the commercialization of their knowledge creation.

[4] The public subsidy to higher education in the U.S. to create and disseminate knowledge is significant. In FY 2008 public universities received $85 billion from state and local governments for their wide-ranging activities from teaching, research, to outreach (SHEEO 2009, Table 6). The federal government, in FY 2007, contributed $30.4 billion to the research and development activities of colleges and universities (NSF 2009). In addition, many individuals, foundations and firms donate large sums to universities, often to enhance the performance of institutions they support or to sponsor specific research endeavors. In FY 2008 universities received $31.6 billion in voluntary support from non-governmental sources (CAE 2009).

[5] See, for example, Bania, Eberts, and Fogerty (1993), Audretsch and Feldman (1996), Anselin, Varga, and Acs (1997, 2000), Zucker, Darby, and Brewer (1998), Varga (2000), Adams (2002), Cohen, Nelson, and Walsh (2002), Woodward, Figueiredo, and Guimarães (2006), Abramovsky, Harrison, and Simpson (2007), Toole (2007), Furman and MacGarvie (2007), Rosenbloom (2007), Andersson, Quigley, and Wilhelmsson (2009), and Hausman (2011). Beeson and Montgomery (1993) took a broader approach and tested whether the quality of a university had an impact on regional employment growth rates, the percentage of the labor force employed as

shown the importance of academic research to the development of specific local industries, such as pharmaceuticals or electrical and electronic equipment, and that the productivity gains from academic research tend to be highly localized, we still have little understanding of the causal role that research university activities play in contributing to broad-based regional economic development or the extent to which they facilitate knowledge-based agglomeration.[6]

This paper seeks to address this question directly. We focus specifically on relatively densely populated counties from 1981 to 1996 and examine how research university activity in these urban counties affected the wages that were paid to workers outside the higher education sector. The main challenge we face is that university activity does not occur randomly. The endogeneity arises because the activities of universities themselves may be directly affected by the presence of highly productive and innovative firms in a region. Highly productive firms may provide the intellectual or physical capital needed for a university-industry partnership to be successful. In addition, if knowledge spillovers are present, then they are likely to flow in both directions. Universities benefit from the presence of highly productive and innovative neighboring firms and workers, much as innovative firms do from the presence of a research university. Furthermore, the presence of highly productive firms may increase the local demand for workers trained in a university setting who transition to local jobs – that is, graduating undergraduate and graduate students, as well as former postdoctoral researchers. Thus, naively

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scientists and engineers, regional income, employment, net migration, or the share of employment in high-tech industries.

[6] Aghion, Boustan, Hoxby, and Vandenbussche (2009) consider the impact of research university activity on state economies in an endogenous-growth framework. Their study finds that exogenous increases in research university activity has a greater impact on economic growth for states close to the technological frontier. Part of the reason for this disproportionate benefit is that potential beneficiaries of such education migrate to the frontier states and away from the distant-frontier states. They also find that innovation, in the form of patent activity, increases as a result of the exogenous shocks to higher education.

examining the cross-sectional correlation between university activity and labor income of workers in the neighboring area may lead one to conclude that universities are the source of productive knowledge spillovers, when in fact the causal link is unclear. Our estimation strategy seeks to isolate the spillover effects of research universities' activities on their local economies.

To address the endogeneity concern we develop an instrumental variables strategy based on the fact that universities typically spend a rigid fraction of the market value of their endowments in each year.[7] We take advantage of the facts that shocks to stock market returns occur at the national level and that prior levels of university endowments are exogenous to the future economic activity that may occur in their respective counties.[8] For example, much of the variation in the size of universities' endowments across counties is simply a function of when the institutions were founded and how long their endowments have been able to grow. As there is little reason to expect a direct effect of the age of the university (often founded before the 20th century) on changes in local non-education sector wages other than through university activity, we regard using prior endowment values as a compelling instrumental variable for contemporaneous university expenditures. As urban counties across the U.S. had universities with different levels of initial endowments, when interacted with national stock price

[7] Recent work by Brown, et. al. (2010) analyzing university financial decisions from 1987 to 2008 has demonstrated that universities tend to deviate from their chosen, fixed endowment spending policies when confronted with negative returns to their endowment investments, which were especially salient during the dot com bust. The authors found no statistical deviation from the chosen spending policy when the returns were positive. While we believe that universities were less likely to adjust their spending policy to stock market shocks during our sample period (1981 to 1996), we examine the robustness of our results to heterogeneous endowment spending policies.

[8] Conceptually, our instrumental variables strategy of using exogenously-determined price changes to gain information on local exposure to an economic phenomenon is very similar to that recently used by Black, Daniel, and Sanders (2002) to estimate the effect of local economic activity on disability program participation using the coal boom and bust, and Acemoglu, Finkelstein and Notowidigdo (2009) who estimate the effect of local income on health spending using oil price shocks.

fluctuations, the instrument will capture variation in university activity that is exogenous to changes in local income. Using this method we can estimate the causal effect of university activity on local labor income in non-education sector firms, which is the parameter of interest.

Our empirical analysis reveals that research university activity results in modest, but statistically significant, productivity spillovers to other industries. Our IV estimates indicate that a ten percent increase in higher education spending in an urban county increases the average worker's income in the non-education sector labor income by 0.8%. Put another way, a one-dollar increase in university spending generates an 89 cent increase in non-education labor income. We also find that these effects are persistent, at least measured out five years, thus suggesting that an expenditure shock to a university produces something more profound than a simple fiscal "multiplier effect."

While the broad spillover effects from universities appear rather modest, we further investigate whether the intensity of university research or closer economic links between universities and local industries magnifies the effect, as the prior literature on academic research spillovers would suggest. We first show that the impact of university expenditure on the wages paid by other local firms is nearly three times larger in counties with above-median fractions of graduate students at the local universities than in those with lower levels of graduate students. We then consider three linkage measures.[9] First, we examine whether industries that pool labor markets with the higher education sector receive larger spillovers. Second, we look at how frequently industry patents cite a patent issued by a university to measure industry-specific utilization of higher education knowledge. Finally, we measure the degree to which each

[9] We follow Moretti (2004b), Ellison, Glaeser, and Kerr (2007), and Greenstone, Hornbeck, and Moretti (2010) in measuring disparate spillover effects based on different measures of economic proximity to higher education.

industry employs college graduates – the other primary output of local universities. We find that the impact on labor income in industries that used university knowledge (patents) more intensively, that were more likely to share a labor market with universities, or that hired more college graduates was between 20 and 100 percent greater than the impact in industries that were technologically more distant from universities.

II. Conceptual Framework

The mechanism by which universities – or any industry – contribute to knowledge spillovers is a topic of active ongoing research. On the one hand, we might think that the basic research in which university faculty and staff are engaged has broad applicability that may not accrue locally in any disproportionate manner. Research is produced locally, but disseminated in international scholarly outlets and, hence, available for anyone worldwide to adopt. Yet the empirical research has found otherwise. Jaffe, Tratjenberg, and Henderson (1993), for example, show that nearby industrial firms and universities are much more likely to have their patents cited by others who are geographically close. In an analysis of R&D laboratories owned by U.S. firms, Adams (2002) finds that knowledge spillovers from universities are much more localized than industrial spillovers – "firms go to nearby universities for advice, research, and students. In contrast, industrial interactions take place over a greater distance and occur selectively. . . (p. 254)."[10] The localized network effects associated with faculty, research staff, and graduate and undergraduate students, based on recent empirical research, seems to be a critical feature of the relationship between universities and their industrial counterparts that rely on knowledge

[10] For recent corroborating research that industries locate near universities to capture the unique local benefits of their research activities, see Zucker, Darby, and Brewer (1998), Woodward, Figueiredo, and Guimarães (2006), Abramovsky, Harrison, and Simpson (2007), and Furman and MacGarvie (2007).

generation. While highlighting the paradox of the finding that universities, as institutions that are oriented toward generating public knowledge, seem to benefit local private firms disproportionately, Adams (2002, 274) suggests that it is the nature of open science that draws firms to locate near academic institutions. Firms "go to local universities to obtain information that is reasonably current and not proprietary . . . This increases the localization of academic spillovers." Yusuf (2008, 1173) explains that "The closer one gets to the knowledge frontier, the larger the human factor in the transmission process. Networking and circulation of knowledge workers take on a much greater importance." Universities, according to Yusuf, often acts as the hub that connects the creators and users of path-breaking knowledge that will set the stage for future economic development.

If academic spillovers are indeed highly localized, then how should that impact non-education local labor markets?[11] Theoretically, both wages and land rents would be required to estimate the spillover effects of university activity on total factor productivity (see Roback, 1982). However, as Moretti (2004c) and Rosenthal and Strange (2008) point out, nominal income differences across locations are sufficient to estimate the spillover effect on the marginal product of labor. To see why, consider an adaptation of the open-city model from Rosenthal and Strange (2008). The model is based on the concept of spatial equilibrium, where firms and workers are indifferent across locations. In the model, firms and workers make decisions about where to locate. Spatial equilibrium wages and rents are determined by two indifference conditions. First, real wages must adjust so that workers are indifferent across locations with different amenities. Second, nominal wages must adjust so that they are equal to differences in the value of the marginal product of labor across locations.

[11] Our discussion closely follows that in Rosenthal and Strange (2008) who examine evidence for human capital spillovers in nominal wages.

To understand the effect of the presence of university activity on equilibrium wages and land rents, consider two different locations with and without a university. Suppose that universities enhance local workers' productivity, but do not directly affect workers' utility.[12] In equilibrium, when universities generate knowledge spillovers, firms will expand until the unit cost of production is equalized across locations. As land is an immobile factor some of the external productivity gains will be capitalized into higher land rents. In this case, the impact of knowledge spillovers on wages is a lower bound estimate of the overall productivity gains, holding rents constant, even though the impact on nominal wages is an exact measure of the impact on the marginal productivity of labor.[13]

III. Empirical Approaches

A challenge in estimating the causal effect of university activity on wages, as we note above, is the endogenous nature of university research activity. We implement two strategies to address the endogeneity concern. Our first strategy is to restrict our analysis to counties with a research university presence, and to difference-out time-invariant characteristics of counties and industries, which addresses a wide class of potential selection problems. Any permanent differences across counties that are correlated with the scale of university activity such as

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[12] Of course, it is also possible that locations with and without a university presence have different levels of amenities that workers value. Shapiro (2006) recently estimated that 60 percent of the growth rate in employment across metropolitan areas from 1940 to 1990 can be attributed to the agglomeration effects associated with the enhanced productivity of college graduates in a city. The remainder can be attributed to the notion that more highly educated areas experience more rapid growth in quality of life, which in turn contributes to growth in employment, wages, or rents.

[13] Arzaghi and Henderson (2008) caution, however, that the benefits of agglomeration may be capitalized into rents more than previous research has realized. In their study of the advertising industry in Manhattan, they show that the information spillovers that occur within a close proximity (i.e., occurring within 750 meters) influences rents much more than wages within the industry.

university quality, the presence of a Silicon Valley, or a highly skilled labor force is factored out in the differencing. Moreover, permanent differences in the location of industries, which may be correlated with university activity, are also effectively controlled. Thus, cross-sectional differences in university activity, or factors associated with universities, across counties do not contribute to the identification. Our results are identified from within-county changes in university activity over time. To allay further concerns that we have not effectively dealt with endogeneity, our second strategy is to adopt an instrumental variables approach.

III.1 Difference Equation

Our goal is to estimate the responsiveness of changes in labor income to changes in university expenditures in a county using a long-differences specification. We estimate the model as,

(1) $\Delta Y_{ijt} = \alpha_1 \Delta UE_{it} + T + \varepsilon_{ijt}$,

where ΔY_{ijt} is the long-difference in the logarithm of average non-education sector labor income in county i, industry j, in year t relative to year t-x (i.e., $Y_{ijt} - Y_{ijt-x}$), ΔUE_{it} is the long-difference in per capita total expenditures by universities in county i in year t relative to year t-x (i.e., $(UE_{it} - UE_{it-x})$), T is a set of year fixed effects, and ε_{ijt} is the error term. Our parameter of interest is α_1. The time horizons we examine are three- and five-year long-differences.

The long-difference specification in equation (1) effectively addresses concerns that time-invariant county and industry characteristics might bias our estimates of the true impact of university activity. However, a couple of concerns remain. First, many local productivity shocks are unobservable and are likely to affect both local wages and university activity. For example, if a local firm produces an innovation that increases its productivity and also leads to an increase in the demand for collaboration on future research projects with a local university, this unobserved innovation shock would affect both the level of wages and university activity.

The second concern with equation (1) arises because there is likely to be measurement error in the level of university expenditures in a county. Estimating the model in long-differences magnifies any problems that measurement error in university expenditures poses for the estimation of the effect on labor income. If the measurement error in university activity is classical, α_1 will be biased towards zero and we will underestimate the effect of university activity on local labor income. This attenuation effect may well be important, as Rosenthal and Strange (2008) demonstrate in the context of education externalities. Thus, we turn to an instrumental variables estimation strategy to mitigate the concerns that the endogeneity of changes in university activity and measurement error in university expenditure will lead to bias in our estimates of α_1. The direction of the bias, we should note, is ambiguous.

III.2 Instrumental Variable Strategy

Our empirical strategy attempts to identify potentially exogenous sources of variation in university expenditures in a county. We develop our instrument by taking advantage of the fact that many universities follow a rigid spending formula to determine how much of their endowments are spent in a given year. This spending formula rigidity allows us to instrument for overall university expenditure by exploiting differential impacts of stock price changes across counties where universities had different levels of endowments. In particular, we instrument for ΔUE_{it} in equation (1) with the first-stage specification,

(2) $\Delta UE_{it} = \beta_1(\Delta SM_t \times IE_{it-x-1}) + T + \xi_{it},$

where ΔUE_{it} is the long-difference in per capita university expenditures in county *i* in year *t* relative to year *t-x*, $(\Delta SM_t \times IE_{it-x-1})$ is the long-difference in the Standard and Poor's 500 Stock Index in year *t* relative to year *t-x* (ΔSM_t) interacted with the per capita market value of the endowments of all universities in county *i* in the year prior to *t-x* (IE_{it-x-1}), *T* is a set of year fixed effects, and ξ_{it} is the error term. As the year fixed effects flexibly control for any time-series variation in ΔUE_{it}, we do not include the main effect of stock market shocks (ΔSM_t) in the model.

The intuition behind our identification strategy is straightforward. Universities tend to spend a fixed fraction of the market value of their endowments in any year for a number of reasons, including legal constraints on the spending of endowment resources held in trust and constraints placed upon them by creditors. As Ehrenberg (2000 and 2009) notes, many universities follow a rule of spending 4 to 5 percent of the market value of their endowments each year. Yoder (2004, 10) finds that the average spending rate for all universities in 1999 was 4.7 percent of the market value of their endowments, with the most highly endowed spending 4.1 percent and the least endowed 4.8 percent. To see why the 4 to 5 percent spending rule has become a standard among universities, consider that a typical endowment portfolio of 70 percent stocks and 30 percent bonds would be expected to yield an average annual return of 9 percent over the long-term. With an historic inflation rate for university costs of 4 percent, this leaves a real return of 5 percent. Thus, spending up to 5 percent of the market value of an endowment ensures the long-term sustainability of its real value. Universities may have different target spending rates depending on the composition of their portfolios, their investment returns, their preferences for intergenerational equity, or their desires to increase the long-term real growth rate of their endowments, but in practice there is little variation among institutions.[14]

Universities seek the long-term sustainability of their endowments, so they should not arbitrarily adjust their spending rule to short-term fluctuations in economic conditions, whether unusually favorable or negative. In other words, excess returns would be reinvested in the endowment in a favorable year in order to weather below-normal returns in another. The fixed nature of the spending rule has generated substantial controversy. In the late 1990s and early 2000s, especially, the fact that university spending from endowment funds was far below the returns they were able to achieve in financial markets led to congressional hearings on the nature of the spending policies and whether the favorable tax treatment of endowment income should continue. More recently, with the collapse in endowment values due to the 2008 financial crisis, universities have faced pressure from faculty and students to increase the spending rate from the endowment to preserve the academic quality of the institution. The fact that universities have by and large held firm on their spending policy in the face of significant pressure is largely due to the responsibility they have to protect the principal value of gifts to their endowments on behalf

[14] While differences across institutions in their target spending rates are small, differences in the rate of return they experience may well be larger. Lerner, Schoar and Wang (2008) show that the colleges and universities in the top quartile of the SAT admission distribution experienced a 1.4 percent greater return on their endowments from 1992 to 2005 than those of a median SAT institution. Much of the difference in the rates of return are explained by different portfolio allocations, with asset selection and management differences explaining a smaller portion. One change that has generated much discussion recently is the increasing allocation toward relatively new, alternative assets such as hedge funds, private equity, and venture funds. This change is quite recent and many institutions still have very small holdings in these asset classes. Lerner, Schoar and Wang (2008) note that in 1992 these types of assets accounted for only 1.1 percent of all assets, but grew to 8.1 percent in 2005. Thus, in our sample period of 1981 to 1996, these alternative assets made up only a small portion of endowment portfolios.

of the long-term sustainability of the institution.[15] In fact, Jeffrey Brown, et. al. (2010) find that it is only during negative market shocks that universities deviate from their established payout policies by reducing payout rates to preserve principal, which has a resulting impact on university expenditures. This finding will not have a material impact on our analysis below since we consider three- and five-year changes in variables and during our sample period the stock market never experienced negative returns over any three- or five-year span.

Since universities generally follow their own stable payout rule and all have different endowment values, then exogenous stock market shocks will lead to variation in the amount of endowment income each university will be able to spend in any one year. As stock market shocks and the level of the initial endowment are exogenous to trends in local economic activity across counties, this variation provides a compelling source to identify the effects of overall university expenditures on local economies.

III.3 Potential Challenges to the Identification Strategy

Our identifying assumption is that absent stock price changes, labor income in counties with different levels of initial university endowments would have grown at similar rates. This assumption is reasonable since both national stock market prices and the level of initial endowment should not be correlated with subsequent changes in a county's level of economic

[15] See Salem (1992). It is worth noting that while we have discussed endowments as if they were one entity, in practice each separate gift has a separate endowment account. Many endowment gifts are restricted to funding a certain chair, scholarship, or building at an institution and universities are legally bound to disburse the money of the endowment in accordance with the donor's intent. While many gifts to university endowments have strings attached, endowment disbursements are largely fungible. That is, donors typically provide gifts to support the core activities of the university, such as hiring faculty and offering student aid, so the restrictions that donors place on gifts are unlikely to substantively alter the composition of a university's expenditures. A university could always decline gifts that were inconsistent with its mission or strategic plans.

activity. Of course, counties with different initial levels of university endowment may differ in other ways that could affect local labor income, such as the skill level of the population, the productivity of local firms, or the availability of valuable amenities. Any such differences that are time-invariant will be differenced out in the long-differences model. Only differential trends in income across counties driven by unobservables that are correlated with the level of initial endowment could pose a threat to our identification strategy. While it seems reasonable that our assumption is valid, it is instructive to consider cases where it might be violated.

First, it is possible that stock market shocks affect firms differentially. For example, small firms that are more credit constrained may be more sensitive to cyclical conditions (see, e.g., Moscarini and Postel-Vinay 2009). If the location of credit constrained firms is correlated with the initial endowment of universities in a county, then our identification assumption may be undermined. We address this and other potential concerns with firms' differential exposure to stock market shocks by estimating additional models where we allow for changes in labor income in each industry to be differentially correlated with changes in stock prices.

Second, it is possible that stock market shocks affect universities differentially. For example, higher-quality universities hold a different portfolio of assets in their endowments (see Lerner, Schoar, and Wang, 2008). If higher-quality institutions hold assets that are less correlated with stock market shocks, then this will weaken our first stage for this group of universities. To address this concern we estimate models where we allow changes in labor income in each county to be differentially correlated with changes in the stock market depending on the average quality of universities in the county and examine models where we allow universities to be differentially exposed to stock market shocks. To measure institutional quality we use the average of the 1991 *U.S. News and World Report* quality rankings of the institutions within a county.[16]

In sum, while we cannot completely rule out the possibility that some of the effect reported below reflects time-varying county-specific changes in unobserved labor productivity within a county, it appears that many sources of spurious correlation are controlled.

III.4 Other Estimation Considerations

A few other estimation details are worth noting. First, we cluster the standard errors at the county level to address the fact that university expenditure is measured at the county level and the same expenditure is impacting all industries within the county (see Moulton 1986). This clustering also allows us to address the concern that changes in labor income may by serially correlated within a county-industry cell. Second, we weight all of the industry-county cells by their employment level in 1981. Our estimates, then, represent the effect of university activity on the income of the average worker, not on the average industry-county cell. Third, in measuring the scale of university activity, we use total university spending from all revenue sources, ranging from tuition, state support, federal grants, to endowment income.

Fourth, as noted above, we estimate alternative versions of equations (1) and (2) where we define the long-differences as occurring over a three-year and five-year time horizon. Differences in estimates of α_I between models with different temporal lags help us to understand whether any spillovers are persistent or only transitory. We examine a five-year change in labor income to better capture potential migration responses to changes in university activity. As

[16] As relative institutional quality is very stable over time and the 1991 issue of USNWR was the first to include all national colleges in the rankings algorithm, we treat these data as time invariant measures of quality.

twenty percent of Americans change counties about every five years (Glaeser and Gottleib 2009, 7), the lagged responses may better capture those discussed in the spatial equilibrium literature.

Finally, we probe the validity and robustness of our estimates with a number of alternative specifications. For example, as noted above, we allow stock market shocks to differentially impact different industries or types of universities. We also present specifications where the long-differences in university expenditures are lagged instead of contemporaneous.

IV. Data

The primary data needed to implement the empirical analysis are overall university expenditures, endowment market values, and local labor income in the non-education sector. We obtain annual financial data on each university, as well as data on their characteristics, from the U.S. Department of Education's Higher Education General Information Survey (HEGIS) and Integrated Postsecondary Education Data System (IPEDS) from 1981 to 1996. The HEGIS/IPEDS data provide a census of all four-year colleges and universities in the U.S. and reports information on revenue, expenditure, enrollment, and institutional characteristics from each institution. HEGIS was replaced with the IPEDS survey in 1984. We end our analysis in 1996 because the U.S. Department of Education has unfortunately not released the institutional financial data from the 1997 to 2000 surveys. In addition, there were significant changes in the accounting methods used to report expenditure and revenue beginning with the 2000 survey, thus making it difficult to compare to the earlier data. In addition, universities began investing in much more complicated financial assets after the end point of our study, so the use of stock market changes should prove to be a more powerful instrument for the period of our study. Nonetheless, we test the robustness of our results by examining whether they are sensitive to constructing our instrument using endowment market value held in equities alone. These portfolio data were collected from the National Association of College and University Business Officers (NACUBO). We construct our measure of equity holding based on the average percentage held in domestic equities over the entire sample period.[17] Our second central data source is the U.S. Census Bureau's County Business Patterns (CBP) dataset that contains information on annual labor income and employment by industry for each county. We also use baseline demographic information on counties from the U.S. Census Bureau's 1983 County and City Data Book (CCDB). As a measure of the quality of each institution, we use the *U.S. News and World Report* (USNWR) College Rankings from 1991. Lastly, our instrumental variable uses annual data on the Standard and Poor's 500 (S&P 500) stock market index.

We form our analysis sample by first limiting the set of institutions to the leading research colleges and universities. We define the population of research institutions as those classified as Research I, Research II, Doctoral I, or Doctoral II in the 1994 Carnegie Classification of Higher Education Institutions. This initial sample contains 229 institutions. Since we restrict our attention to counties with populations above 250,000 and exclude the District of Columbia, the resulting sample of colleges and universities is 138 institutions. We impose this geographic restriction as we are interested in estimating the effect of research-university activity in large, diversified local economies that contain the broadest representation of industries. In addition, to preserve confidentiality, the CBP data mask industry-county cells with a small number of establishments, which are more likely to occur in relatively small counties. This sample restriction results in the loss of a few prominent research universities that are located in small counties, such as Duke University. Further, we drop three institutions that

[17] We use an average over the entire sample period because some universities did not report in the NACUBO data in every year.

do not report expenditures in at least 15 years of our 16-year sample period.[18] For 14 institutions that are missing only one year of expenditure data, we impute the missing value by inflating the institution's prior year expenditure by the national growth rate in all institutions' expenditures. The final sample consists of 135 colleges and universities located in a total of 85 counties.

We aggregate the institution-level data to the county-level. We keep all SIC 2-digit industries in the CBP data, but drop tobacco manufacturing (2100) as it is a highly geographically concentrated industry. We also drop the education sector (SIC 8200) and agriculture, minerals and mining (SIC of less than 1500) from the analysis. As there is some entry and exit of small county-industry cells in the CBP data, likely caused by the masking of confidential information, we restrict our analysis to the industries that are reported consistently over time within a county. There are a potential 58 industries, across 85 counties, over 15 years included in the dataset, although not all industries are reported in each county.

We construct our instrument by interacting the endowment market value in each county in the year prior to the three- or five-year period under consideration with the change in the Standard & Poor's 500 Index over that three- or five-year period. We normalize the S&P 500 Index so that the 1981 value is one. As university expenditure is reported for the fiscal year from July to June, we use the average value of the S&P Index over the fiscal year so that the timing of stock market shocks lines up with the timing of university expenditures.

Columns (1) and (2) of Table 1 show the means and standard deviations of various county characteristics, computed over all large counties (populations greater than 250,000) in the first year of the sample, dividing large counties by whether or not they have a university. Column

[18] As a result of dropping the three universities with missing expenditure data, we were forced to drop one county that only had the single research university (Rutgers (New Brunswick) – Middlesex County, NJ). For the other two universities, their counties remain in the sample.

(3) presents t-statistics for a test of differences in the means between columns (1) and (2). The comparison yields a number of interesting results. First, nominal labor income in non-education industries is statistically significantly higher in research university counties than in non-university counties. Second, university counties are much larger, have higher crime rates, and are more racially diverse. There is little difference in the education level of the work force or housing rents across the sets of counties, however. Third, there are also significant differences in the industry distribution of the workforce. University counties have less employment concentrated in retail trade, and more employment concentrated in transportation and communications, finance, insurance, real estate services, and other services. Table 1 demonstrates that the differences between university and non-university counties in non-education sector labor income could be due to a number of observable differences. As there are also likely significant differences in unobservable determinants of nominal income between university and non-university counties, our central empirical analysis focuses on university counties alone.

Table 2 presents descriptive statistics for the subsample of 85 urban (populations greater than 250,000) counties that have research university activity. Columns (1) and (2) show the means and standard deviations of various county characteristics, dividing the sample counties based on whether their university expenditures in 1981 fell above or below the median value. Columns (4) and (5) divide the counties based on whether their university endowments in 1981 fell above or below the median. Columns (3) and (6) presents t-statistics for a test of differences in the means between columns (1) and (2) and between (4) and (5), respectively. The table reveals, perhaps unsurprisingly, that counties with above-median university expenditures have statistically significantly larger endowments and those counties with larger endowments spend more. But, interestingly, while counties with relatively larger endowments have relatively higher nominal labor income in non-education sectors, the same difference does not carry over to counties with above- and below-median university expenditures. Thus, in contrast to Table 1, this cursory look would suggest little marginal impact of university activity itself on non-education labor income.

Table 2 reveals other important connections between university expenditures, endowments, and characteristics and their relationships to county characteristics. The data show that older universities have larger endowments and spend more on current operations. While below-median endowment counties tended to have a greater share of public universities, there was no significant difference when considering expenditures. Further, the data reveal that above-median expenditure and endowment counties had higher quality institutions.

There are also significant differences between the groupings of counties in terms of the average skill levels of the populations. Counties with relatively greater university expenditure and endowment levels had more skilled workers, as measured by the percentage of the population with a college degree. As these characteristics are likely to affect county wage levels independently of university spending, and likely correlated with important unobservables, this comparison demonstrates the value of using an IV strategy to achieve a causal estimate of the impact of university activity.

Table 2 also reveals that above- and below-median university activity counties differ in terms of how their labor forces are distributed across industries. Counties with above-median university expenditures have a larger fraction of the labor force in finance, insurance, real estate services, than those with below-median university expenditures. Similarly, counties with above-median university endowments have a lower fraction of the labor force concentrated in retail trade. This difference suggests, like Table 1, that the unobserved characteristics of firms are likely to differ across counties with varying levels of university activity. As the location and scale of high-productivity firms may well determine university activity, this comparison again demonstrates the value of using an IV approach.

V. Regression Results

First Stage

Our IV strategy exploits variation in university expenditures across counties arising from the fact that counties had varying levels of initial research university endowments that were all exposed to similar financial market shocks over the three- or five-year time period we consider in our long-difference analysis. In Table 3 we present the results from estimating the first-stage model in equation (2). The estimates in the table show that the coefficient on the interaction between initial endowment and stock market fluctuations results in a strong first stage. The F-statistic on the excluded instruments in the first stage is above the threshold level of 10 that has been established as key to reducing potential weak instrument bias (Bound, Jaeger, and Baker, 1995).

The coefficient estimate of the instrument's impact on the change in university expenditures reported in Table 3 column (2) translates into a 9 cent marginal effect from a one dollar increase in endowment value, which is higher than the typical endowment spending policy of four to five percent reported above. The higher coefficient estimate is likely the result of the fact that our first-stage model is based on endowment value as of the year prior to the three- or five-year period under consideration. Universities, of course, determine their current spending from endowment funds based on the portfolio's value in the years immediately surrounding the year the decision is made. Our use of the smaller endowment value in the year prior to the time horizon in question will cause the coefficient estimate to be greater than the actual spending rate.[19]

Second-stage Long-Difference Estimates

Table 4 reports the central results of the paper. The top panel presents the results from estimating long-difference equation (1) considering the three-year time horizon; the bottom panel presents results from the five-year long-difference model. Each column presents the results from one estimation. Column (1) reports OLS estimates of the model and column (2) presents the TSLS estimates.

In column (1) of the top panel of the table, the OLS estimate indicates that a one-standard-deviation increase in university activity per thousand residents within a county ($1.01) statistically significantly increases non-education labor income by 6.5 percent. In column (1) of the bottom panel, the estimated effect remains statistically significant at the five-year horizon, suggesting that increasing the scale of research university activity in a county has longer term spillovers to other industries within a county. We provide evidence below on the timing of the expenditure shocks that further indicates that these estimated spillovers are persistent, and not merely the short-term result of a fiscal "multiplier effect."

[19] If the difference between the parameter that our approach estimates and the typical spending rule is due to the use of an earlier endowment market value, then a similar regression with annual differences in expenditure and endowment values should lead to point estimates closer to the spending rate. (We thank an anonymous referee for this suggestion.) Consistent with this explanation, in an (unreported) analysis we find an implied spending rate of 2.4 percent in an annual first-differences model. Measurement error, exacerbated by the first-differencing, is likely attenuating the coefficient.

In column (2) of Table 4 we present the TSLS estimates. In the top panel the estimate indicates that a one-standard-deviation increase in university activity ($1.01) increases non-education labor income by 11.5 percent. This estimate is statistically significantly different from zero at the 1 percent level. In the lower panel the five-year long-difference result is very similar to the magnitude of the three-year effect and is statistically significant at the one percent level. The estimated coefficient implies that an elasticity of university expenditures with respect to non-education labor income of 0.08.[20] Put differently, a one-dollar increase in university expenditures would lead to a $0.89 increase in non-education sector labor income.[21] In other words, the overall multiplier for university activity is roughly 1.9 (the university's own one-dollar effect plus the external effect).

Employment Effects

The final set of core results we present is an analysis of employment effects. As Ciccone and Hall (1996) and Ciccone (2002) point out, the relative strength of the employment- and output-density externalities will depend on such factors as the prevalence of decreasing returns to immovable factors, such as land, or the availability of physical capital. Furthermore, in the textbook spatial equilibrium model, workers will migrate costlessly, thus eliminating any gains from spatial arbitrage and causing nominal wages to equal the marginal revenue product of labor. However, when there are meaningful costs to migration, the wages of local workers can increase by more than the change in their labor productivity would otherwise dictate in a long-run

[20] That is, increasing the average level of university expenditures per capita (/1,000) by one percent (0.0071) would increase non-education labor income by 0.0008 (0.0071 × 0.115)
[21] A one dollar per capita (/1,000) increase in university expenditures (which amounts to $940.7 million) increases non-education labor income by 0.115 percent or $835.8 million ($15,325 income/worker × 474,262 workers × 0.115) .

equilibrium. Thus, if there were frictions in the reallocation of labor across space, then the effects of research university expenditures on non-education sector wages would represent an upper bound on the total factor productivity effects of research university activity. Examining the employment effects of university expenditure provides a sense of whether such frictions exist in the mobility of workers across space in the relatively short time periods considered in our analysis.

We analyze the employment effects of university activity by estimating models similar to equations (1) and (2), but we replace changes in wages with changes in employment levels. The results are reported in Table 5. We find little evidence of a positive employment response, which can be explained by short-term labor market frictions, physical capital constraints, or decreasing returns to immovable factors such as land.[22]

VI. The Mechanisms Underlying the Spillover Effects

In this section we seek to shed light on the mechanisms underlying the spillover effects we have identified. First, we present evidence on the timing and persistence of the measured effect to suggest that it is not merely driven by a "stimulus effect" from increased local university expenditures. Next, we analyze how stock market driven shocks to the endowment market value affected the universities' spending behavior. These results provide some insight into the source of the spillover effect we measure for the county at large.

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[22] It is worth noting that Hausman (2011) finds statistically and economically significant employment growth as a result of the Bayh-Dole Act (1980) that permitted universities to commercialize their federally-funded research. Her analysis covering the 20-year period 1977 to 1997 finds that each university patent translated into 15 more workers employed outside the university sector.

Timing and Persistence of the Spillover Effect

Table 6 reports results from an OLS regression that seeks to decompose the three- or five-year long-difference in non-education sector labor income as a function of the yearly first-differences in university expenditures over the period in question. While it would be impractical to instrument for each of the first-differences, the OLS provides some insights into the dynamics of the spillover effect on labor income. The results from the three-year estimation show that the annual difference in university expenditures from the second and third lags are both statistically significant and contribute to the three-year change in labor income roughly equally. The five-year estimation shows even more clearly the longevity of the spillover effect. While the baseline estimate presented in Table 4 would reflect the average of the annual first-differences in university expenditures, the results in Table 6 indicate that the substantially larger and statistically stronger effects are coming from the fourth and fifth lags. In other words, it does not appear that increases in non-education labor income result primarily from short-term stimulus-like increases in university expenditures that die off quickly. Instead, the dynamic pattern of the decomposed estimate is consistent with the idea that spillovers from university activity take time to manifest and remain persistent.

Our equations up to this point consider the contemporaneous effects of three- or five-year changes in university expenditures on labor income. In Table 7 we re-estimate the OLS and TSLS models, but instead of examining the impact of contemporaneous changes in university expenditures, we consider the changes in the universities' expenditures that took place over the three- or five-year period preceding the long-difference period we consider for the changes in labor income. The estimates of both the OLS and TSLS three- and five-year long-difference models are roughly the same as those found in the baseline contemporaneous models, although the power of the instrument falls in the five-year equation. These results demonstrate the persistence of the effect of expanded research university expenditures on nominal wages. The estimated effect seems to be something other than a short-term fiscal stimulus effect.

Changes in Other University Outcomes

In Table 8 we seek to begin to identify the mechanism by which increased research university activity might spillover to the non-education sector. The results thus far have shown that the current expenditures of universities in a county have meaningful effects on the wages paid by other firms, but have said little about the potential sources of the research universities' impact on labor income in other industries. To shed light on this issue we examine how research universities adjust their spending as a result of changes in endowment income. Table 8 reports OLS estimates of the three- and five-year long-difference models, similar to equation (2), with undergraduate enrollment, graduate enrollment, university donations, building expenditures, and equipment expenditures as outcomes. Interestingly, the strongest impact of a stock market driven endowment shock comes in the form of expanded graduate student enrollment. Undergraduate enrollment is unaffected. Taken together these results suggest that increased income from endowment sources translate into an increase in research intensity.

The results here again indicate that our findings represent something more substantive than a simple short-term stimulus effect. We cannot reject the hypothesis that increased endowment income had no effect on university building expenditures over a five-year time period or equipment expenditures under either the three- or five-year period. We do detect a small, statistically significant increase in building expenditures over the three-year horizon, however. The small size of this estimate, coupled with the relatively small size of the higher education sector within a county, imply that an implausibly large multiplier effect would be required for a pure stimulus effect to account for our central findings.[23]

Finally, we find a positive, but statistically insignificant, effect on changes in donations as a result of relatively greater stock market gains. This finding provides evidence that our instrument satisfies the exclusion restriction. A potential concern with our instrument is that stock market shocks might be differentially correlated with local industries that experienced productivity gains. If this were the case, we might expect to see such gains manifest in greater contributions to local universities, which is not borne out in the data.

Heterogeneous Effects Across Industries

Some studies of agglomeration spillovers suggest that the magnitude of the effect is related to input and output linkages or the pooling of labor markets (see, e.g., Moretti 2004b, Ellison, Glaeser, and Kerr 2007, and Greenstone, Hornbeck and Moretti 2010). In addition, as noted earlier, previous research has found that knowledge spillovers from universities seem to be more localized than for other industries. Therefore, to explore more explicitly the sources of the research university spillovers that we have identified, we test for evidence of heterogeneous responses depending on the research intensity of the universities within the county and how technologically close an industry is to the higher education sector.

[23] To see this we calculate the building expenditure-log(labor income) effect needed to entirely account for our results and compare it to the estimated total expenditure-log(labor income) effect reported in Table 4. Consider the effect of a 1 unit change in Δ Stock Index × Lagged Market Value of Endowment. From the three year results in Tables 3 and 4 the total log(labor income) effect is given by: $1 \times \beta_l \times \alpha_l = 1 \times 0.077 \times 0.114 = 0.008778$. The building expenditure-log(labor income) effect required to account for a change in log(labor income) of 0.008778 is given by α_b in: $1 \times 0.008 \times \alpha_b = 0.008778$. As α_b is 1.09 and α_l is only 0.114, building expenditure would need to have more than nine times the effect on log(non-education sector labor income) than a typical dollar of expenditure to account for our results.

We first stratify the sample of urban counties based on the fraction of the universities' students who are graduate students. If the magnitude of the spillover effect varies based on the research intensity of the universities, then this will be suggestive of the idea that knowledge spillovers provide a source of the measured beneficial effect on local industries. We next examine whether industries that pool labor markets with the higher education sector receive larger spillovers. This measure is based on workers' transitions out of (into) higher education and into (out of) their pooling industry counterparts. Our labor market pooling measure is constructed from CPS data on the frequency of transitions of workers between higher education and other industries. We then consider two measures of how intensively an industry uses the output of universities. First, we look at how frequently industry patents cite a patent issued by a university to measure industry-specific utilization of higher education knowledge.[24] Second, we measure the intensity of each industry's employment of college graduates. The measure is based on the fraction of workers in each industry who are college graduates, as calculated from the 1980 IPUMS Census micro-data.

In Table 9 we present TSLS results where we stratify the sample along these dimensions. Columns (1) and (2) in Table 9 show the TSLS results when we stratify the sample based on the graduate-education intensity of the county's universities. The estimated effect of increased university expenditures on non-education labor income is remarkably higher in relatively research intensive counties, as measured by above-median graduate education. For example, considering the five-year time horizon, a one-standard-deviation increase in university

[24] We construct our industry patent citation measure from the NBER patent database (Hall, Jaffe, and Tratjenberg, 2001). For each industry we calculate the fraction of citations to other patents that were issued to universities. For this particular measure, we consider all patents issued by universities, not just the sample of universities located in urban areas that are considered in the paper.

expenditures per thousand residents ($1.01) in the research-intensive county caused a 13.5 percent increase in labor income in the above-median counties, but only a 4.2 percent increase in the below-median counties.

Turning next to the industry stratification, we find that industries that pool labor with universities have approximately twice the responsiveness to university activity when compared to the low-pooling intensity industries (see columns (3) and (4)). Increases in university activity, at the three- and five-year timeframes, are more likely to benefit those workers who are employed in industries that experience a robust two-way labor market relationship with higher education.

In columns (5) through (6) we present the results when we stratify the sample by industry patent citation intensity.[25] There is clearly a difference in the impact of university activity across above-median and below-median patent citation industries. The TSLS estimates for the above-median industries at five years reported in column (5) in the bottom panel is 32 percent larger than the estimate for the below-median industries in the bottom panel of column (5). This result suggests that larger spillover effects tend to accrue in counties more heavily populated with industries that utilize university knowledge more intensively in their own innovation processes. Finally, in columns (7) and (8) we present results where we stratify industries based on their employment of college graduates. We find weak evidence that industries that use college-educated labor receive larger spillovers. Industries that employ an above-median fraction of college graduates experience between 20 and 26 percent higher labor income relative to below-median industries when universities increase their expenditures.

[25] As many industries do not issue patents, the sample size here is necessarily smaller than the full sample used above.

These stratified results strongly suggest that it is research and technological innovation that spills over from universities, which is then capitalized in higher nominal wages enjoyed by workers in local non-education industries. Workers in industries that are technologically closer to the knowledge generated from universities disproportionately benefit.

VII. Robustness of the Results

In this section we explore the robustness of the results as we alter various assumptions of the baseline empirical estimation. We first explore a potential cause for the TSLS estimate exceeding the OLS estimate (see Table 4). Such an outcome suggests that measurement error in university activity may be attenuating the OLS long-difference results toward zero. In Table 10, columns (1) and (2), we re-estimate the models, but trim the sample of observations for which the endogenous university expenditure variable is in the top or bottom fifth percentile. Eliminating these "outlying" observations causes the OLS estimate to converge significantly toward the TSLS value, which suggests that the IV approach seems to be an important counter-balance to measurement error in the endogenous variable. We further experiment with the same top and bottom fifth percentile trim on the outcome variable (see columns (3) and (4)) and find similar (but more precisely estimated) results to our baseline estimation, though the TSLS estimate is somewhat smaller. This analysis suggests that our baseline IV estimates are larger in magnitude than the OLS estimates most likely because of measurement error in the endogenous variable, diminishing the concern about upward simultaneity bias.

We further explore the sensitivity of the baseline results to various assumptions we have imposed on the empirical model. In column (5) of Table 10 we cluster the standard errors at the county-year level, instead of at the county level. This approach increases the precision of the estimates and dramatically raises the power of the instrument. In column (6) we run the TSLS model unweighted. While statistically significant, the coefficient estimates are smaller and the power of the instrument declines such that the F-statistic falls below 10. Our goal in weighting the regression to account for employment in the industry-county-year cell is to capture the effect of university activity on the average worker within the county, as opposed to the average effect across all industries. The relatively large difference between the weighted and unweighted regressions suggests that industries that disproportionately benefit from university activities will have a greater than average presence in such university counties. The evidence above that industries that are technologically closer to universities experience relatively greater spillovers provides a rationale for such industries to co-locate near universities.

Finally, because our university expenditure and endowment data are measured at the county-year level, which is then tied to all industries in the county-year cell, we re-estimate the equation considering the average non-education labor income at the county-year level as well. Column (7) shows that the estimated coefficient is about half the magnitude as our baseline regression using individual industry observations. Again, this finding suggests that industries that disproportionately benefit from a research university's presence are generating heterogeneous effects, which in turn dampens the county-aggregate effect.[26]

Alternative University Endowment Specifications

We further examine whether our results are robust to important changes in our instrument strategy. We begin by testing whether the results are robust to allowing stock market shocks to

[26] In Appendix Table A2 we present the results of the heterogeneous effects analysis, comparable to Table 9, but using data that aggregate above- and below-median observations to the county level.

have differential impacts on university expenditures, as the findings in Brown et al. (2010) would indicate. We do this in two ways. First, we construct a measure of the extent to which university endowments within a county were invested in domestic equities, instead of using the overall market value of the endowment. We are then able to examine whether accounting for differences in observable portfolio allocations affect the robustness of our results. The results of this analysis are presented in Table 11 column (1). The results demonstrate that the positive and statistically significant effect of university expenditure on non-education labor income remains in both the three- and five-year differences. Adding more precision to our measure of the domestic equity exposure within endowments does not seem to affect the results in a dramatic way.

Our second strategy is to allow expenditures by universities with different time-invariant characteristics to be differentially sensitive to stock market shocks. To do so we allow the sensitivity of expenditures to stock market shocks to depend on university quality and the fraction of graduate students within the county. The first-stage results in Appendix Table A3 demonstrate that university expenditure at higher-quality universities is indeed positively responsive to stock market shocks but negatively responsive at universities with a higher proportion of graduate students. We see in Table 11 column (2) that incorporating the heterogeneous responses leads to positive and statistically significant estimates of the effect of university expenditure on non-education labor income, with slightly larger magnitudes than the baseline estimates above. In addition, the incorporation of heterogeneous responses significantly strengthens the first-stage, leading to F-statistics of 74 and 59 in the three- and five-year models, respectively.

As a further robustness check we examine whether our TSLS results are sensitive to the precise specification of the endowment variable. In column (3) of the table we use the initial endowment value in 1981 to construct our instrument and in column (4) we use the logarithm of the lagged endowment value. We find that the positive and statistically significant effect remains, though the magnitudes of the estimate vary slightly depending on the specification. Thus, the results in the first four columns of Table 11 indicate that our findings are robust to allowing universities of various types to be differentially responsive to stock market shocks and are not sensitive to the precise construction of the endowment market value variable.

<u>*Alternative Stock Market Exposure Controls*</u>

Next, we examine the robustness to allowing labor income in different industries and counties to be differentially correlated with stock market shocks. If, for example, industries that are more sensitive to cyclical financial conditions are located in counties with relatively higher levels of university endowments, then our IV strategy would be weakened. To test for these possibilities, we first estimate various versions of the models in equations (1) and (2) where we allow the effect of stock market shocks to affect labor income through other time-invariant characteristics of universities, industries, and counties. We allow for different flexible time trends in non-education sector wages across industries, states, and counties with higher quality colleges by including year fixed effect interactions. Specifically, we extend models (1) and (2) as,

(3) $\Delta Y_{ijt} = \alpha_1 \Delta UE_{it} + T + \alpha_2 C_{i,j} + \alpha_3 (T \times C_{i,j}) + \varepsilon_{ijt}.$

The first stage for the IV model above becomes,

(4) $\Delta UE_{it} = \beta_1 (\Delta SM_t \times IE_{it-x-1}) + T + \beta_2 C_{i,j} + \beta_3 (T \times C_{i,j}) + \xi_{it},$

where ΔUE_{it} is the long-difference change in per capita university expenditures in county i over the three or five year time period under consideration, ΔSM_t is the long-difference change in the S&P stock index over the time period, $C_{i,j}$ represents the additional initial characteristics of county i or industry j, T is a set of year fixed effects, and ε_{ijt} and ξ_{it} are the error terms.

We consider five measures of relevant differences across industries, universities, and counties. The first measure of $C_{i,j}$ is a set of state dummy variables. This approach allows each state to be differentially impacted by stock market shocks. While this method does not seek to explain why labor income in some states is more or less correlated with stock market shocks, it is very flexible. The second measure of $C_{i,j}$ is a set of industry dummy variables. Similarly, this approach allows each industry to be differentially impacted by stock market shocks. If stock market shocks impact labor income differentially across states or industries, then including the additional controls should significantly alter our estimate of α_1. Third, we consider the average quality of the universities within the county, measured in 1991. If universities of different quality levels were disparately impacted by stock market shocks, perhaps because of different donor or student characteristics, then this would undermine our identification. This specification allows for counties with higher quality universities to be differentially correlated with stock market shocks for reasons other than university endowment spending policies because the difference nature of our estimation would factor that out. Our fourth measure of $C_{i,j}$ is the level of housing rent within the county in 1980. If counties with varying degrees of unobserved amenities, as manifest in rental prices, were differentially impacted by stock market shocks, then our identification strategy would be weakened. Finally, we allow for county-specific time trends based on characteristics of the county in 1900. Specifically, we include year interactions with both 1900 population and manufacturing output per capita in 1900. If historical characteristics of counties, which may be correlated with the size of the modern endowment, have a differential impact from stock market shocks, our instrument may be threatened.

The results for models with these additional stock market shock interactions are shown in Table 11, columns (5) through (8). There are a number of notable findings in the table. First, the results in columns (5) and (6) demonstrate that the inclusion of state and industry-specific flexible time trends has little effect on the statistical significance of the main results, though the magnitude of the effect is somewhat smaller than in Table 4. For instance, allowing industries to be deferentially impacted by stock market shocks (Table 11, column (6)), the TSLS estimate of the five-year long-difference effect is 78 percent the size of the estimate in Table 4. Thus, while allowing changes in labor income in each state or industry to be differentially correlated with stock market shocks does not change conclusions about the sign of the relationship, it does weaken the response somewhat.

We show the results for the university quality interaction in column (7). We see that allowing income in counties with different levels of college quality to be differentially correlated with stock market shocks does little to alter the main results. This finding is important given the potential concern that universities and firms in research-university counties might be differentially exposed to stock market shocks depending on university quality, independent from the levels of university endowment in the local economies. Moreover, the magnitudes of the estimates are quite similar to their counterparts in Table 4, though the power of the instrument is somewhat weakened. Column (8) shows that allowing for a rough proxy for amenities (i.e., housing rents) to be differentially correlated with stock market shocks has little bearing on the results. Finally, accounting for historical differences across counties that might be correlated with endowment size has little bearing on the results.

VIII. Concluding Remarks

In this paper we demonstrate that university activity does indeed generate persistent spillovers to local firms and workers. The estimates indicate that a 1 percent increase in university expenditures in a county increases local labor income in other sectors by 0.08 percent. We find evidence that the spillovers are larger when local universities are more intensively focused on research and when research universities are technologically closer to local firms, in the sense that they share a labor market with higher education and are more likely to cite university patents. In our models estimating the spillover effect over five years, we found that firms in these technologically closer industries enjoy a spillover that is double that of the typical firm that is not close. Our findings tend to confirm previous research that knowledge spillovers from universities tend to be concentrated on particular local industries, such as pharmaceuticals or electronics, and are not broad based.

While our empirical results indicate a causal link between university research activities and productivity gains in neighboring firms, future work would benefit from a careful analysis of the mechanism that generate such productivity gains. Understanding how industries that are closely related to higher education in terms of innovation and shared labor markets respond to the presence of nearby university activity would help to shed light on the pathways through which university activity impacts its neighbors and help to address fundamental public policy questions with respect to public support for research universities. The findings provide a rationale for place-based university policies, so long as they focus on industry fundamentals. Our results also suggest that the longer-term effects that universities have on their local economies may grow over time as the composition of local industries evolve to take advantage of the knowledge spillovers we identify.

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TABLE 1: Baseline County Characteristics – University and Non-University Locations

	University Counties (1)	Non-University Counties (2)	(1) - (2) t-stat (3)
(1) Outcome:			
Average Annual Labor Income in Non-Education Sector (1981)	$15,325 ($1,419)	$14,719 ($1,303)	2.97
(2) University Characteristics:			
University Expenditure (per '000 population; 1981)	$0.71 ($1.01)	--	--
University Endowment Market Value (per '000 population; 1981)	$0.47 ($1.27)	--	--
Percent of Endowment in Invested in Domestic Equity	50 (12)	--	--
Year of Opening	1882 (51)	--	--
Fraction Public (1981)	0.61 (0.42)	--	--
Average Quality Ranking (1991)	2.22 (1.12)	--	--
(3) Economic and Demographic Characteristics (1980):			
Population	940,703 (1,007,882)	440,303 (186,825)	4.73
% College Graduate	16 (4)	15 (5)	1.03
% Black	16 (13)	9 (9)	4.13
Average Rent	$255 ($34)	$258 ($40)	-0.57
Crime Rate (Per '000 Population)	7,384 (2,477)	5,850 (1,795)	4.78
% Service Spending on Amusements	12 (18)	8 (12)	1.59
Population 1900	225,704 (363,076)	83,129 (73,337)	3.66
Manufacturing Output Per Capita 1900	223 (153)	240 (265)	-0.49
(4) Industry Distribution of Labor Force (1981; %):			
Construction	0.06 (0.02)	0.06 (0.04)	-0.09
Manufacturing	0.23 (0.08)	0.26 (0.11)	-1.84
Transportation and Communications	0.07 (0.03)	0.06 (0.02)	2.60
Wholesale Trade	0.07 (0.02)	0.07 (0.03)	1.15
Retail Trade	0.20	0.23	-3.34

	(0.04)	(0.05)	
Finance, Insurance, and Real Estate	0.08	0.07	3.53
	(0.03)	(0.02)	
Services	0.27	0.25	2.84
	(0.04)	(0.06)	
Number of Counties	85	94	

Notes and Sources: Labor income data are from U.S. Census Bureau County Business Patterns; data relating to university expenditures, endowments, and ownership status are from the U.S. Department of Education Higher Education General Information Survey (HEGIS) and the Integrated Postsecondary Educational Data System (IPEDS); and college and university quality data are from U.S. News & World Report (1991). Socioeconomic county characteristics are from the U.S. Census Bureau County and City Data Book (1983) and the industrial distribution of the labor force is from U.S. Census Bureau County Business Patterns. The sample contains one observation for each county. The main entries in columns (1) and (2) are the means of the selected variable. The entries in parentheses in columns (1) and (2) are the standard deviation of the selected variables. Reported t-statistics are obtained from a regression of university county indicator on the selected variable. All reported monetary amounts are in nominal dollars.

TABLE 2: Baseline County Characteristics for University Counties, by University Expenditure and Endowment Level

	Above Median University Expenditure Per Capita (1)	Below Median University Expenditure Per Capita (2)	(1) - (2) t-stat (3)	Above Median University Endowment Per Capita (4)	Below Median University Endowment Per Capita (5)	(4) - (5) t-stat (6)
(1) Outcome:						
Average Annual Labor Income in Non-Education Sector (1981)	$15,211	$15,441	-0.74	$15,724	$14,916	2.72
	($1,405)	($1,441)		($1,281)	($1,451)	
(2) University Characteristics:						
University Expenditure (per population / 1000; 1981)	$1.18	$0.23	4.87	$1.07	$0.35	3.50
	($1.26)	($0.11)		($1.32)	($0.22)	
University Endowment Market Value (per population / 1000; 1981)	$0.86	$0.07	2.97	$0.91	$0.02	3.41
	($1.71)	($0.11)		($1.69)	($0.02)	
Percent of Endowment in Invested in Domestic Equity	48	52	-1.60	47	52	-1.94
	(13)	(10)		(10)	(13)	
Year of Opening	1862	1901	-3.78	1867	1897	-2.84
	(50)	(44)		(46)	(48)	
Fraction Public (1981)	0.69	0.54	1.67	0.50	0.73	-2.53
	(0.40)	(0.43)		(0.40)	(0.42)	
Average Quality Ranking (1991)	2.76	1.67	5.15	2.69	1.74	4.32
	(0.94)	(1.02)		(0.94)	(1.09)	
(3) Economic and Demographic Characteristics (1981):						
Population	720,413	1,166,238	-2.08	1,070,128	808,196	1.02
	(454,457)	(1,329,148)		(1,299,491)	(561,948)	
% College Graduate	17	14	4.24	17	14	3.36
	(4)	(3)		(4)	(4)	
% Black	16	16	-0.21	17	15	0.45
	(14)	(13)		(14)	(12)	
Average Rent	$257	$252	0.60	$250	$260	-1.19

	($32)	($37)		($31)	($37)	
Crime Rate (Per '000 Population)	7,215	7,559	-0.64	7,349	7,421	-0.18
	(2,304)	(2,660)		(2,551)	(2,429)	
% Service Spending on Amusements	12	11	0.26	14	9	1.35
	(23)	(10)		(23)	(8)	
Population 1900	217,973	234,690	-0.86	316,272	125,603	2.31
	(376,860)	(351,330)		(447,134)	(200,763)	
Manufacturing Output Per Capita 1900	210	239	-0.20	260	183	2.42
	(157)	(149)		(161)	(134)	
(4) Industry Distribution of Labor Force (1981; %):						
Construction	0.06	0.05	0.75	0.05	0.06	-1.58
	(0.03)	(0.02)		(0.02)	(0.03)	
Manufacturing	0.22	0.24	-1.20	0.24	0.22	1.45
	(0.08)	(0.08)		(0.08)	(0.08)	
Transportation and Communications	0.07	0.07	-0.43	0.07	0.07	0.23
	(0.02)	(0.03)		(0.03)	(0.03)	
Wholesale Trade	0.07	0.08	-0.44	0.08	0.07	0.57
	(0.02)	(0.02)		(0.02)	(0.02)	
Retail Trade	0.20	0.20	0.23	0.19	0.22	-3.91
	(0.04)	(0.04)		(0.03)	(0.04)	
Finance, Insurance, and Real Estate	0.09	0.08	1.89	0.08	0.08	1.35
	(0.04)	(0.02)		(0.03)	(0.02)	
Services	0.28	0.27	1.39	0.28	0.27	0.54
	(0.04)	(0.04)		(0.05)	(0.04)	
Number of Counties	43	42		43	42	

Notes and Sources: See Table 1. The sample contains one observation for each county. The main entries in columns (1), (2), (4) and (5) are the mean of the selected variable. The entries in parentheses in columns (1), (2), (4) and (5) are the standard deviation of the selected variables. Reported t-statistics in columns (3) and (6) are obtained from a regression of the selected variable on an indicator variable for counties in the above-median-university-expenditure or above-median-university-endowment category, respectively. All reported monetary amounts are in nominal dollars.

TABLE 3: The Effect of Stock Market Shocks Interacted with the Value of Lagged Endowments on University Expenditures, 1981-1996

Dependent Variable = Δ University Expenditure Per Capita; period t – (t-x)

	Three Year Differences (1)	Five Year Differences (2)
Δ Stock Index × Lagged Market Value of Endowment	0.078*** (0.022)	0.091*** (0.025)
F-Statistic: Δ Stock Index × Lagged Market Value of Endowment	12.96 [0.0005]	13.31 [0.0005]
Observations	40380	33650

Notes and Source: See Table 1. The stock market index is the Standard & Poor's 500 Stock Index. The estimates presented are for model (3) in the text. The unit of observation is at the county-industry-year level. University Expenditure is measured as the spending rate per county population/1000, Lagged Market Value of Endowment is measured as the portfolio value per county population /1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The entries in the first row of columns (1) and (2) are coefficient estimates. The entries in parentheses in second row of columns (1) and (2) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row of columns (1) and (2) report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported in the main entry and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 4: The Effect of University Activity on Local Labor Income, 1981-1996

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector); period t – (t-x)

Model =	OLS	TSLS
	(1)	(2)
Model l: Three Year Differences		
Δ University Expenditure Per Capita	0.064**	0.114***
	(0.029)	(0.036)
F-Statistic: Excluded Instruments		12.96
		[0.0005]
Observations	40380	
Model 2: Five Year Differences		
Δ University Expenditure Per Capita	0.071**	0.115***
	(0.032)	(0.038)
F-Statistic: Excluded Instruments		13.31
		[0.0005]
Observations	33650	

Notes and Sources: See Table 1. The estimates presented are for model (2) in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) and (2) are coefficient estimates. The entries in parentheses in columns (1) and (2) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and sixth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 5: The Effect of University Activity on Local Employment, 1981-1996

Dependent Variable = Δ log (Employment in Non-Education Sector); period t – (t-x)

Model =	OLS	TSLS
	(1)	(2)
Model l: Three Year Differences		
Δ University Expenditure Per Capita	-0.020	-0.123
	(0.061)	(0.081)
F-Statistic: Δ Stock Index × Lagged Market Value of Endowment		12.96
		[0.0005]
Number of Observations	40380	
Model 2: Five Year Differences		
Δ University Expenditure Per Capita	-0.042	-0.162
	(0.070)	(0.097)
F-Statistic: Δ Stock Index × Lagged Market Value of Endowment		13.31
		[0.0005]
Number of Observations	33650	

Notes and Sources: See Table 1. The estimates presented are for a model similar to (2) in the text with the change in employment in the non-education sectors as the outcome variable. The unit of observation is at the county-industry-year level and the sample includes all large university counties. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) and (2) are coefficient estimates. The entries in parentheses in columns (1) and (2) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and sixth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 6: The Dynamic Effects of University Activity on Local Labor Income, 1981-1996

Dependent Variable = log (Annual Labor Income in Non-Education Sector); period t – (t-x)

Differences In Log Income =	Three Year	Five Year
Model =	OLS	OLS
	(1)	(2)
Δ_1 University Expenditure Per Capita (t-1)	0.057*	0.053
	(0.031)	(0.038)
Δ_1 University Expenditure Per Capita (t-2)	0.070**	0.053
	(0.032)	(0.036)
Δ_1 University Expenditure Per Capita (t-3)	0.065**	0.056
	(0.029)	(0.038)
Δ_1 University Expenditure Per Capita (t-4)		0.076**
		(0.030)
Δ_1 University Expenditure Per Capita (t-5)		0.120***
		(0.043)
Number of Observations	40380	33650

Notes and Sources: See Table 1. The estimates presented are for model (2) in the text where the long difference in university expenditure is decomposed into a sequence of first-differences in university expenditure variables. The unit of observation is at the county-industry-year level and the sample includes all large university counties. Δ_1 University Expenditure Per Capita (t-x) is measured as spending rate county population/1000. The main entries in columns (1) and (2) are coefficient estimates. All estimates are weighted by the level of employment in the industry-county cell in 1981. The entries in parentheses in columns (1) and (2) are the standard errors of the coefficient estimates clustered at the county level.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 7: The Persistent Effect of University Activity on Local Labor Income, 1981-1996

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector); period t – (t-x)

Model =	OLS	TSLS
	(1)	(2)
Model l: Three Year Differences		
Δ University Expenditure Per Capita (t-3)	0.070**	0.105***
	(0.028)	(0.040)
F-Statistic: Excluded Instruments		14.16
		[0.0003]
Observations	30285	
Model 2: Five Year Differences		
Δ University Expenditure Per Capita (t-5)	0.077**	0.121**
	(0.032)	(0.049)
F-Statistic: Excluded Instruments		8.01
		[0.0058]
Observations	16825	

Notes and Sources: See Table 1. The estimates presented are for a modified version of model (2) in the text where the long-difference in university expenditure is lagged by the length of the long-difference. The unit of observation is at the county-industry-year level and the sample includes all large university counties. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) and (2) are coefficient estimates. The entries in parentheses in columns (1) and (2) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and sixth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 8: The Effect of Stock Market Shocks Interacted with the Value of Lagged Endowments on Other University Outcomes, 1981-1996

Dependent Variable =	Δ University Undergraduate Enrollment Per Capita	Δ University Graduate Enrollment Per Capita	Δ University Donation Revenue Per Capita	Δ University Building Expenditure Per Capita	Δ University Equipment Expenditure Per Capita
Model =	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Model l: Three Year Differences					
Δ Stock Index × Lagged Market Value of Endowment	0.051 (0.119)	0.177* (0.106)	0.002 (0.003)	0.008** (0.003)	0.001 (0.001)
Observations	1020	850	1014	561	569
Model 2: Five Year Differences					
Δ Stock Index × Lagged Market Value of Endowment	0.026 (0.145)	0.256** (0.102)	0.002 (0.001)	0.006 (0.004)	0.002 (0.002)
Observations	850	765	845	320	322

Notes and Source: See Table 1. The stock market index is the Standard & Poor's 500 Stock Index. The estimates presented are for a modified version of model (3) in the text with the indicated university outcome variable replacing university expenditure. The unit of observation is at the county-year level. All estimates are weighted by the level of employment in the county cell in 1981. All University Expenditure variables and Lagged Market Value of Endowment are measured as the spending rate per county population/1000. University Undergraduate Enrollment Per Capita and University Graduate Enrollment Per Capita variables are measured as the enrollment rate per county population × 1000. The entries in the first and fourth rows of columns (1) - (5) are coefficient estimates. The entries in parentheses in second and fifth rows of columns (1) - (5) are the standard errors of the coefficient estimates clustered at the county level.

* indicates significantly different from zero at the 10% level of significance;
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*** indicates significantly different from zero at 1% level of significance.

TABLE 9: The Effect of University Activity on Local Labor Income, 1981-1996: Heterogeneous Effects

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector; period t – (t-x)

Stratification=	Fraction of Graduate Students in County:		Industry's Labor Market Pooling With Higher Education:		Industry Citation of University Patents:		Industry Employment of College Graduates:	
	Above-median	Below-median	Above-median	Below-median	Above-median	Below-median	Above-median	Below-median
Model =	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model l: Three Year Differences								
Δ University Expenditure Per Capita	0.130*** (0.038)	0.031* (0.017)	0.125*** (0.039)	0.063*** (0.016)	0.131*** (0.028)	0.107*** (0.018)	0.112** (0.051)	0.093*** (0.018)
F-Statistic: Excluded Instruments	11.63 [0.0015]	29.91 [0.0000]	10.87 [0.0014]	19.85 [0.0000]	19.04 [0.0000]	16.37 [0.0001]	11.70 [0.0010]	16.38 [0.0001]
Observations	20124	20256	22008	15900	8592	8748	20256	20124
Model 2: Five Year Differences								
Δ University Expenditure Per Capita	0.134*** (0.042)	0.042*** (0.014)	0.130*** (0.041)	0.060*** (0.015)	0.125*** (0.027)	0.095*** (0.014)	0.115** (0.055)	0.091*** (0.020)
F-Statistic: Excluded Instruments	12.74 [0.0009]	32.64 [0.0040]	11.06 [0.0013]	20.76 [0.0000]	18.97 [0.0000]	17.35 [0.0001]	12.27 [0.0007]	16.20 [0.0001]
Observations	16770	16880	18340	13250	7160	7290	16880	16770

Notes and Sources: See Table 1. The estimates presented are of model (2) for the sample stratified by characteristics of the counties or industries as described in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties.

University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) - (8) are coefficient estimates. The entries in parentheses in columns (1) - (8) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and eighth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance

TABLE 10: The Effect of University Activity on Local Labor Income, 1981-1996: Alternative Samples, Inference Procedures, and Levels of Aggregation

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector; period t – (t-x)

Specification =	Trim Sample on Endogenous Variable		Trim Sample on Outcome Variable		Cluster County-Year Level	Unweighted	County Level
Model =	OLS	TSLS	OLS	TSLS	TSLS	TSLS	TSLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
				Model l: Three Year Differences			
Δ University Expenditure Per Capita	0.114*** (0.035)	0.131*** (0.039)	0.055*** (0.020)	0.090** (0.021)	0.114*** (0.016)	0.028** (0.014)	0.051** (0.019)
F-Statistic: Excluded Instruments		9.12 [0.0034]		13.24 [0.0005]	41.62 [0.0000]	6.16 [0.0151]	12.96 [0.0005]
Observations	36217	36217	36404	36404	40380	40380	1020
				Model 2: Five Year Differences			
Δ University Expenditure Per Capita	0.113*** (0.033)	0.122*** (0.041)	0.052*** (0.019)	0.076*** (0.017)	0.115*** (0.015)	0.035*** (0.013)	0.055** (0.023)
F-Statistic: Excluded Instruments		11.22 [0.0012]		13.74 [0.0004]	41.77 [0.0000]	7.55 [0.0073]	13.31 [0.0005]
Observations	30167	30167	30351	30351	33650	33650	850

Notes and Sources: See Table 1. The estimates presented are of model (2) for various alternative samples and inference procedures as described in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties unless otherwise indicated. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) – (7) are coefficient estimates. The entries in parentheses in columns (1) - (7) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and sixth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets. The first-stage results are presented in Appendix Table A3.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

TABLE 11: The Effect of University Activity on Local Labor Income, 1981-1996: Alternative Instrumental Variable and Additional Stock Market Exposure Control Specifications

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector; period t – (t-x)

Specification =	Stock Market Endowment Only	Differential Stock Market Correlations	Initial Market Value of Endowment	Log (Lagged Endowment)	Year × State Fixed Effects	Year × Industry Fixed Effects	Year × College Quality Fixed Effects	Year × High Rent Fixed Effects	Year × 1900 Outcomes Fixed Effects
Model =	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Model l: Three Year Differences									
Δ University Expenditure Per Capita	0.103*** (0.033)	0.155*** (0.025)	0.127*** (0.034)	0.094** (0.041)	0.081*** (0.028)	0.087*** (0.023)	0.124*** (0.033)	0.106*** (0.033)	0.093*** (0.024)
F-Statistic: Excluded Instruments	12.85 [0.0006]	74.13 [0.0000]	11.40 [0.0011]	18.43 [0.0001]	16.31 [0.0001]	14.72 [0.0002]	8.64 [0.0042]	13.38 [0.0004]	17.43 [0.0001]
Observations	35256	40380	40380	36983	40380	40380	40380	40380	37956
Model 2: Five Year Differences									
Δ University Expenditure Per Capita	0.103*** (0.034)	0.162*** (0.028)	0.131*** (0.035)	0.088** (0.043)	0.074*** (0.027)	0.090*** (0.025)	0.126*** (0.036)	0.106*** (0.035)	0.094*** (0.023)
F-Statistic: Excluded Instruments	13.49 [0.0005]	59.19 [0.0000]	12.25 [0.0007]	20.21 [0.0000]	16.27 [0.0001]	14.96 [0.0002]	8.82 [0.0039]	13.62 [0.0004]	17.71 [0.0001]
Observations	29380	33650	33650	31075	33650	33650	33650	33650	31630

<u>Notes and Sources</u>: See Table 1. The estimates presented in columns (1)-(4) are for various alternative versions of model (2) as described in the text. The estimates presented in columns (5)-(8) are for various alternative versions of model (4) as described in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1)-(8) are coefficient estimates. The entries in parentheses in columns (1)-(8) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and sixth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets. The first-stage results are presented in Appendix Table A4.

* indicates significantly different from zero at the 10% level of significance;
** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance

APPENDIX TABLE A1: The Effect of University Activity on Local Labor Income, 1981-1996: Heterogeneous Effects, Ordinary Least Squares Estimates – Aggregated to County Level

Dependent Variable = Δ log (Annual Labor Income in Non-Education Sector; period t – (t-x)

Stratification=	Fraction of Graduate Students in County:		Industry's Labor Market Pooling With Higher Education:		Industry Citation of University Patents:		Industry Employment of College Graduates:	
	Above-median	Below-median	Above-median	Below-median	Above-median	Below-median	Above-median	Below-median
Model =	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS	TSLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Model l: Three Year Differences								
Δ University Expenditure Per Capita	0.061*** (0.020)	-0.007 (0.016)	0.058* (0.030)	0.046*** (0.012)	0.101*** (0.029)	0.045** (0.019)	0.053 (0.039)	0.058*** (0.013)
F-Statistic: Excluded Instruments	11.63 [0.0015]	29.91 [0.0000]	10.87 [0.0014]	19.85 [0.0000]	19.04 [0.0000]	16.37 [0.0001]	11.70 [0.0010]	16.38 [0.0001]
Observations	492	528	1020	1020	1020	1020	1020	1020
Model 2: Five Year Differences								
Δ University Expenditure Per Capita	0.066** (0.027)	0.018 (0.013)	0.062** (0.028)	0.051*** (0.017)	0.109*** (0.031)	0.029 (0.031)	0.059 (0.043)	0.061*** (0.015)
F-Statistic: Excluded Instruments	12.74 [0.0009]	32.64 [0.0000]	11.06 [0.0013]	20.76 [0.0000]	18.97 [0.0000]	17.35 [0.0000]	12.27 [0.0007]	16.20 [0.0001]
Observations	410	440	850	850	850	850	850	850

Notes and Sources: See Table 1. The estimates presented are of model (2) for the sample stratified by characteristics of the counties or industries as described in the text. The unit of observation is at the county-year level and the sample includes all large university counties for models in columns (1)-(2). The unit of observation is at the county-year-industry group level and the sample includes all large university counties for models in columns (3)-(8). University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) - (8) are coefficient estimates. The entries in parentheses in columns (1) - (8) are the standard errors of the coefficient estimates clustered at the county level. The entries in the third row and eighth row report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
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APPENDIX TABLE A2: The Effect of University Activity on Local Labor Income, 1981-1996: Alternative Levels of Aggregation, Samples and Inference Procedures – First Stage Estimates

Dependent Variable = Δ University Expenditure Per Capita; period t – (t-x)

Specification =	Trim Sample on Endogenous Variable	Trim Sample on Outcome Variable	Cluster County-Year Level	Unweighted	County Level
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
			Model l: Three Year Differences		
Δ Stock Index × Lagged Market Value of Endowment	0.074*** (0.024)	0.077*** (0.021)	0.078*** (0.012)	0.049** (0.020)	0.078** (0.022)
F-Statistic: Excluded Instruments	9.12 [0.0034]	13.24 [0.0005]	41.62 [0.0000]	6.16 [0.0151]	12.96 [0.0005]
Observations	36217	36404	40380	40380	1020
			Model 2: Five Year Differences		
Δ Stock Index × Lagged Market Value of Endowment	0.081*** (0.024)	0.089*** (0.024)	0.091*** (0.013)	0.060*** (0.022)	0.091*** (0.025)
F-Statistic: Excluded Instruments	11.22 [0.0012]	13.74 [0.0004]	41.77 [0.0000]	7.55 [0.0073]	13.31 [0.0005]
Observations	30167	30351	33650	33650	850

Notes and Sources: See Table 1. The estimates presented are for model (3) in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties unless otherwise indicated. The main entries in columns (1) - (5) are coefficient estimates. University Expenditure is measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The entries in parentheses in columns (1) - (5) are the standard errors of the coefficient estimates clustered at the county level. The entries in the last row of each panel report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

* indicates significantly different from zero at the 10% level of significance;
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APPENDIX TABLE A3: The Effect of University Activity on Local Labor Income, 1981-1996: Alternative Instrumental Variable and Additional Stock Market Exposure Control Specifications – First Stage Estimates

Dependent Variable = Δ University Expenditure Per Capita; period t – (t-x)

Specification =	Stock Market Endowment Only	Differential Stock Market Correlations	Initial Market Value of Endowment	Log (Lag Endow)	Year × State Fixed Effects	Year × Industry Fixed Effects	Year × College Quality Fixed Effects	Year × High Rent Fixed Effects	Year × 1900 Outcomes Fixed Effects
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Model l: Three Year Differences									
Δ Stock Index × Lagged Market Value of Endowment × Percent Domestic Equity	0.167*** (0.047)								
Δ Stock Index × Lagged Market Value of Endowment		0.117** (0.058)			0.083*** (0.021)	0.076*** (0.020)	0.074*** (0.025)	0.079*** (0.022)	0.067*** (0.016)
Δ Stock Index × Lagged Market Value of Endowment × Share Graduate		0.002** (0.001)							
Δ Stock Index × Lagged Market Value of Endowment × Quality Ranking		-0.031** (0.014)							

Δ Stock Index × Initial Market Value of Endowment			0.215*** (0.064)						
Δ Stock Index × Log(Lag Market Value of Endowment)				0.39*** (0.009)					
F-Statistic: Excluded Instruments	12.85 [0.0006]	74.13 [0.0000]	11.40 [0.0006]	18.43 [0.0000]	16.31 [0.0001]	14.72 [0.0002]	8.64 [0.0042]	13.38 [0.0004]	17.43 [0.0001]
Observations	35256	40380	40380	36983	40380	40380	40380	40380	37956

Model 2: Five Year Differences

Δ Stock Index × Lagged Market Value of Endowment × Percent Domestic Equity	0.198*** (0.054)								
Δ Stock Index × Lagged Market Value of Endowment		0.137* (0.071)			0.099*** (0.024)	0.088*** (0.023)	0.086*** (0.029)	0.092*** (0.025)	0.078*** (0.019)
Δ Stock Index × Lagged Market Value of Endowment × Quality Ranking		0.002** (0.001)							
Δ Stock Index × Lagged Market Value of Endowment ×		-0.035* (0.018)							

Share Graduate									
Δ Stock Index × Initial Market Value of Endowment			0.227*** (0.065)						
Δ Stock Index × Log(Lag Market Value of Endowment)				0.041*** (0.009)					
F-Statistic: Excluded Instruments	13.49 [0.0005]	59.19 [0.0000]	12.25 [0.0007]	20.21 [0.0000]	16.27 [0.0001]	14.96 [0.0002]	8.82 [0.0039]	13.62 [0.0004]	17.71 [0.0001]
Observations	29380	33650	33650	31075	33650	33650	33650	33650	31630

Notes and Sources: See Table 1. The estimates presented are for various alternative versions of model (3) and (5) as described in the text. The unit of observation is at the county-industry-year level and the sample includes all large university counties. University Expenditure and Lagged Market Value of Endowment are measured as the spending rate per county population/1000. All estimates are weighted by the level of employment in the industry-county cell in 1981. The main entries in columns (1) - (8) are coefficient estimates. The entries in parentheses in columns (1) - (8) are the standard errors of the coefficient estimates clustered at the county level. The entries in the last row of each panel report the F-Statistic for the test of whether the excluded instrument is zero. The test statistic value is reported as the main entry, and the p-value of test is reported in square brackets.

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** indicates significantly different from zero at the 5% level of significance;
*** indicates significantly different from zero at 1% level of significance.

Gale K. Vick
Dba GKV&Sons LLC
2075 Becker Ridge Road , Fairbanks, Alaska 99709
e-mail: gkvsons@alaska.net

February 22, 2016

TO: Members, House Finance, Alaska Legislature
Rep. Mark Neuman, Co-Chair, Representative.Mark.Neuman@akleg.gov
Rep. Steve Thompson, Co-Chair Representative.Steve.Thompson@akleg.gov
Rep. Dan Saddler, Representative.Dan.Saddler@akleg.gov
Rep. Bryce Edgmon, Representative.Bryce.Edgmon@akleg.gov
Rep. Lynn Gattis, Representative.Lynn.Gattis@akleg.gov
Rep. Cathy Munoz, Representative.Cathy.Munoz@akleg.gov
Rep. Lance Pruitt, Representative.Lance.Pruitt@akleg.gov
Rep. Tammie Wilson, Representative.Tammie.Wilson@akleg.gov
Rep. Les Gara, Representative.Les.Gara@akleg.gov
Rep. David Guttenberg, Representative.David.Guttenberg@akleg.gov
Rep. Scott Kawasaki, Representative.Scott.Kawasaki@akleg.gov
Rep. Mike Hawker, Representative.Mike.Hawker@akleg.gov

RE: University of Alaska Budget

Dear House Finance Members:

I am writing in urgent support of the University of Alaska budget.

As a 48 year resident of this great state, I have been involved with the University on an incredible number of research, committees and other projects, not to mention having many members of my family attend and/or graduate from UAF.

In short, the University of Alaska is an icon for our state and a mainstay of education, research and alliances with almost every major community, tribal and business organization. It is a community resource in many locations and provides a unique structure for rural attendees. It is an integral part of so much in this state that it would be hard to fully recognize its important, and I would even say, vital, contributions.

I urge you to consider cuts to the University budget no deeper than the recommendations made by Governor Bill Walker's.

Thank you.

Sincerely

Gale K. Vick

From:	Byron Whitesides
To:	House Finance
Subject:	Cut the State Operating Budget!
Date:	Thursday, February 25, 2016 6:04:34 PM

Dear House Finance Committee General,

I am writing you today because I am concerned about our state deficit.

Right now it looks like we will be running a deficit of $3.5 billion for the second year in a row.

But please do not raise my taxes in order to fix this problem. Instead, we should cut our state operating budget by at least $500 million.

You could also repeal the favorable tax on the oil industry and restore the ACES tax structure abolished by Parnell.

I am asking you today to please cut the state operating budget!

Thank you,
Byron Whitesides
PO Box 9200
Ketchikan, AK 99901

From: Shannon Donahue
To: House Finance
Subject: In support of funding public radio
Date: Thursday, February 25, 2016 6:02:58 PM

Dear House Finance Committee Members,

I am writing in support of state funding for public radio. I am aware that this week, the State House Administration Subcommittee approved a 100% cut to public radio and public television. Respectfully, I urge you to restore funding to public media.

Here in Haines, and in rural communities across Alaska, public radio is our lifeblood. We absolutely depend on our public radio station, KHNS for the local services it provides, including crucial, up to date information on emergencies, road closures, disruptions to ferry service, community and government affairs, meetings, events, cancellations, and as a means of communication through listener personals when out of cell, internet, and phone service areas. Local businesses, nonprofits, schools, and clubs rely on the radio for communication and dispersal of information. In the winter months, our radio station keeps us together as a community.

The proposed 100% slash to public media in Alaska would mean an estimated loss of $109,000 to the station's income from state budget cuts alone. This comes on the heals of last year's 23% cut, that has already resulted in loss of beloved programs we used to enjoy. This year's cut would drop KHNS below the minimum funding levels required for eligibility for federal grants. That means, without state funding, KHNS would automatically face an additional loss of $122,000 in federal grant income, effective October 1, resulting in a total loss of $231,000--over half of KHNS annual operating budget. These cuts would make KHNS unable to offer any local services. We would lose the public radio that we depend on. I'd imagine this is true of other public radio stations across Alaska. Our community would also lose an important employer that offers some of the few professional level jobs in our community.

KHNS is the lifeblood of our community, a service I would be lost without. Our local radio station has earned tremendous support from our community, by offering excellent services that we absolutely depend upon. Our community radio station boasts an impressive number of volunteers in a community already tapped out on volunteer time and energy. We donate generously to KHNS fundraisers, even when we can't really afford to give. Although we as a community go above and beyond when it comes to supporting our radio station, it is just impossible for us to provide the level of support that would make up for these drastic budget cuts.

I understand that our state faces an incredible challenge in the current fiscal climate. I appreciate that services must be cut across all sectors, and that public media will inevitably lose some funding. However, I urge you to honor the importance of public radio to rural Alaska, and restore funding to public media.

I appreciate the hard work you are all doing on behalf of the State of Alaska.

Thank you,

Shannon Donahue

PO Box 1616
Haines, AK 99827
(907) 766-2188

From: philip raymond
To: House Finance
Subject: Cut the State Operating Budget!
Date: Thursday, February 25, 2016 5:50:11 PM

Dear House Finance Committee General,

I am writing you today because I am concerned about our state deficit.

Right now it looks like we will be running a deficit of $3.5 billion for the second year in a row.

But please do not raise my taxes in order to fix this problem. Instead, we should cut our state operating budget by at least $500 million.

I am asking you today to please cut the state operating budget!

Thank you,
philip raymond

North Pole, AK 99705

From: JAMES FARR
To: House Finance
Subject: Cut the State Operating Budget!
Date: Thursday, February 25, 2016 5:44:47 PM

Dear House Finance Committee General,

I am writing you today because I am concerned about our state deficit.

Right now it looks like we will be running a deficit of $3.5 billion for the second year in a row.

But please do not raise my taxes in order to fix this problem. Instead, we should cut our state operating budget by at least $500 million.

I am asking you today to please cut the state operating budget!

Thank you,
JAMES FARR
PO Box 201839
Anchorage, AK 99520