Nicolas Bunde, *Nina Czernich*, *Oliver Falck* and *Gabriel Felbermayr*

What Works? Regional Effects of Universities*

KEY MESSAGES

- **Universities exert a positive impact on the development of a region**
- **They increase employment in high-tech and knowledge-intensive industries and raise long-term wages**
- **Research results from universities are the basis for technological progress, new products, and start-ups**
- **Framework conditions and institutional characteristics play an important role for such effects**
- **Innovation ecosystems grow over years and decades. Therefore, higher-education policy must be long-term**

Economic research has always emphasized the importance of a well-educated population for the level and dynamics of per capita income and other key economic variables. Hanushek and Woessmann (2022) provide a current overview. Foreseeable demographic changes – especially the stagnation or even decline of the active labor force – make investments in the quality of human capital particularly necessary.

The literature attributes a significant role to universities for the development of a region. Their research and education activities generate qualified graduates, spawn innovative companies, and spur stronger economic and employment growth. Universities may particularly have an impact on their immediate surroundings. Stanford University is an often-cited example of universities spawning significant technology clusters in their vicinity, such as Silicon Valley. They are considered a major cause of high-quality employment and prosperity in their regions. But despite the theoretically well-founded positive effects of universities, many channels are not easy to prove empirically and are more likely to be classified as anecdotal evidence, which is why a critical examination of the postulated effects is needed.

The challenge for empirical scrutiny of the effects of universities on their environment is that causal effects are difficult to separate from pure correlations. For example, the presence of a university regularly correlates with high regional per capita income. But it is likely that completely different factors, such as a central or urban location, can explain the presence of a university on the one hand and high per capita incomes on the other, without the former necessarily causing the latter. In addition, it is quite possible that the causality (also) runs in the opposite direction: where per capita incomes are high, there are more resources for universities. Similar problems arise when researching the effect of tertiary education and research institutions on other variables such as start-up dynamics, innovation activity, unemployment, and much more.

The associated methodological challenges have been amply discussed in various studies and addressed by different means. To better assess which regional effects can be expected from universities, this article summarizes the results of selected impact studies from different countries on the effects of universities on their region. The report was preceded by a comprehensive literature study, with only those studies being considered that could demonstrate a particularly high internal validity, i.e., a methodically convincing implementation.

EFFECT CHANNELS

Universities exert direct and indirect investment and employment effects through their establishment and maintenance and the demand for services necessary for their operation. Indirect effects stem from university employees and students, who usually live in the region, increasing demand for housing, consumer goods, and services. Beyond this, universities may exert other effects on their location that go beyond the mere generation of purchasing power.

Nicolas Bunde

is a Specialist at the ifo Center for Industrial Organization and New Technologies.

Nina Czernich

is a Specialist and Deputy Director of the ifo Center for Industrial Organization and New Technologies.

* Based on the study "What Works? Regionale Auswirkungen von Hochschulgründungen und der Fall der neuen TU Oberösterreich" commissioned by the Federation of Upper Austrian Industry.

Oliver Falck

is the Director of the ifo Center for Industrial Organization and New Technologies and CESifo Professor of Economics at the University of Munich.

Gabriel Felbermayr

is the Director of the Austrian Institute of Economic Research (WIFO) and Professor of Economics at the Vienna University of Economics and Business (WU).

Universities are also important drivers of innovation through their research activities and cooperation with companies. Their creation and dissemination of new knowledge is not limited to the publication of research papers or patents: the importance of further channels such as consulting services, master's theses and doctoral dissertations, conferences, internships, and informal exchange between university researchers and company representatives should not be underestimated. The literature also attributes a significant role to personal exchange between innovation actors (see Agrawal and Henderson 2002, on knowledge transfer). It is therefore not surprising that spatial proximity is relevant for the diffusion of innovation. This explains, among other things, why innovation activities often occur in clusters.

Universities, through their research activities and the infrastructure they provide (e.g., laboratories), can ideally represent anchor points for innovation networks and attract companies seeking proximity to science and a qualified workforce. There is also evidence that such companies produce more valuable patents, which again shows the importance of networks between universities and local business (on cooperation between universities and economic actors, see Fritsch et al. 2008).

In addition to economic effects, universities are also associated with a strengthening of the institutional fabric. As platforms for democratic dialogue, they contribute to the exchange of ideas through events, publications, and reports for policymakers. They bring together people of different cultures, mindsets, and disciplines and are also often associated with strengthening the cultural and creative scene. Universities, for example, are often involved in the work of museums, galleries, or theaters, and staff and students also act as consumers of culture. Influences of this kind are not always precisely quantifiable, but are nevertheless important.

METHODOLOGICAL CHALLENGES

Many studies on the impact of higher education institutions on their environment have identified a whole range of possible impact channels. However, not every study can be generalized, for example because some correlations only apply to certain types of higher-education institutions or were investigated in specific country contexts. The methods used and the data sources also differ from study to study, which can result in differences in the validity of the findings. In addition, many findings are not proven causal relationships, but merely correlations. For example, a positive correlation between the presence of a university and business start-ups could simply be due to the fact that universities are often found in conurbations that favor the establishment of businesses. Before drawing conclusions, it is therefore important to pay close attention to the methodological approach of the respective studies.

The proof of causal relationships is one of the great challenges in empirical economic research. While counterfactual methods are often used to determine causal effects and prevent erroneous conclusions, this is not possible when analyzing the local effects of universities, since an existing university cannot simply be wished away for the sake of the counterfactual. Therefore, one compares—similar to medical research—the development of a randomly selected group that receives a certain treatment with a randomly selected control group that receives no treatment or a placebo. Since the two groups were randomly selected, they should only differ on average in terms of treatment, but not in terms of other characteristics, making it possible to attribute differences in development to the intervention. In the case of the local effect of universities, such a setting can be obtained by random selection from a group of potential university locations.

Since in economic research it is often not possible to conduct experiments with defined control groups, the next-best option are so-called "natural experiments", i.e., situations in which part of the population is affected by a measure, and part is not. Whether a location is affected by the establishment of a university must not depend on aspects that also influence the outcome variables, e.g., the innovativeness of firms, the share of highly qualified workers, or regional growth. The challenge is therefore to find a control group of regions without universities that do not differ from the university locations except for the absence of a university. In essence, such studies must be measured by the extent to which they succeed in identifying a convincing control group.

EFFECTS ON INNOVATION AND GROWTH

In a large international comparative study, Valero and van Reenen (2019) examine the importance of universities based on nearly 15,000 universities in about 1,500 regions in 78 countries. They look at the period after World War II, when higher-education expansion was accelerating in most countries, and analyze how

the establishment of universities is related to future economic growth. To do this, they estimate an econometric model at the sub-national level for the period 1950 to 2010, and demonstrate that increases in the number of universities are positively related to future GDP per capita growth: a 10%-increase in the number of universities per capita in a region is associated with a 0.4%-increase in future GDP per capita in that region. The authors show that this effect goes beyond the influence of the direct expenditure of the university, its staff and students: the increased supply of human capital and innovation also play a role.

The following studies make use of institutional characteristics of higher-education policy combined with modern statistical methods to further explore the channels through which universities affect their surroundings and to identify causal effects.

Education Spending Boosts Innovation and Growth

Aghion et al. (2009) develop an endogenous growth model in which they assumed different effects of basic education (school) and higher education (university, doctorate). They postulate that the latter leads to more knowledge, new research results, and technological innovations. Basic education, in turn, creates a foundation upon which the new developments can flourish, as basic skills are necessary for their implementation and realization. In the empirical part of the study, the authors test the model by examining how additional financial resources for universities influence per capita income. To identify a possible causal relationship, they used so-called instrumental variables, i.e., indicators that influence the level of education spending but have no direct effect on income levels.

For their empirical approach, the authors used specifics of the appointment process of members of the US Congressional Appropriations Committees, which are responsible for allocating federal funds for research. The committees allocate a lump sum to a funding institution, such as the National Science Foundation, which then awards funding through competitive application processes. However, committees may also fund individual projects without regard to merit or larger policy considerations. Such individual projects are the main route through which MPs can channel funds to their constituencies, which makes a seat on these committees highly desirable. MPs who hold such a seat do not give it up voluntarily and both houses of Congress respect the right of a sitting committee member to remain on that committee. As a result, MPs tend to stay on the committee for several years, and almost all vacancies occur because a member dies in office or retires from political life. A vacancy sets in motion a complex internal political process of replacement based on a combination of majorities, regional proportionalities, and the distribution of seats in other committees. The authors use this for their instrumental variables approach. The process of appointments causes variations in the level of funding of different universities; at the same time, it is neither plausible that this process influences the performance of universities in any other way than through the allocation of funds, nor that the performance of universities influences the appointment to committees. It is crucial that these instruments emerge through internal political details and are not influenced by general political tendencies.

Thus, the additional funding to universities located in members' constituencies resulting from such members' political appointment process can be viewed as a natural experiment that allows to infer causal effects by comparing universities that received additional funding and those that did not. The authors show that this additional funding increases the growth of real per capita income in US states. However, as expected in the theoretical model, the effects differ depending on the type of funding and the state's technological level. Overall, the US is a technologically advanced country, so that positive growth effects of additional investment in four-year college education are shown for all states. However, additional research-related investments only have positive growth effects in states that are relatively close to the technological frontier, i.e., where the industry is a technology leader. An additional US$1,000 of research-related investment per person in a cohort increases economic growth in that state by 0.04 percentage points. Additional budget for research-related investment averages US$500 per person over a 6-year period. Thus, an average budget increase raises growth by 0.12 percentage points. The effect of additional budget for a four-year college education is higher (0.07). However, the average budget increase here is lower than for research-related investments, which is why the average effect is lower (0.011). In US states that are behind the technology frontier, the effects differ significantly and, as predicted by the model, are smaller or negligible.

The size of the effects on income suggest that beyond the additional individual human capital, indirect effects such as innovation also play a role. Therefore, the authors investigate whether budget increases have an impact on university patents. In states at the technology frontier, an additional US$1,000 of research-related investment per person in a cohort leads to a 0.06-pp increase in patents per person (the effect of additional budget for four-year college education is similar). In states behind the technology frontier, there is no effect on patent activity.

Autonomy and Competitive Funding Procedures Make Universities More Productive

In another study using the same methodology, Aghion et al. (2010) analyze the role of university governance on the impact of additional research funding. They

hypothesize that universities are more productive when they are both highly autonomous and highly competitive. The idea behind this is that the production function for research and knowledge is hardly observable or comprehensible for outsiders, such as politicians or funding institutions. In such a setting, dirigiste measures seem to make little sense, compared to a combination of autonomy for the research institutions coupled with competitive funding procedures in which the research institutions must prove their productivity.

The authors show that increasing funding for a university increases patents and publications more when the university has more autonomy and faces stronger competition. This confirms the authors' hypothesis that cutting-edge research is a highly complex process that is most successfully promoted by granting research institutions freedom, but at the same time requiring them to prove their productivity in performance-based competition. From this they derive recommendations for European universities: greater autonomy combined with greater accountability by pushing for competitive grants, greater student and faculty mobility, and competitive procedures and assessment programs.

Local Spillover Effects of Research Institutions: US Agriculture

Kantor and Whalley (2019) examine one specific type of research and its effects, in the field of agriculture. At the end of the 19th century, agriculture experiment stations were established at many US universities, driven not by regional difficulties, but increased global competition. Instead of implementing protectionist measures, the productivity of US agriculture was to be increased.

The authors investigate whether the agriculture experiment stations had spillover effects on local agriculture production. Again, a mere correlation does not allow any conclusion on the direction of the effect, e.g., farmers who were very interested in technological novelties and therefore already had above-average productivity might have lobbied for such an experiment station to be set up at a university near them. To identify a causal effect, the authors go back in the history of the US higher-education system to the founding of the so-called land-grant colleges, since it was near these types of colleges that agricultural experiment stations were set up. The crucial question was therefore how the locations of the land-grant colleges were determined.

Land-grant colleges are state universities in the US whose foundation and funding are based on the Morrill Land-Grant Colleges Acts of 1862 and 1890. The US federal government transferred land ownership to each state under the condition that the proceeds from the sale or use of this land be applied to the establishment and running costs of an institution of higher education. Being the site of a land-grant college was highly coveted, and a veritable competition began between local governments within the individual states. Political skill and good connections to the state government were helpful, but geographical location also played a role. The authors argue that because of these different criteria the decision for the locations of land-grant colleges was independent of the economic development and the productivity of agriculture at the location.

The authors find that the effects of proximity to research were initially small and only increased after a few years, peaking 20 to 30 years after the opening of the experiment station, until they disappeared again 50 years after the stations opened. Before 1920, the spatial proximity to a station was important for innovation; after 1920, this cannot be confirmed. The spread of innovations was much faster in the post-1920 period. Cars and telephones were widely available and an agricultural extension program was available in almost every district. The increasing speed of innovation diffusion largely explains the decline in the observed effect of proximity.

Varying Role of Proximity by Sector

The waning importance of proximity for the diffusion of innovations is a peculiarity in this study and is not confirmed in other studies on knowledge spillovers. One explanation for this is the different degree of complexity of the innovations. No interaction with the research institution is likely to be necessary for the use of a new seed. It is enough to know about it and sow it. Complex technologies, on the other hand, often require face-to-face interaction. For example, patent research has found that the mere patent description is often not enough to replicate technologies or processes. Inventors often have no incentive to write patents in such a way that they can be used as recipes or blueprints. Therefore, direct exchange between researchers and inventors is necessary to build on patents and their own research (Moser and Voener 2012; Watzinger et al. 2020). The following papers, which mainly use patents as outcome variables, confirm the importance of spatial proximity.

Importance of Spatial Proximity for Knowledge Spillovers

Li et al. (2020) examine the importance of local knowledge spillovers in a study on China, looking at the effects of increased student numbers on innovation activity. Again, it is not sufficient to prove a mere correlation between the indicators to determine the direction of the effect: do more students lead to more innovation, or are there many innovative companies in a region which demand university graduates, leading thus to more students at nearby universities?

For their analysis, the authors use the fact that the Chinese higher-education system is centrally

planned and managed from Beijing. Students are allocated to universities nationwide based on test scores. Therefore, higher-education policies are independent of regional developments such as economic growth or demand for graduates. In 1999, China began an educational expansion with the aim of significantly increasing the number of university graduates to counter the effects of the Asian financial crisis, as well as of the massive layoffs resulting from the reforms of the state-owned enterprises in the late 1990s. In June 1999, a new university recruitment plan envisaged 1.5 million freshmen in the autumn of that year, a 42-percent increase over the previous year. The distribution of the additional new students was based on centrally determined quotas, which were primarily oriented towards central plans and existing capacities at the universities.

In their analysis, the authors find that the expansion of universities significantly increased innovation capacity and led to a marked rise in patenting activity by nearby companies. Moreover, corporate patents cited university patents more frequently. As a measure of the actual generation of innovations, the authors also examine the introduction of new products by companies in the vicinity of universities. Here, too, they find clear effects of expansion. However, the effects strongly decreased with spatial distance. Overall, the authors concluded that the knowledge spillovers from universities are considerable, but highly localized.

Executive Networks as a Channel for Knowledge Spillovers

In a study for the US, Charles (2021) analyzes the channels of local knowledge spillovers between universities and companies. He investigates whether research at universities leads to more patents in existing companies or whether it is mainly that new innovative companies settle nearby. For his analysis, the author uses universities that have evolved from land-grant colleges (described above), since their location can be seen as exogenous to current economic development.

The author analyzes changes in university budgets and research activities, particularly in research-intensive faculties such as medicine or engineering, resulting from philanthropic donations by university alumni. The links between a university and its alumni were forged decades earlier and should therefore be independent of current developments. It turns out that companies whose executives are more strongly connected to the university produce more valuable patents in the years following the donation. The effects are particularly strong if the connection was forged through an executive's master's degree or doctorate at the university and are largely driven by companies that settle near the universities, since these are more closely connected to the university (even before the donation) than other companies.

Type of University Decisive for Regional Impacts

The study by Howard et al. (2021) suggests that the location and type of university is relevant for knowledge spillover and co-location effects. They examine the effect of universities that have developed in the US from so-called normal schools, which train teachers to the "norm" of good teaching (Labaree 2008).

Social reform movements of the 19th century included the expansion of education and advocacy for better care for people with mental illness. Local governments established community schools, creating a great demand for qualified teachers. To meet this demand, many states established normal schools. At the same time, a movement for better care of the mentally ill began, which contributed to states establishing mental health facilities. The location of both kinds of institutions was a political decision, with proximity and easy access to population centers, an attractive natural environment, and transport routes all playing an important role. Location decisions typically depended on the political influence of a district, and in both cases entailed large government investments associated with jobs and economic opportunities.

At the beginning of the 20th century, normal schools and mental health facilities were similar in size in relation to the district's population. But by the mid-20th century, most normal schools had expanded into regional state colleges and universities, and students made up a large proportion of the district's population. Today, these colleges generally focus on undergraduate and master's education and are not as research-intensive as flagship state universities. By 1980, they awarded about 42% of all bachelor's degrees in the US. Unlike the normal schools, the psychiatric institutions never grew large, and most are still state-owned.

The authors find that universities that have emerged from normal schools have a clear positive influence on the number of students and graduates in a region, but that they seldom stay around after graduation. The latter may be one explanation for the fact that such universities have hardly any effect on the local economy. Another possible reason is that these universities are not very research-intensive, which results in little potential for knowledge spillover and attraction of companies to their proximity.

LABOR MARKET EFFECTS OF UNIVERSITIES

It has been shown that for the individual, higher education leads to higher income. The central question for education policy, however, is whether there are effects beyond individual incomes. This has often been postulated but was not empirically proven until Moretti (2004), in a seminal paper, showed that the

social returns to education are indeed higher than the sum of additional income of individuals.

Moretti compares the salaries of people in the US who are similar in many respects but live in cities with different proportions of university graduates. Several aspects must be taken into account to interpret the differences as a causal effect, such as unobservable characteristics of individuals and cities. For example, employees with high levels of unobservable skills, like talent, competence, or motivation, often move to cities with a high-skilled workforce. Furthermore, city-specific unobserved characteristics are correlated with the share of graduates. For instance, the boom in the computer industry has driven up the wages of skilled workers, attracting high-skilled workers to places like Silicon Valley. In this case, the high wages lead to an increase in the number of graduates in the city and not the other way around.

Moretti uses special econometric methods to take these unobservable characteristics into account. First, he examines longitudinal data to observe individuals over time. Second, he uses an instrumental-variables approach based on differences in the age structure of cities to account for the trend of increasing participation in education in recent decades. Further, he exploits whether a city has a land-grant college.

The results of the different approaches provide consistent results. A 1-percentage point increase in the share of graduates raises average wages by 0.6 to 1.2%, over and above the private returns to education. To find out whether spillover effects also play a role, Moretti compares the effects of changes in the share of graduates on the wages of different education groups. Classical economic theory predicts lower wages in the presence of higher supply, i.e., in the absence of knowledge spillovers, the wages of graduates should fall. Empirical analysis shows that a 1-percentage point increase in the share of graduates in the labor force increases graduate salaries by 0.4%. Hence, there must be positive spillover effects: a higher supply of well-educated workers increases the incomes of the well-educated. The salaries of school dropouts and high school graduates also increase, by 1.9% and 1.6% respectively.

The social returns of more university graduates therefore consist, on the one hand, of increased wages for the low-skilled, whose jobs are complementary to those of the highly qualified, and on the other, knowledge spillovers that increase the knowledge of the labor force beyond that imparted at universities.

University Research and Local Entrepreneurship Ecosystems

Stern and Tartari (2021) examine the importance of universities and research institutes (national laboratories) for regional entrepreneurship ecosystems in the US, and in particular whether the effects of the two institutions differ. Both universities and research institutes conduct research that can become the basis for new businesses. However, universities also generate graduates who can potentially become entrepreneurs or employees of start-ups in the region.

Universities, research institutes, and regional entrepreneurship ecosystems influence each other, for example through infrastructure, amenities, or knowledge transfers. Therefore, the authors used for their causal analysis the changes in the amount of federal funds allocated to both research-oriented and general, non-research-oriented institutions. Most of these funds are allocated through competitive processes that are independent of future changes in the regional entrepreneurship ecosystem.

The authors document a clear influence of universities and research institutes on the regional entrepreneurship ecosystem. However, the influence differs along some dimensions. First, while federal funds for non-research activities increase the quantity of entrepreneurship (but decrease its average quality), funds for research activities increase both the quantity and the quality-adjusted quantity of entrepreneurship. Second, the research activities of universities are more strongly associated with spillover effects on the regional entrepreneurship ecosystem.

University Expansion in Germany in the 20th Century

At the beginning of the Industrial Revolution, several universities were founded in Germany, mostly in the south and Prussia, while there were still no universities in large parts of the country. Emperor Wilhelm II feared the “free spirit” educated at universities in areas where Prussia had less influence and control. During the First World War, founding universities was hardly possible. The subsequent Nazi dictatorship was little inclined to found universities that could foster free thought and intellectual human capital. Therefore, new universities were only founded in the late 1950s and early 1960s (Slavtchev and Noseleit 2011).

Typical criteria for a new university were the creation of spatially evenly distributed educational opportunities and the avoidance of overcrowding at existing universities. Consequently, mainly regions without universities at the time were considered. The final location decision was complex and depended on a variety of different factors, such as a repeated postponement of university establishment for the reasons mentioned above; or geographical distribution considerations, or simply good contacts between local administration and state government (for more details, see Slavtchev and Noseleit 2011). Overall, the establishment of new universities cannot be considered a typical reaction to structural change. Therefore, university expansion in Germany is well-suited to analyze the causal effects of new universities. In

the following, three studies are presented that take advantage of this and evaluated various outcome variables using different statistical methods.

Proximity to Universities Increases a Region's Proportion of University Graduates

Siegler (2021) examines the effect of new universities on the likelihood of the local population to obtain a university degree. A new university near one's place of residence can potentially increase the probability of entering university, thanks to lower monetary costs such as through the possibility of continuing to live in the parental home, or due to personal preferences such as staying close to familiar surroundings and friends and family.

For his analysis, Siegler uses geographical differences in local access to university. He compares cohorts who were at a typical age for entering university at the time when a new university was founded in a county nearby a county without a university. The results show that a new university in a neighboring county increased the proportion of university graduates in a county by 8 to 10 percentage points. Women and immigrants in particular were more likely to graduate from higher education institutions due to their proximity to a university.

More Employment in High-Tech and Knowledge-intensive Sectors

Slavtchev and Noseleit (2011) analyze the effects of new universities on regional development in West Germany by going one step further than graduates and examining the effects of universities on regional employment. The results show positive effects on employment and start-up activity in high-tech and knowledge-intensive industries. Overall, the results suggest that the establishment of a new university is associated with a shift in the local economy towards this type of industries.

Long-Term Positive Impact of University Start-ups on Local Wages

Do the higher numbers of graduates and increased employment in high-tech and knowledge-intensive sectors ultimately translate into higher wages? The question was examined by Fuest and Immel (2021) using the event-study method (also called dynamic differences-in-differences estimator). Their results show that new universities have a long-term positive effect on wages in a region, but that the effects differ along the wage distribution. In the higher-wage bracket, the effect sets in earlier and is stronger than in that of lower wages. This is consistent with the findings for the US (Moretti 2004) and suggests spillover effects of education. A detailed analysis of the types of higher education institutions shows that regional wage increases are mainly due to universities of applied sciences and higher-education institutions in urban regions.

POLICY CONCLUSIONS

Methodologically valid studies have shown that higher-education institutions positively influence the development of a region in various ways. Universities have a positive effect on the share of graduates in the region, as well as on the region's employment in high-tech and knowledge-intensive industries and on long-term wages. Social returns exceed individual returns to education. Research results from universities and highly qualified graduates are the basis for technological progress, new products, and start-ups. In addition to spin-offs from universities, companies are also settling in the vicinity of universities.

However, the positive effects do not occur automatically and everywhere to the same extent. Existing framework conditions and institutional characteristics play an important role. For example, the effectiveness of education and research budgets depends, among other things, on university governance – autonomy combined with accountability – and the level of technological development of a region. Furthermore, the impact differs depending on whether the funds are used for research or rather for undergraduate education. The former has the potential to trigger innovation, especially if there is a suitable innovation ecosystem with innovative companies in the vicinity of the university.

Despite modern communication technologies, spatial proximity, and close personal connections are important for knowledge spillovers, cooperation, and joint development of innovations. This is especially true for complex technologies and methods.

Finally, it has been shown that the effects of new universities take time to materialize: networks, cooperation, and innovation ecosystems grow over years and decades. Therefore, higher-education policy must be long term and strategic.

REFERENCES

Aghion, P., L. Boustan, C. Hoxby and J. Vandenbussche (2009), *The Causal Impact of Education on Economic Growth: Evidence from US*, Harvard University, Mimeo.

Aghion, P., U. Akcigit, A. Bergeaud, R. Blundell and D. Hemous (2019), "Innovation and Top Income Inequality", *The Review of Economic Studies* 86, 1–45.

Agrawal, A. and R. Henderson (2002), "Putting Patents in Context: Exploring Knowledge Transfer from MIT", *Management Science* 48, 44-60.

Charles, C. (2021), *Company-College Co-Location: Do Universities Create Local Innovation Clusters?*, http://dx.doi.org/10.2139/ssrn.3499277.

Fritsch, M., T. Henning, V. Slavtchev and N. Steigenberger (2008), "Hochschulen als regionaler Wachstumsmotor? Innovationstransfer aus Hochschulen und seine Bedeutung für die regionale Entwicklung", *Arbeitspapier* 158, Hans-Böckler-Stiftung, Düsseldorf.

Fuest, C. and L. Immel (2021), "University Openings and Their Long-term Impact on Regional Wages: Evidence from West Germany", in L. Immel, *The Regional Distribution of Income and Wages: Causes and Consequences*, ifo Beiträge zur Wirtschaftsforschung 9, Munich.

Hanushek, E. and L. Wössmann (2022), "Education and Economic Growth", *Oxford Research Encyclopedia of Economics and Finance*, Oxford University Press, Oxford.

Howard, G., R. Weinstein and Y. Yang (2021), "Do Regional Universities Make Their Local Economy More Resilient?", *IZA Discussion Paper* 14422.

Kantor, S. and A. Whalley (2019), "Research Proximity and Productivity: Long Term Evidence from Agriculture", *Journal of Political Economy* 127, 819-854.

Li, J., S. Liu and Y. Wu (2020), Identifying Knowledge Spillovers from Universities: *Quasi-experimental Evidence from Urban China*, http://dx.doi.org/10.2139/ssrn.3621422.

Moretti, E. (2004), "Estimating the Social Return to Higher Education: Evidence from Longitudinal and Repeated Cross-sectional Data", *Journal of Econometrics* 121, 175–212.

Moser, P. and A. Voener (2012), "Compulsory Licensing: Evidence from the Trading with the Enemy Act", *American Economic Review* 102, 396–427.

Saxenian, A. (1994), *Regional Advantage: Culture and Competition in Silicon Valley and Route* 128, Harvard University Press, Cambridge MA.

Siegler, B. (2012), "The Effect of University Openings on Local Human Capital Formation: Difference-in-Differences Evidence from Germany", *BGPE Discussion Paper* 124.

Slavtchev, V. and F. Noseleit (2011), "Universities as Agents of Change", *ERSA Conference Papers* ersa10p340, European Regional Science Association.

Stern, S. and V. Tartari (2021), "More Than an Ivory Tower: The Impact of Research Institutions on the Quantity and Quality of Entrepreneurship", *NBER Working Paper* 28846.

Valero, A. and J. van Reenen (2019), "The Economic Impact of Universities: Evidence from Across the Globe", *Economics of Education Review* 68, 53-67.

Watzinger, M., T. A. Fackler, M. Nagler and M. Schnitzer (2020), "How Antitrust Enforcement Can Spur Innovation: Bell Labs and the 1956 Consent Decree", *American Economic Journal*: Economic Policy 12: 328–359.