ISSN 2042-2695

CENTRE *for* ECONOMIC PERFORMANCE

CEP Discussion Paper No 1444

Revised September 2018
(Replaced revised January 2018 version)

The Economic Impact of Universities: Evidence from Across the Globe

Anna Valero
John Van Reenen

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Abstract
We develop a new dataset using UNESCO source materials on the location of nearly 15,000 universities in about 1,500 regions across 78 countries, some dating back to the 11th Century. We estimate fixed effects models at the sub-national level between 1950 and 2010 and find that increases in the number of universities are positively associated with future growth of GDP per capita (and this relationship is robust to controlling for a host of observables, as well as unobserved regional trends). Our estimates imply that a 10% increase in a region's number of universities per capita is associated with 0.4% higher future GDP per capita in that region. Furthermore, there appear to be positive spillover effects from universities to geographically close neighbouring regions. We show that the relationship between GDP per capital and universities is not simply driven by the direct expenditures of the university, its staff and students. Part of the effect of universities on growth is mediated through an increased supply of human capital and greater innovation. Furthermore, we find that within countries, higher historical university presence is associated with stronger pro-democratic attitudes.

Keywords: universities, growth, human capital, innovation
JEL codes: I23; I25; J24; O10; O31

This paper was produced as part of the Centre's Growth Programme. The Centre for Economic Performance is financed by the Economic and Social Research Council.

Acknowledgements
We would like to thank Andy Feng, Sandra McNally, Henry Overman, Katheryn Shaw, Andrei Shleifer and participants at seminars at the CEP, LSE, MIT, RES Conference and HM Treasury for helpful comments. Nicola Gennaioli, Rafael La Porta and Florencio Lopez De Silanes were kind enough to make their regional data available to us. Financial support from the ESRC through the CEP (grant ESRC ES/M010341/1) is gratefully acknowledged.

Anna Valero, Centre for Economic Performance and London School of Economics. John Van Reenen, MIT, Centre for Economic Performance, London School of Economics and NBER.

Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

A striking feature of the last hundred years has been the enormous expansion in university education. In 1900, only about one in a hundred young people in the world were enrolled at universities, but over the course of the Twentieth Century this rose to about one in five (Schofer and Meyer, 2005). The term "university" was coined by the University of Bologna, founded in 1088, the first of the medieval universities. These were communities with administrative autonomy, courses of study, publicly recognised degrees and research objectives and were distinct from the religion-based institutions that came before (De Ridder-Symoens, 1992). Since then, universities have spread worldwide in broadly the same form, and it has been argued that they were an important force in the Commercial Revolution through the development of legal institutions (Cantoni and Yuchtman, 2014) and the industrial revolution through their role in the building of knowledge and its dissemination (Mokyr, 2002).

While there is an extensive literature on human capital and growth, there is relatively little research on the economic impact of universities themselves. In this paper, we develop a new dataset using the World Higher Education Database (WHED) that contains the location of universities in 1,500 regions across 78 countries in the period since World War II (when consistent sub-national economic data are available). We focus on how university formation is correlated with future economic growth. Over this period university expansion accelerated in most countries; a trend partially driven by the view that higher education is essential for economic and social progress. This was in contrast to the pre-War fears of "over-education" that were prevalent in many countries, should enrolments much extend beyond the national elites (Schofer and Meyer, 2005; Goldin and Katz, 2008).

There are a number of channels through which universities may affect growth including (i) a greater supply of human capital; (ii) more innovation; (iii) support for democratic values; and

(iv) demand effects. Firstly, and most obviously, universities are producers of human capital and skilled workers are more productive than unskilled workers. Geographical distance seems to matter as areas with better university access benefit both from improving the chances that locally born young people will attend college (e.g. Card, 2001) and also because students who graduate are more likely to seek work in the area where the university is located. The empirical macro literature has generally found that at the country level, human capital (typically measured by years of schooling) is important for development and growth (e.g. Sianesi and Van Reenen, 2003). Growth accounting and development accounting relate educational attainment to economic performance and find a non-trivial contribution.[1] Explicit econometric analysis usually, although not always, confirms this positive relationship.[2]

A problem with these empirical studies is that they are at the country level and subject to the concern that there are omitted aggregate variables (e.g. Bils and Klenow, 2000; Hanusheck and Woessman, 2009). At the sub-national level, Gennaioli et al. (2013) show that *regional* years of schooling is important for *regional* GDP per capita in the cross section and Gennaioli et al. (2014) confirm this relationship also holds for growth regressions. Furthermore, human capital appears to also have an indirect effect via spillovers which are analysed *inter alia* by Moretti (2004a) at the firm level, and Moretti (2004b) and Glaeser and Lu (2018) at the individual level. In an historical setting, Squicciarini and Voigtländer (2014) show that "upper tail" knowledge was important in the industrial revolution, and they measure this type of knowledge using city level subscriptions to the Encyclopédie in mid-18th century France.

---

[1] For example, Mankiw et al. (1992), Hall and Jones (1999) and Caselli (2005).
[2] For example, Barro (1991), de La Fuente and Domenech (2006) and Cohen and Soto (2007).

A second channel through which universities may affect growth is innovation. This may be an indirect influence because, as in the previous point, universities increase educational supply.[3] But it could also be a direct influence as university researchers themselves produce innovations, sometimes in collaboration with local firms. A number of empirical papers have found that universities increase local innovative capacity.[4] A drawback of this literature is that it uses proxies for innovation such as patents rather than looking at economic output directly. Moreover, the work is also focused on single countries, somewhat limiting its generalisability.

A third way universities may matter is by fostering pro-growth institutions. Universities could promote strong institutions directly by providing a platform for democratic dialogue and sharing of ideas, through events, publications, or reports to policy makers. A more obvious channel would be that universities strengthen institutions via their role as human capital producers. The relationship between human capital, institutions and growth are much debated in the literature. Indeed, there remains controversy over whether institutions matter at all for growth.[5] Some papers have argued that human capital is the basic source of growth, and the driver of democracy and improved institutions (e.g. Glaeser et al., 2004). But the relationship between education and democracy/institutions is contested by Acemoglu et al. (2005b) who argue that the effects found

---

[3] This may be wider than just via technology, Feng and Valero (2018) and Bloom et al. (2017) also find a role for the universities in helping diffuse productivity-enhancing managerial best practices.

[4] This literature stems from Jaffe (1989) who uses US state level data to provide evidence of commercial spillovers from university research in patenting (in specific technical sectors) and R&D spending or patenting by firms. A number of papers have shown that such effects are localised (see for example, Jaffe et al. (1993), Acs et al. (1997), Fischer and Varga (2003), Belenzon and Schankerman (2013)). Andrews (2017) exploits quasi random allocation of universities to US counties over the period 1839-1954 to estimate their causal impact on patenting. Toivanen and Väänänen (2014) consider how universities affect innovation via their role as human capital producers: they use distance to a technical university as an instrument in estimating the effect of engineering education on patents in Finland (which they find to be positive and significant). Watzinger et al. (2018) show how the hiring of new science professors impacts on local private sector innovation.

[5] See, for example, Acemoglu et al. (2005a, 2014) who argue institutions matter a lot, and Gerring et al. (2005) for a summary of papers that conclude that they do not.

in the cross section of countries are not robust to including country fixed effects and exploiting within-country variation.

Finally, universities may affect growth through a more mechanical "demand" channel. Increased consumption from students and staff and the universities' purchase of local goods and services could have a material impact on GDP. This would occur when a new university attracts new students and staff into the region, or when university costs are financed though national governments from tax revenues raised mainly outside the region where the university is located.

We show that university growth has a strong association with later GDP per capita growth at the sub-national level. Even after including a host of controls (including country or region fixed effects to control for differential regional trends, and year dummies) we find that a 10% increase in the number of universities in a region is associated with about 0.4% higher GDP per capita. We show that reverse causality does not appear to be driving this, nor do demand effects. We also find that increases in universities in neighbouring regions is also correlated with a region's growth. Finally, we show that the association of per capita GDP and university presence works partially through increasing the supply of human capital and also through raising innovation, but both these channels appear to be small in magnitude. In addition, in the cross sectional analysis we find that universities appear to be correlated with more pro-democratic views even when we control for human capital, consistent with a story that they may have some role in shaping institutions over longer time horizons.

If policy-makers decided to open new universities in areas with strong economic potential, any positive correlation could simply be due to expectations of growth causing university formation rather than vice versa. Our view is that in the post-war period, university expansion was largely a policy pursued by national governments rather than simply a response to local sub-national conditions. Governments were focused on social equity (Dahrendorf, 1965), improving technological capacity (in response to the Cold War, especially the 1957 Sputnik crisis (Barr, 2014) and a general recognition of the value of human capital (Becker, 1964). This kind of "development planning" (Schofer and Meyer, 2005) stood in contrast to pre-war period views which often saw little need to extend tertiary education beyond a narrow elite.

In the Appendix we describe three country case studies of largescale university expansion which all have a substantial exogenous element to local economic conditions. Nonetheless, we attempt to address endogeneity concerns by using lagged university openings, controlling for a rich set of observables and including both unobserved regional fixed effects and regional trends in the regressions. We do not have credible external instrumental variables to rule out all possibilities of endogeneity bias. In particular, time varying unobservables at the region level cannot be controlled for in this framework. If, for example, some regional policy-makers opened new universities and also pursued other growth enhancing policies, the reported association might emerge without a causal effect of universities on growth. The strength of our analysis is in the comprehensiveness of the new data across space and time and the associations we document should be seen as suggestive rather than definitive.

To date, few papers have explicitly considered the direct link between university presence and economic performance. Cantoni and Yuchtman (2014) argue that medieval universities in 14th century Germany played a causal role in the commercial revolution (using distance from universities following the Papal Schism, an exogenous event which led to the founding of new universities in Germany). In a contemporary setting, Hausman (2017) links university innovation to economic outcomes in US counties, finding that long-run employment and pay rises in sectors closely tied with a local university's innovative strength, and that this impact increases in proximity to university. Aghion et al. (2009) consider the impact of research university activity on US states. Using political instruments, they find that exogenous increases in investments in four year college education affect growth and patenting. Kantor and Whalley (2014) estimate local agglomeration spillovers from US research university activity, using university endowment values and stock market shocks as an instrument for university research spending. They find evidence for local spillover effects to firms, which is larger for research intensive universities or firms that are "technologically closer" to universities.[6] Feng and Valero (2017) use international data to show that firms that are closer to universities have better management practices (Bloom, Sadun and Van Reenen, 2017).

This paper is organised as follows. Section 1 describes the data and some of its key features including interesting trends and correlations which give us a macro level understanding of the global rise in universities over time. Section 2 sets out our econometric strategy, and Section 3 our results. Section 4 explores the mechanisms through which universities appear to affect regional growth and finally, Section 5 provides some concluding comments.

1. DATA

Our regression analysis is based upon information on universities in some 1,500 regions in 78 countries. This represents the set of regions for which our university data can be mapped to a regional time series of key economic variables obtained from Gennaioli et al. (2014), and covers over 90 per cent of global GDP.[7] We first describe the full World Higher Education Database (WHED) across all countries, with some key global trends and correlations. Then we focus on the

[6] In related work, Kantor and Whalley (2016) find evidence of agricultural productivity effects from proximity to research in US agricultural research stations. Effects appear persistent where stations focused on basic research and farmers were already at the technology frontier.

[7] Based on World Bank GDP in 2014 (US dollars, PPP).

78 countries for which regional economic data are available, describing how we aggregate the WHED data into regions, and present some initial descriptive evidence.

1.1 World Higher Education Database

WHED is an online database published by the International Association of Universities in collaboration with UNESCO.[8] It contains information on higher education institutions that offer at least a three year or more professional diploma or a post-graduate degree. In 2010, there were 16,326 universities across 185 countries meeting this criterion. The database therefore excludes, for example, community colleges in the US and further education institutions in the UK and may be thought of as a sample of "higher quality" universities. Key variables of interest include university location, founding date, subjects and qualifications offered and other institutional details such as how they are funded.

Our regional analysis is based on that sample of countries for which GDP and other data are available from 1955, which covers 78 countries, comprising 14,868 (or 91%) of the institutions from the full listing. Our baseline results simply use the year-specific count of universities by region as a measure of university presence, always controlling for regional population. To calculate this, we first allocate each university to a region (for example, a US state), and then use the founding dates of universities in each region to determine the number of universities that were present at any particular date.[9] High rates of university exit would invalidate this type of approach, but we find that this does not appear to be an issue over the decades since the 1950s (see Data Appendix).

---

[8] For more information, see http://www.whed.net/home.php.

[9] Of the full sample of 16,326 universities, we were unable to obtain founding date information for 669 institutions (4% of the total). 609 of these fall into our core analysis sample (in the 78 countries for which regional economic data are available). These institutions are therefore omitted from analysis.

A disadvantage of the "university density" measure is that it does not correct for the size or quality of the university. Unfortunately, this type of data is not available on a consistent basis across all countries over time, but we present robustness results on a sub-sample where we do have finer grained measures of university size, and use various measures of university type as proxies for quality.

1.2 The Worldwide Diffusion of Universities

We begin by presenting some descriptive analysis of the university data at the macro level using the full university database. Figure 1 shows how the total number of universities has evolved over time; marking the years that the number doubled. The world's first university opened in 1088 (in Bologna) and growth took off in the 19th Century, growing most rapidly in the post-World War II period (see Panel A). In Panel B we normalise the number of worldwide universities by the global population to show that university density also rose sharply in the 1800s. It continued to rise in the 20th Century, albeit at a slower rate and has accelerated again after the 1980s when emerging countries like Brazil and India saw rapid expansions.

A number of additional descriptive charts are in the Appendix. The distribution of universities across countries is skewed, with seven countries (US, Brazil, Mexico, Philippines, Japan, Russia and India, in descending order) accounting for over half of the universities in the world in 2010 (the US accounts for 13% of the world's universities). We also examine the "extensive margin" – the cumulative number of countries that have any university over time with Bhutan being the latest country to open a university in 2003. By 2010, the vast majority of countries in the world had at least one university. We also provide an historical overview of the diffusion of universities from the 1880s in four advanced economies: France, Germany, the UK and US, and two emerging economies: India and China at the country level. We compare the timing of historical university expansions to growth and industrialisation. Descriptively, the data looks broadly in line with the thesis of Mokyr (2002) that the building and dissemination of knowledge played an important role in the industrialisation of many countries.

For further description of the data at the national level, we examine the cross sectional correlations of universities with key economic variables. Unsurprisingly, we find that higher university density is associated with higher GDP per capita levels. It is interesting that countries with more universities in 1960 generally had higher growth rates over the next four decades. Furthermore, there are strong correlations between universities and average years of schooling, patent applications and democracy.[10] These correlations provide a basis for us to explore further whether universities matter for GDP growth within countries, and to what extent any effect operates via human capital, innovation or institutions.

1.3 Regional Economic Data

We obtain regional economic data from Gennaioli et al. (2014) who collated key economic variables for growth regressions at the sub-national level.[11] The outcome variable we focus on is regional GDP per capita. Since for many countries, regional GDP data and other variables such as population or years of education are not available annually we follow Barro (2012) and compute average annual growth rates in GDP per capita over five year periods.[12] We also gather patents data at the regional level as a measure of innovation. For 38 countries, we obtain region-level European Patent Office (EPO) patents from the OECD REGPAT database covering 1978 to 2010.

---

[10] We use Polity scores as a measure of democracy, as is common in the literature. See for example Acemoglu et al. (2014)

[11] The availability of regional data for different countries is outlined in Gennaioli et al. (2014).

[12] We interpolate missing years, but do not extrapolate beyond the final year (or before the first year of data). Our results are robust to dropping interpolated data.

Table 1 has some descriptive statistics of our sample of 8,128 region-years. The average region has GDP per capita of just over $13,000, average growth of 2% per annum and nearly ten universities (this is quite skewed with a median of 2, so in our robustness tests, we show that our results are not sensitive to dropping region-years with no universities).[13] As we set out in the next section, our core regressions will control for the level and growth of population[14], and a number of geographic characteristics – including an indicator for whether a region contains a country's capital. Measures of regional human capital (college share and years of education) are available for sub-samples of region-years. People in the average region have an average of seven years of education with just seven percent of them having attended college.

Figure 2 shows that the raw correlations between growth rates of universities and GDP per capita that we saw at the country level are also present within countries. Panel A simply plots the average annual growth in regional GDP per capita (on the y-axis) on the average annual growth in universities (on the y-axis), over the whole time period for which data are available (which differs by region). Average GDP per capita growth rates are plotted within 20 evenly sized bins of university growth, and country fixed effects are absorbed so that variation is within country. Panel B plots GDP per capita growth rates on lagged university growth for the 8,128 region-years (on which we conduct the core of our analysis that will follow). In both graphs it is clear that there is a positive relationship.[15]

[13] A related fact is that the median growth rate of the number of universities is zero (5,856 observations). This implies that 28 per cent of the observations have an increase in the number of universities. We also checked that the results are not driven by regions that increased their number of universities from zero to one or more.

[14] It would be desirable to control for working age population, together with total population, since this is expected to affect production and growth. Unfortunately, demographic data at the regional level over time across a wide range of countries is not available, but we note that the region trends in our core regressions should control for demographic shifts.

[15] In addition, these graphs show that there are observations with very high university growth in the top bin. We explore which region-years were driving this found that they are evenly spread across 60 countries and different years, so they do not appear to be data errors. Dropping the observations in the highest growth bin actually strengthens the

2. EMPIRICAL FRAMEWORK

The underlying model we are interested in is the long-run relationship between universities and economic performance:

(1) $ln(Y/L)_{ic,t} = \alpha_1\, ln(Uni_{ic,t}) + \alpha_2 \ln(Pop_{ic,t})$

where $(Y/L)_{ic,t}$ is the level of GDP per capita ("GDPpc") for region i, in country c, and year t ; and $Uni_{ic,t}$ is the number of universities in the region[16] and Pop is the population. In the empirical application we lag the university coefficient by at least five years as there is unlikely to be immediate effect. Using the fifth lag seems natural as almost all students will have graduated in a five year period and it is standard practice to calculate growth rates in 5 year blocks (for example, Barro, 2012, Gennaioli et al. 2014). In addition, using the lag means that we eliminate the effects of a contemporaneous demand shock that raises GDP per capita and also results in the opening of new universities. Since the impact of universities could take place over a longer period of time we consider this to be a conservative approach.[17] We also look at results using longer distributed lags (which means losing more of the early years of the sample). These specifications result in larger long-run implied impacts of universities, presumably because it takes longer for human capital to build up in the area.

---

correlation in this simple scatter plot. We keep all the data in the main regressions, but show that the results are robust to dropping these observations or winsorising the top and bottom 5% observations of lagged university growth and GDP growth.

[16] We add 1 to the number of universities before taking logs so we can include region-years where there are no universities. We show robustness to other ways of dealing with the zeros such as dropping observations with no universities.

[17] For example, using cross country panel data, Dias and Tebaldi (2012) find effects of human capital growth on GDP growth with a 10 year lag; Breton and Breton (2016) show that increased average schooling takes around 40 years to translate into GDP increases; and Marconi (2018) shows that increases in secondary schooling only show up in GDP when workers are 45-64. Of course, the impact of universities does not necessarily only come from graduate supply. It may also come through university-business linkages, executive education and effects on institutions. We discuss these further below.

The cross sectional relationship is likely to be confounded by unobservable region-specific effects. To tackle this we estimate the model in long (five-year) differences to sweep out the fixed effects. Our main estimating model is therefore:

$$(2) \qquad \Delta ln(Y/L)_{ic,t} = \alpha_1 \Delta\, ln(Uni_{ic,t-5}) + \alpha_2 \Delta\, ln(Pop_{ic,t-5}) + X'_{ic,t-5}\alpha_3 + \eta_i + \tau_t + \varepsilon_{ic,t}$$

We control for a number of observables X, that may be related to GDP per capita growth and also the growth in universities including the lagged level of population, country and regional level GDP per capita (to allow for catch up) and $\varepsilon_{ic,t}$ an error term which we cluster at the region level. Finally, as well as time dummies (τ_t) we include region fixed effects (η_i) which in these difference equations allow for region-specific time trends, which is a demanding specification. We show the robustness of the results to including country by year dummies. We do not initially include any other measure of human capital and innovation in these specifications, so that we can capture the total effect that universities have on growth. However, we explore the effect of adding human capital and innovation when we try to pin down the mechanism through which universities impact on growth. Our data is from the match of the WHED and Gennaioli et al. (2014) databases which attempted to obtain university, education and GDP data from every sub-national regional in the world. Since this is where the variation in the data lives we cluster the standard errors at this regional level in our baseline results (see Abadie et al., 2017). However, to we also show show more conservative approaches, for example by clustering at the country level.

We also explore the extent to which GDP per capita growth in region *i* may be affected by growth of universities in *other* regions within the same country and discuss this econometric specification in subsection 3.4 below.

3. RESULTS

3.1 Basic Relationships

As an initial investigation, we examine the regional cross sectional correlations between universities and regional GDP per capita, based on the year 2000. Column (1) of Table 2 shows that there is a significant and positive correlation between GDP per capita and universities: controlling for population, a 10% increase in the number of universities is associated with around 6% higher GDP per capita. Column (2) includes country fixed effects which reduces the university coefficient substantially from 0.680 to 0.214. We include a host of further geographic controls in column (3) - whether the region contains a capital city, its latitude, inverse distance to ocean, malaria ecology and the log of cumulative oil and gas production.[18] This reduces the coefficient on universities still further to 0.160. In column (4) we add years of education. This reduces the coefficient on universities by around two-thirds.[19] In column (5) we repeat the column (2) specification but restrict to the sample for which patents data are available, and add years of education in column (6). Again, this reduces the coefficient on universities, by about half. In column (7), we see that adding a measure of patent "stock" reduces our coefficient on universities to 0.056, but it remains significant.

3.2 Main Results

Table 3 presents our main results on our core sample.[20] Column (1) is a simple correlation between the growth of regional GDP per capita and the lagged growth of universities with no other

---

[18] Specifically, we take the natural log of 1+ this value, so that we retain zeroes in our sample.

[19] The coefficient on years of education is highly significant and similar in magnitude to the cross section results in Gennaioli et al. (2013). In regressions of regional income per capita on years of education, controlling for geographic characteristics, Gennaioli et al. (2013) estimate a coefficient of 0.2763, see their Table IV column (2).

[20] Allowing for the lag structure, the panel covers 11 waves, from 1960 to 2010 and spans 1498 regions. The panel is unbalanced, driven by the availability of regional economic data which is better in later years. For example, in the core sample of 8,128 region years, there are only 211 observations of GDP per capita growth in 1960 (which requires regional GDP per capita in 1955 for its calculation). This sample includes advanced economies like UK, US, Germany, France and Italy, and some South American countries like Brazil and Mexico. By contrast, most regions are included in our sample in the later years (for example 1304 of the 1498 regions are observed in 2005) though economic data are not available for some countries in later years (for example data for Venezuela spans 1960-1990).

controls. The estimated coefficient is 0.047 and highly significant. To control for the fact that populous regions are more likely to require more universities, we add the lagged level of the population in column (2) which lowers the university coefficient slightly. Adding country and year fixed effects in column (3) has little effect. In column (4) we add the lagged level of regional GDP per capita (as in the convergence literature from Barro (2012) – see below), the growth in population, and several regional covariates (latitude, inverse distance to the coast, malaria ecology, and oil and gas production since 1950) and a dummy for the region with the capital city. In column (5) we control for lagged country-level GDP per capita which should capture time varying macro shocks. Columns (6) and (7) replicate columns (4) and (5) but include *regional fixed effects*, a very demanding specification which allows for regional trends. These do not much affect the university coefficient and in fact it is higher at 0.047 in the most general specification. Overall, these results suggest that on average, a 10% increase in the number of universities in a region is associated with around 0.4% higher GDP per person.[21] Our baseline results cluster at the regional level, but column (8) clusters the standard errors at the much more conservative level of the country and shows that the coefficient on universities remains significant. Finally column (9) includes a full set of country by year dummies which is a very demanding specification. Although the coefficient on universities falls by about half, it remains significant.

The other variables in the regressions take the expected signs. The coefficient on the regional convergence term is nearly 2% in columns (4) and (5).[22] Country GDP per capita has a

[21] Our analysis is carried out on a sample that drops 54 observations from China pre 1970, before and during the Cultural Revolution, when universities were shut down. Our effects survive if these observations are included, with the coefficient on university growth becoming 0.0320, still significant at the 1% level. We drop them because of the unique nature of this historical episode and the fact that this small number of observations (less than 1% of the full sample) seem to have a large effect on the coefficient.

[22] In the fixed effects specifications (7) and (8) this is larger, potentially reflecting the downward (Nickell-Hurwicz) bias in the coefficient of the lagged dependent variable which is particularly an issue in short panels (see Barro (2012) and Gennaioli et al. (2014)).

negative coefficient in these specifications. This becomes a positive relationship once regional fixed effects are included. Having a capital city in a region is associated with around one percentage point higher regional GDP per capita growth. In the Appendix, we show that the geographic controls in columns (4) and (5) generally have the expected signs.

We explore different distributed lag structures, and find that in general a single five year lag is a reasonable summary of the data, although there are smaller but significant effects at the 10 year lag, and even the 25 year lag on the full sample[23] (see Appendix). We might expect the effect of universities on regional GDP to grow over time, due to the gradual accumulation of graduates entering the workforce, or the building of regional innovative capacity. However, over longer time frames, there are more factors at play which are not captured in our estimation framework, and our sample is reduced since a longer time series of economic data is not available for all countries. Interestingly, the contemporaneous (unlagged) effect of university growth is zero or negative (although not significant), suggesting that it takes some time for benefits to be felt, while presumably some costs are incurred at the regional level. There is some evidence for stronger effects at the 10 year lag and longer lags when considering only the US, UK, France and West Germany (advanced Western economies which we might associate with the Sputnik crisis).

3.3 Robustness and Heterogeneity

Specification and Sample Checks

We conduct a large number of robustness checks on our baseline specifications with and without regional trends (i.e. columns (5) and (7) of Table 3), as detailed in the Appendix. Firstly, we do a block of *specification* checks: weighting by the region's population share; controlling for

[23] A similar pattern is found when we include each lag separately.

the current population changes (to partially address the concern that the effect of the university is simply to pull in more people to the region, who spend or produce more and hence raise GDP per capita growth – see section 4 below); and using growth in university density instead of the count. Secondly, we check *sampling* issues: dropping regions which never have a university; dropping region-years with no universities; dropping the observation when a region opens its first university; winsorising the top and bottom 5% of university growth and/or GDP per capita growth as the dependent variable and dropping observations where we have interpolated GDP per capita. A third set of *measurement* issues includes adding a dummy for regions where more than 5% of universities in the original listing have missing founding dates (and are therefore excluded from our analysis) and exploring whether the definition of university in WHED (i.e. only institutions that offer four year courses or postgraduate degrees) may be a problem. The results are robust to all these checks (and some others described in the Appendix).

Finally, to investigate the potential concern that our results are driven by expectations of growth in the region we explore "Granger Causality" tests. We use the growth in universities as the dependent variable and regress this on the lagged growth in regional GDP per capita, and the other controls. We see that even as all controls are added, the lagged growth of regional GDP per capita has no relationship with current growth in universities and does not appear to "Granger cause" the opening up of universities.[24] As another test of reverse causality, we add lagged growth

[24] Interestingly, there is a negative and significant relationship between university growth and the lagged level of universities, suggesting catch-up. Similarly there is a negative relationship between lagged years of education and university growth. There is however, a positive relationship between the growth in years of education and university growth.

in regional GDP per capita to our core specification and find that the coefficient on universities rises to 0.053 and remains significant.[25]

Heterogeneity

To examine the heterogeneity in the university coefficient we first examine whether the university effect differs by groups of countries where we have reasonable numbers of observations: (i) the US, UK, France and West Germany; (ii) the rest of Europe and Canada; (iv) Latin America; (v) Asia (including Australia) and (vi) Africa. There is a positive relationship between university growth and growth in regional GDP per capita in all areas ranging from coefficients of 0.004 to 0.116 (see Appendix), although it is not significant in some groupings. We also examined whether there is heterogeneity across time periods within these groupings. It is interesting to note that in US, France, West Germany and the UK there are significant effects in the pre-1990 period and post-1990 period. Conversely, in Asian countries, we find that there is a positive significant coefficient on university growth in the post 1990 period only.

We also test whether within a country, the university effect is driven by richer or poorer regions – the latter being consistent with catch-up growth. We find that interacting the university effect with a variable that normalises a region's GDP per capita by that country's frontier region (the region with the highest GDP per capita in that year) gives a negative and significant coefficient. It does appear therefore that new universities have a stronger impact on laggard regions within a country.

University Size and Quality

---

[25] While empirical evidence suggests that current growth is not a good predictor of future growth in the long-run (Easterly et al., 1993), there might be persistence in the short run. If this is the case, and lagged growth in universities is correlated with lagged growth in regional GDP per capita, then our results could be affected by reverse causality.

A concern with our econometric strategy is that our use of university numbers is a very imperfect measure of university presence. Universities are not homogeneous, but vary in size and quality. Clearly, both of these dimensions are likely to matter in terms of economic impact (although it is not obvious why this would necessarily generate any *upwards* bias in our estimates). An alternative measure would be to use changes in enrolments over time. Even if such data were available for all countries (which it is not) one would be particularly concerned about demand side endogeneity driving enrolments. This issue notwithstanding, we can focus on the United States where state level enrolments dating from 1970 are published by the National Center for Education Statistics (NCES).[26] We find that university numbers and total enrolments are highly correlated (around 0.9 in a given year) and that there is a strong positive relationship between the growth in universities and growth in students between 1970-2010.[27] This gives us some reassurance that the number of universities is a reasonable measure of university presence at the regional/state level.

Ideally, to measure quality we would like to have global rankings for all our institutions, carried out annually throughout our sample period.[28] However, university rankings tables only tend to cover the top few hundred institutions in the world, and tend to be available only for recent years.[29] Our data do contain some key attributes of universities which may be indicative of quality, specifically whether or not a university is a research institution (as indicated by whether or not a university can grant PhDs); whether it offers STEM (science, technology, engineering or mathematics) subjects, and whether it offers "professional service" related courses (which we

---

[26] See http://nces.ed.gov/fastfacts/display.asp?id=98.
[27] See Figure A4 in the Appendix.
[28] Some studies have considered the quality dimension within individual countries. For example, using data from the UK, Abramovsky and Simpson (2011) find that research quality affects the location of firm R&D; and Helmers and Rogers (2014) find that university quality affects the patenting of small firms. Valero (2018) also finds that universities of higher quality in the UK have a larger impact on start-up activity and productivity in nearby firms.
[29] For example, the Shanghai Rankings have been compiled since 2003 and cover the world's top 500 universities.

define as business, economics, law, accounting or finance related courses).[30] Table 4 adds these variables to the analysis by considering the effect of the growth in the share of each type of university over and above the growth in the number of all universities.[31] Panel A shows the result for the full sample of countries. Each column includes one of these measures in turn. The effects are not significantly different from zero, suggesting that on the entire sample there seems to be a general university effect which does not vary much by type of university as defined here.

Again, we disaggregate this analysis between the more advanced economies of Western Europe and the US in Panel B of Table 4 and other countries (in Panel C). Increases in the share of PhD granting institutions, STEM and professional course institutions *are* significant in Panel B but not in Panel C. When all of these shares are included together in column (5), only the share of PhD granting institutions remains significant. This analysis is suggestive evidence that the research channel may be more important in countries nearer the technology "frontier" (as in Aghion et al., 2006).

Barro Growth Regressions

Our main specifications in Table 3 included lagged regional (and country) GDP per capita, as is standard in growth regressions to capture convergence. There are of course issues of bias when including a lagged dependent variable, particularly in fixed effects regressions with a short

[30] The way we ascertain subjects offered by each university is by extracting key relevant words from the information provided in WHED. For some universities the descriptions offered can be quite broad (e.g. it may specify "social sciences" instead of listing out individual subjects). We try to keep our STEM and professional course categories broad to account for this, but there are likely to be cases where we do not pick up the accurate subject mix at a university.

[31] We note that these characteristics apply to the universities' status in 2010. In the absence of a full time series of when universities begin to offer different courses or qualifications, we simply assume that these characteristics apply since the universities were founded.

time dimension,[32] and in fact our baseline results are robust to dropping these regressors.[33] An alternative econometric approach is to consider Barro (1991, 2012) "conditional convergence" regressions. In the Appendix (Table A7) we replicate as closely as possible the results in Gennaioli et al. (2014). Column (1) has their basic specification and column (2) includes years of education. Columns (3) and (4) repeat these specifications but adds in the lagged level of universities.[34] Universities have a positive and significant coefficient over and above years of education. As we would expect if some of the effect of universities is via their production of human capital, the effect of universities is higher when years of education are omitted. Note that the interpretation of the university coefficient is different because in steady state we need to divide by the absolute value of the convergence coefficient (0.015). This implies a 10% increase in universities generates a 1.6% increase in long-run GDP per capita (= 0.1*0.00243/0.015). This is much *larger* than our baseline estimates of 0.4%. Due to the econometric difficulties of interpreting the coefficient on the lagged dependent variable in these kind of dynamic panel data models, we prefer our baseline estimates, but note that we might be under-estimating the strength of the growth- university relationship in our more conservative approach.[35] Finally, to understand better the difference between the growth and levels effects, we include also the lagged level of universities in our core regression (Table 3, column (7)). This actually raises the coefficient on lagged university growth

---

[32] See Hurwicz (1950) and Nickell (1981), and discussion in the context of growth regressions in Barro (2012).

[33] Estimating our core regression (Table 3, column (7) without lagged regional and country GDP per capita, the coefficient is 0.0434, significant at the 1% level.

[34] Column (1) follows their Table 5, column (8), omitting years of education, and column (2) includes years of education. The coefficients are very similar: the convergence term is between 1.4% and 1.8%, and the coefficient on years of education is nearly identical at around 0.004.

[35] Table A8 in the Appendix presents a similar analysis, but in long difference format. For each region the dependent variable is the average annual growth rate over a 50, 40 or 30 year time horizon to 2010. This is regressed on starting period universities and other controls. The samples differ according to availability of regional economic data over different time frames. These specifications also show positive (and significant in the case of the 50 year and 30 year differences) relationships between initial period universities and subsequent growth once country fixed effects are included.

to 0.059, still significant at the 1% level. The coefficient on the lagged level of universities is -0.005 (significant at the 5% level), so it does not appear that there is any substantive effect of the level of universities on growth.

Summary on Robustness

We have shown that our results are robust to different specification and, to the extent that the data allow, consideration of the size and quality dimensions. However, this framework does not allow us to address potential endogeneity due to time-varying unobservables. Although there is no direct way to address this without an external instrumental variable, there are non-trivial time lags between (i) an unobservable local shock and a policy decision to build a university; (ii) the decision to build and opening up of the institution and (iii) the opening of the university and the economic impact. Hence, in our view such local shocks are unlikely to be the reason we observe the relationships documented in our data.

3.4 Geographical Spillover Effects of Universities

If the effects we are finding are real we would expect to see that universities do not just affect the region in which they are located, but also neighbouring regions. To examine this we extend equation (2) to include the growth of universities in other regions, which may be the nearest region (*j*) or simply all other regions in the country (-*i*). Therefore, we include the growth in region *i*'s own universities ($\Delta lnUni_{ic,t-5}$) as well as a potential spillover effect from universities located in neighbouring regions ($\Delta lnUni_{jc,t-5}$):

$$(3) \qquad \Delta ln\left(Y/L_{ic,t}\right) = \theta_1 \Delta\, ln\left(Uni_{ic,t-5}\right) + \theta_2 \Delta ln\left(Uni_{jc,t-5}\right) + X'_{ic,t-5}\theta_3 + X'_{jc,t-5}\theta_4 + \eta_i + \tau_t + u_{ic,t}$$

The lagged population level and population growth in region *j* are in the controls, $X'_{jc,t-5}$.

We allow for spatial variation by interacting university growth with the term $dist_j$ which is the distance between region *i* and its nearest region *j* relative to the median distance to nearest region in the same country. This measure is time invariant, so the term itself in absorbed by region fixed effects. The estimating equation therefore becomes:

$$(4) \qquad \Delta ln\left(Y/L_{ic,t}\right) = \phi_1 \Delta \ln(Uni_{ic,t-5}) + \phi_2 \Delta \ln(Uni_{jc,t-5}) + \phi_3 dist_j * \Delta \ln(Uni_{jc,t-5}) + + X'_{ic,t-5}\phi_4 + X'_{jc,t-5}\phi_5 + \eta_i + \tau_t + u_{ic,t}$$

where the effect of the nearest region of median distance within a country (so the distance term equals 1) is $\phi_2 + \phi_3$. We expect ϕ_3 to be negative so that the effect of region *j* gets smaller for regions further away within a country.

Table 5 contains the spillover analysis with column (1) replicating our baseline result with column (2) including lagged university growth in the nearest region. This shows that universities in the nearest region have a positive but insignificant association with home region growth. However, on closer inspection it appears that some "nearest regions" are actually very geographically distant. A fifth of observations are in regions over 200km from the next nearest region (based on distance between centroids), so column (3) we drop these observations. In this sample the nearest region university coefficient is around half the magnitude of the home region's universities. Therefore, using the full sample again in column (4), we control for the growth in universities in the nearest region interacted with the distance to that region relative to the country's median.[36] Consistent with column (3), the interaction is negative and significant. In column (5) we add the relevant controls for the neighbouring region – the lagged population and population

[36] We take this measure relative to median to reduce the effects of outliers (for example Hawaii and Alaska in the US). However, the results are similar when we normalise by country mean.

growth (which should also control for a demand shock in the neighbouring region in the previous period). These have little effect on our coefficients or their significance.

Finally, we look at the effects of university growth in all other regions (including nearest region) in the country on our home region. Column (6) adds the lagged growth in universities in all regions of a country, excluding the home region. Column (7) also adds the relevant controls (lagged population and population growth for the other regions). These effects are now larger than our main effect and again highly significant.[37] The implication is that a 10% increase in universities in the rest of the country (which in most cases will represent a greater absolute increase than a 10% increase in home region universities) is associated with an increase in home region's GDP per capita of around 0.6 per cent.

Overall, this analysis suggests that universities not only affect the region in which they are built, but also their neighbours and that there does appear to be a spatial dimension to this, in the sense that geographically closer regions have stronger effects.

3.5 Magnitudes

Using the coefficients in Table 5 we can estimate a country-wide effect of a university expansion on the typical region in our dataset. The average region has nearly 10 universities (see Table 1), and the average country has 20 regions (and therefore 200 universities). Increasing the universities in one region by 10% (from 10 to 11) is associated with a 0.4% uplift to its GDP per capita according to our main result. For each other region, this represents a 0.5% increase in universities in the rest of the country (a rise from 190 universities to 191). Multiplied by 6% (the coefficient on other regions in column (7) of Table 5), this implies an uplift to all other regions'

---

[37] Standard errors in this analysis are clustered at the region level. Conservatively clustering at the country level does not affect significance in the nearest region analysis. The coefficients on growth in all other regions (columns (6) and (7)) remain significant at the 10% level.

GDP per capita of 0.03%. Assuming the regions in this hypothetical country are identical, the uplift to country-wide GDP per capita is simply the average of these effects: 0.05%.

As a sense check for this result, we collapse our regional dataset to the country level and run macro regressions of GDP per capita growth on lagged university growth. The coefficient on universities is 0.047 (but insignificant). According to these results, a 10% increase in universities at the country level would be associated with a 0.47% increase in GDP per capita. Therefore a 0.5% increase in universities at the country level (equivalent to our hypothetical expansion) would imply a 0.03% uplift – this is smaller (but in the same ballpark) as the 0.05% we calculate using the results from our better identified regional analysis.

While this seems like a significant amount of benefit, we also need to consider the costs of university expansion.[38] Given that the costs of building and maintaining universities will vary widely by country, we choose to focus on a particular institutional setting for this calculation. In the UK in 2010, there were 171 universities across its 10 regions. As an experiment we add one university to each region, a total increase of 10 universities (6%) at the country level. Using similar steps as in our hypothetical country above (but taking into account the actual numbers of universities in each UK region in 2010), we calculate that the overall increase to GDP per capita (or GDP, assuming population is held constant) is around 0.7%.[39] Applied to UK GDP in 2010

[38] It is unlikely that these are controlled for in our regressions: a large portion of university financing tends to be at the national level, and costs are incurred on an ongoing basis (e.g. property rental or amortisation and staff salaries are incurred every year) and so would not be fully captured by the inclusion of lagged country GDP per capita as a covariate.

[39] For each of the ten regions in the UK in turn, we calculate the log difference implied by adding one university to that region's universities, and multiply this by 0.047 (the coefficient on university growth from Table 3 column (7)). We then calculate the log difference in the count of universities in all other regions, and raise home region GDP per capita by that multiplied by 0.06 (the coefficient on university growth in "other regions" from Table 5). We abstract from the 5 year lag in this calculation. We then add up the total uplifted GDP across regions, and divide by total population (assumed unchanged).

(£1,614 billion according to the ONS[40]) this comes to just over £11 billion per year. A crude approximation of the annual costs associated with a university can be made based on university finance data: in 2009-2010 the average expenditure per institution in the UK was around £160 million.[41] Multiplying this by the 10 universities in our experiment, the implied annual cost for the additional universities is £1.6bn, or 0.1% of GDP. So, in this example the potential benefits of university expansion appear far larger than the costs (0.7% vs. 0.1%).

While this calculation is highly simplified, it shows that there is a large margin between the potential benefits of university expansion implied by our regression results and likely costs. We note that the costs of setting up universities, and methods of university finance vary by country so we cannot generalise this result to other countries, nor make statements about the optimal number of universities in particular regions. Similar calculations for other countries could be made by delving into particular institutional settings.

4. MECHANISMS

Having established a robust association of GDP per capita with universities we now turn to trying to understand the mechanisms through which universities may affect growth.

4.1 Human Capital

---

[40] Series ABMI, Gross Domestic Product: chained volume measures: Seasonally adjusted £m, Base period 2012

[41] Data on university finance, by institution, can be found at the UK Higher Education Statistical Authority (HESA) website (https://www.hesa.ac.uk/index.php?option=com_content&view=article&id=1900&Itemid=634). Total expenditure in the year 2009/10 was nearly £26 billion across 163 institutions listed in HESA, implying around £160 million per institution. University expenditure contains staff costs, other operating expenses, depreciation, interest and other finance costs. We checked if this figure has been relatively stable over time, finding that by 2013-14, average expenditure was £180 million. At this higher amount, the implied costs of our expansion rise to 0.11% of GDP. Note that the number of institutions present in 2010 was 171. The majority of institutions in WHED correspond to those listed in HESA, but there are a small number of discrepancies due to differences in the classifications of some institutes or colleges between the two listings. This does not matter for our purposes, as are simply using the HESA data to calculate the average expenditure of a typical university.

We add measures of growth in human capital to our baseline regressions to see how this influences the university coefficient. In Table 6 we consider the relationship between universities and college share. Column (1) replicates the core result from Table 3 column (7), and column (2) shows the same specfication on the reduced sample where college share is non-missing, for which the university coefficient is a bit larger at 0.08. Column (3) adds the lagged growth in college share which in itself is highly significant, and reduces the university coefficient slightly from 0.084 to 0.080. Column (4) uses contemporaneous growth in college share and column (5) adds in the lagged college share which reduces the coefficient to 0.078. This represents a reduction in the university coefficient of 8% compared with column (2). In column (6) we include also the level with both lags, with little change in the university coefficient. In column (7) we look at the raw correlation between contemporaneous growth and the lagged growth in universities (with only country fixed effects as controls), and find it to be relatively small but highly significant. Adding all the other controls dampens this relationship further and this small effect of university growth on college share is what explains the fact that adding in growth in human capital causes only a small reduction in the coefficient on universities. This analysis suggests that a 1% rise in the number of universities gives rise to around a 0.4 percentage point rise in the college share.[42]

4.2 Innovation

The best available measure of innovation output available consistently at the regional level over time is patents, although unfortunately patents with locational information are not available for our entire sample of countries and years. We consider the effects of adding the growth in

[42] Table A9 in the Appendix uses another measure of human capital: years of education, which is available for a larger sample of countries and years. The qualitative results are similar. Appendix A2.2 gives some simple simulations showing that the magnitude of effect of universities on human capital is consistent with the variation we are using in the data.

cumulative patent stocks [43] to our regressions, using patents filed at the European Patent Office which are available for over 38 of our countries between 1975 and 2010 (Table 7). Column (1) runs the core regression for the this sample of countries, and over the time period that we have patents data. Column (2) then includes the contemporaneous change in patents stock (allowing five years for the university growth to have an effect), which reduces the coefficient on university growth from 0.016 to 0.013 (a reduction of nearly 20 per cent). Patents themselves have a positive and significant association with GDP per capita growth: A 10% increase in the patent stock is associated with 0.5% higher per capita GDP. Column (3) considers the raw correlation between lagged university growth and current patent stock growth (including only year dummies), and shows it is positive but not significant. Column (4) then adds the standard controls with little effect.

This analysis provides tentative evidence that innovation is part of the story of why universities have an economic impact, though not the entire story. This may be because the effect of newer universities on patents takes a while to accumulate.

4.3 Institutions and Democracy

The use of country fixed effects throughout our analysis should rule out the possibility that the effects of universities simply reflect different (time invariant) institutions, since these tend to differ mainly at the country level. We have shown that the results survive the inclusion of country-year fixed effects in the robustness, this would capture country specific changes in institutions or changes in government. To the extent that time invariant institutions vary within countries, say at the US state level, our regional fixed effects analysis should address this.

---

[43] Patent stocks are calculated with an assumed depreciation rate of 15%. Initial patent stocks are calculated by dividing the first observed patent flow for a region by the depreciation rate plus the average growth rate in patents flow over the sample period for that region. Results are not sensitive to alternative depreciation assumptions.

Institutions do vary over time, however, and it is possible that universities contribute to this. There is a positive and significant correlation between country level democratic institutions (as proxied by Polity scores[44]) and universities. This correlation also exists when we consider the 1960-2000 change in universities and polity scores (see the online Appendix for more discussion). To our knowledge, a time series of data on regional institutions over our sample period is not available, but we can explore the relationships between perceptions of democracy, as obtained from the "World Values Survey" and lagged university presence in the cross section. Our measure is a categorical variable which gives the approval of a democratic system for governing one's own country, as this is more widely available across survey waves compared with other questions on democracy.[45] We note however, that the experience in one's own country (for example, if corruption prevents democracy operating effectively) may affect this judgement. Therefore, in the robustness we test whether results hold for a another more general survey question[46] (available for fewer survey waves). World Values Survey data begins in the 1980s and we pool data into a cross section due to insufficient observations in some region–year cells to generate reliable variation over time.

Table 8 shows the results of these regressions.[47] We start with a simple correlation between our measure of university density lagged by 15 years from the survey year, controlling for country

[44] Polity scores were sourced from the Policy IV project (http://www.systemicpeace.org/inscrdata.html), the polity2 variable is used as this is more suited for time series analysis.
[45] Specifically, the question asks respondents to say whether having a democratic political system is a (1) very good, (2) fairly good, (3) fairly bad, (4) bad way of governing their country. The scale is reversed for our estimation so that a higher score reflects higher approval.
[46] This question asks respondents if they (1) agree strongly, (2) agree, (3) disagree or (4) strongly disagree whit this statement "Democracy may have problems but is better than any other form of government". Again, the scale is reversed for our estimation so that a higher score reflects higher approval.
[47] This analysis is carried out on 58 of the 78 countries in our core sample, where World Values Survey data are available. World Values Survey data are available for Nigeria which is in our core sample, but it was not possible to map the regions to the regions used in WHED due to the fact that both sources used very aggregated but different regions.

and year fixed effects (column (1)).[48] This shows that there is a highly significant association between university presence in a region and approval of a democratic system. The relationship is robust to including a host of individual demographic characteristics (column (2)) and education (column (3)). The result that one's own education is positively related to approval of democracy is consistent with Chong and Gradstein (2009). But the result that local universities matter over and above an individual's education suggests that they may be a mechanism whereby democratic ideals spillover from those who have had direct contact with universities, or there is some kind of direct diffusion of ideas from universities into their surrounding regions.[49] Column (4) adds our standard geographic controls. While data constraints mean it is not possible to account for any potential impact of this type of mechanism on growth, this analysis suggests that institutions could be part of the story, albeit on a longer term basis.

4.4 Demand

Could our results simply be driven by a mechanical impact of universities on regional GDP? Students and staff in a university consume more goods and services. Including changes in population in our regressions (lagged, and contemporaneous) should have largely controlled for the possibility that universities simply contribute to growth through a mechanical demand channel associated with people coming into the region. Moreover, showing that our university coefficient remains significant after including changes in human capital (see Table 6) should also address the concern that the effects are simply driven by higher earners entering the region.

[48] We explored different lag structures, and found that it takes time for universities to affect perceptions (see column (3) in Table A10 which shows a smaller positive, but insignificant effect of five year lagged university density on democratic approval). By contrast, on the full sample of countries there appear to be no effects for longer lags. When we consider the sub-sample of OECD countries where the results are stronger we see that the effects are similar in magnitude and significance for the 30 year lag.

[49] Further supporting this, we find that the result survives dropping students and graduates from the regression entirely (see Table A10 for more robustness tests and further discussion).

To the extent that university finance comes from inside the same region, there should be no mechanical demand effect as this should already be netted off. For example, in the US, states have historically provided more assistance to tertiary institutions and students: 65 per cent more on average than the federal government over the period 1987 to 2012, though now the share is more equal.[50] But if university finance comes from outside the region this could also result in higher GDP per capita as the university purchases goods and services within the region (including paying salaries to staff and support services).

We think it unlikely that the regressions are merely capturing this type of effect. The initial shock to region GDP associated with the new university is likely to occur in the year it is founded (when transfers begin, and include capital and set up costs), and the level effect should be captured by lagged regional GDP which we control for in the regressions. Ongoing transfers may rise incrementally over the years as the university increases its size and scope, but we might expect the largest effect on growth would be in the initial years rather than in the subsequent five year period. Furthermore, the evidence of university spillovers from other regions (Table 5) also suggests demand is not the main mechanism.

Notwithstanding these arguments, we carry out a simple calculation to show that even under very generous assumptions, direct effects are unlikely to explain a large portion of our results. We use the hypothetical experiment of a new university of 8,500 students and 850 staff opening in the average region of our dataset. We estimate the effects of the transfer into the region

[50] This difference has narrowed in recent years as state spending declined since the financial crisis, and federal investments grew sharply. Today the total expenditure is similar, though spending categories differ: state funding focuses more on general running expenditure and federal funding on research and student grants. For detail, see an analysis of federal and state funding of higher education in the US by Pew Charitable Trusts, http://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2015/06/federal-and-state-funding-of-higher-education

assuming that all the costs of our new university are met from sources outside the region, and that these are spent within the region. We assume that the average cost per student is $10,000, and therefore the cost for a university of 8,500 students is $85 million. With a university of constant size, building up year-group enrolments over four years, there would be no effect in the following five year period. If we assume total enrolments grow by 5% per year, we can explain around 15% of the regression coefficient on universities.[51]

4.5 Summary on Mechanisms

In summary, it appears some of the effects of university growth on GDP growth work via human capital and innovation channels, though the effects of these are small in magnitude. In addition, universities may affect views on democracy but this appears to be on a longer term basis. We have shown that the university coefficient is not merely driven by demand effects.

5. CONCLUSIONS

This paper presents a new dataset on universities in nearly 1,500 regions in 78 countries since 1950. We have found robust evidence that increases in university presence are positively associated with faster subsequent economic growth. A 10% increase in the number of universities is associated with over 0.4% higher GDP per capita in a region. This is even after controlling for regional fixed effects, regional trends and a host of other confounding influences. The benefit of universities does not appear to be confined to the region where they are built but spills over to neighbouring regions, having the strongest effects on those that are geographically closest. Using these results, we estimate that the economic benefits of university expansion are likely to exceed their costs.

[51] For further detail, see Appendix A2.2.

Our estimates use sub-national time series variation and imply smaller effects of universities on GDP than would be suggested from cross sectional relationships. But we believe our effects underestimate the long-run effect of universities through building the stock of human and intellectual capital which are hard to fully tease out using the panel data available to us. We reiterate that the coefficients on universities are conditional correlations as we do not have compelling instrumental variables to establish causality. Nevertheless, in our view the empirical evidence here does suggest some effect of universities on growth.

Understanding the mechanisms through which the university effects works is an important area to investigate further. We find a role for innovation and human capital supply although these appear to be small in magnitude, and show that the university effects do not appear to be driven by demand or transfers into a region. Better data on the flow of business-university linkages, movements of personnel and other collaborations would help in unravelling the underlying mechanisms. In addition, focusing on the relationships between universities and local economic performance in individual countries where better causal designs and richer university data is available would be a valuable extension.

We provide suggestive evidence that universities play a role in promoting democracy, and that this operates over and above their effect as human capital producers. Exploring the extent to which this may account for part of the growth effect is another important area for future research.

REFERENCES

Abadie, A., S. Athey, G. Imbens and J. Wooldridge (2017) "When Should You Adjust Standard Errors for Clustering?" MIT mimeo

Abramovsky, L. and Simpson, H. (2011), 'Geographic proximity and firm–university innovation linkages: evidence from Great Britain', Journal of Economic Geography 11 (2011) pp. 949–977

Acemoglu, D., Johnson, S. and Robinson, J.A. (2005a). 'Institutions as a Fundamental Cause of Development', in (P. Aghion and S, Durlauf eds.) *Handbook of Economic Growth*, Amsterdam; North-Holland.

Acemoglu, D., Johnson, S., Robinson, J.A., and Yared, P. (2005b). 'From education to democracy?', *American Economic Review*, 95(2) 44-49.

Acemoglu, D., Naidu, S., Restrepo, P. and Robinson, J.A. (2014). 'Democracy does cause growth', NBER Working Paper No 20004

Aghion, P., Boustan, L., Hoxby, C. and Vandenbussche, J. (2009). 'The Causal Impact of Education on Economic Growth: Evidence from U.S.', Harvard University working paper

Aghion, P., Meghir, C. and Vandenbussche, J. (2006). 'Growth, Distance to Frontier and Composition of Human Capital', *Journal of Economic Growth*, 11(2): 97-127

Andrews, S.. 2017. "The Role of Universities in Local Invention: Evidence from the Establishment of U.S. Colleges." Job Market Paper.

Anselin L., A. Varga and Z. Acs (1997) "Local geographic spillovers between university research and high technology innovations," *Journal of Urban Economics*, 42.

Bairoch, P. (1982), 'International industrialisation levels from 1750 to 1980', *The Journal of European History*, 2, pp. 269-333.

Baldwin, R. (2012). 'Global Supply Chains: Why they emerged, why they matter, and where are they going?', CEPR Discussion Paper No.9103

Barr, N. (2014). 'Shaping higher education, 50 years after Robbins', LSE

Barro, R.J. (1991). 'Economic Growth in a Cross Section of Countries', *Quarterly Journal of Economics*, Vol. 106, No. 2, pp. 407-443.

Barro, R.J. (1999). 'Determinants of democracy', *Journal of Political Economy*, 107, 158–183.

Barro, R.J. (2012). 'Convergence and Modernization Revisited', NBER Working Paper No. 18295.

Becker, G.S., (1964). 'Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education,' University of Illinois

Belenzon, S. and Schankerman, M. (2013). 'Spreading the word: geography, policy and knowledge spillovers', *Review of Economics and Statistics*, 95 (3). pp. 884-903.

Beloff, M. (1968). 'The Plate Glass Universities', *Martin Secker and Warburg Limited*

Bils, M. and Klenow, P. (2000). 'Does Schooling Cause Growth?', *American Economic Review*, 90, 1160-1183

Bloom, N., Sadun, R. and Van Reenen, J. (2017). 'Management as a Technology', Centre for Economic Performance Discussion Paper 1433

Bloom, N., Lemos, R., Sadun, R. and Van Reenen, J. (2017) "Healthy Business? Managerial Education and Management in Healthcare" Centre for Economic Performance Discussion Paper 1500

Breton, Theodore R., and Breton, Andrew S., 2016, "Education and Growth: Where All the Education Went," SSRN working paper

Cantoni, D. and Yuchtman, N. (2014). ‘Medieval universities, legal institutions, and the Commercial Revolution’, *The Quarterly Journal of Economics*, 823–887.
Card, D. (2001). ‘Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems’, *Econometrica*, 69(5), 1127-60
Caselli, F. (2005). ‘Accounting for Cross-Country Income Differences’, in (P. Aghion and S. Durlauf eds.) *Handbook of Economic Growth I*, 1(9) 679-741 Amsterdam: Elsevier.
Chong, A., and Gradstein, M. (2009). ‘Education and Democratic Preferences’, Inter-American Development Bank, Research Department Working Papers; 684
Cohen, D. and Soto, M. (2007). ‘Growth and Human Capital: Good Data, Good Results’, *Journal of Economics Growth*, 12(1) 51–76.
Dahrendorf, R. (1965). *Bildung ist Bürgerrecht:* Nannen Verlag
de La Fuente, A., and Domenech, R. (2006). ‘Human Capital in Growth Regressions: How Much Difference Does Data Quality Make?’, *Journal of the European Economics Association*, 4(1) 1–36.
De Ridder-Symoens, H. and Rüegg, W. (1992). *A History of the University in Europe*, Cambridge University Press, 16 Oct 2003
Dias, J. and E. Tebaldi (2012) “Institutions, human capital, and growth: The institutional mechanism,” *Structural change and Economic Dynamics*, v23, 300-312
Easterly, W., M. Kremer, L. Pritchett and L. Summers (1993): “Good Policy or Good Luck: Country Growth Performance and Temporary Shocks.” *Journal of Monetary Economics*, 32(3), 459-83
Feng, A. and Valero, A. (2017). ‘Skill biased management: Evidence from Manufacturing firms’, *Mimeo*
Fischer, M. and A. Varga (2003), “Spatial knowledge spillovers and university research: evidence from Austria,” *Annals of Regional Science*, 37, 303-22
Gennaioli, N., La Porta, R., Lopez de Silanes, F. and Shleifer, A. (2014). ‘Growth in Regions’, *Journal of Economic Growth*, 19:259-309
Gennaioli, N., La Porta, R., Lopez de Silanes, F. and Shleifer, A. (2013). ‘Human Capital and Regional Development’, *Quarterly Journal of Economics*, 128(1) 105-164
Gerring, J., Bond, P., Barndt, W. and Moreno, C. (2005). ‘Democracy and Growth: A Historical Perspective’, *World Politics*, 57 (3), 323-64
Glaeser, E.L., LaPorta, R., Lopez-de-Silanes, F., and Shleifer, A. (2004). ‘Do institutions cause growth?’, *Journal of Economic Growth*, 9, 271–303.
Glaeser, E.L., and Lu, M. (2018). Human-Capital Externalities in China, NBER Working Paper No.24925, August 2018
Goldin, C. and Katz, L. (2008). *The Race between Education and Technology*, Harvard: Harvard University Press
Hall, R.E. and Jones, C.I. (1999). ‘Why Do Some Countries Produce so Much More Output per Worker than Others?’, *Quarterly Journal of Economics*, CXIV, 83-116.
Hanushek, E.A. and Woessmann, L. (2009). ‘Do Better Schools Lead to More Growth? Cognitive Skills, Economic Outcomes, and Causation’, NBER Working Paper No. 14633
Hausman, N., (2012). ‘University Innovation, Local Economic Growth, and Entrepreneurship’, US Census Bureau Centre for Economic Studies Paper No. CES-WP- 12-10.
Helmers, C. and Rogers, M. (2015), ‘The impact of university research on corporate patenting: evidence from UK universities’, *Journal of Technology Transfer*, 40:1–24

Hurwicz, L. (1950). 'Least-Squares Bias in Time Series', in Tjalling C. Koopmans, ed., *Statistical Inference in Dynamic Economic Models*, Wiley, New York.

Jaffe, A.B. (1989). 'Real Effects of Academic Research', *American Economic Review*, 79(5), 957-70.

Jaffe, A.B., Trajtenberg, M. and Henderson, R. (1993). 'Geographic Localization of Knowledge Spillovers As Evidenced By Patent Citations', *Quarterly Journal of Economics* 108, 577-98.

Jäeger, S. (2013). 'Labour market returns to higher education, Evidence from University Openings in Germany', MIT Mimeo

Kantor, S. and Whalley, A. (2014). 'Knowledge spillovers from research universities: evidence from endowment value shocks', *Review of Economics and Statistics*, 96 (1) 171 – 188.

Kantor, S. and Whalley, A. (2016). 'Research Proximity and Productivity: Long-Term Evidence from Agriculture', *Mimeo*.

Mankiw, N.G., Romer, D. and Weil, D.N. (1992). 'A Contribution to the Empirics of Economic Growth', *The Quarterly Journal of Economics*, 107 (2) 407-437.

Marconi, Gabriele, 2018, "Education as a Long-Term Investment: The Decisive Role of Age in the Education-Growth Relationship," *Kyklos*, v71, n1, 132-161

Mokyr, J. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*, Princeton University Press

Moretti, E., (2004a), "Worker's Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions," *American Economic Review*, 94, nº3, 656-690.

Moretti, E., (2004b). 'Estimating the social return to higher education: evidence from longitudinal and repeated cross-sectional data', *Journal of Econometrics*, 121(1-2), 175-212

Nickell, S. (1981). 'Biases in Dynamic Models with Fixed Effects', *Econometrica*, 49 (5): 1417-1426.

Robbins, L. (1963). 'Higher Education', Report of the Committee appointed by the Prime Minister under the Chairmanship of Lord Robbins, London: HMSO

Rüegg, W. (2010). *A History of the University in Europe: Volume 4, Universities since 1945*, Cambridge University Press

Schofer, E. and Meyer, J.W. (2005). 'The Worldwide Expansion of Higher Education in the Twentieth Century', *American Sociological Review*, 70(6) 898-920

Shattock, M. (2012). 'Making Policy in British Higher Education 1945–2011', Maidenhead: McGraw-Hill and Open University Press

Sianesi, B. and Van Reenen, J. (2003) "Education and Economic Growth: A review of the literature" *Journal of Economic Surveys*, 17(2), 157-200

Squicciarini, M. and Voigtländer, N. (2014). 'Human Capital and Industrialization: Evidence from the Age of Enlightenment', NBER Working Paper No. 20219

Toivanen, O. and Väänänen, L. (2016). 'Education and Invention', *The Review of Economics and Statistics*, 98(2): 382–396

Valero, A. (2018). 'The Local Economic Impact of Universities: Evidence from UK Firms', *mimeo*

Watzinger, M., Treber, L. and Schnitzer, M.. (2018). 'Universities and Science-Based Innovation in the Private Sector', *mimeo*

Table 1: DESCRIPTIVE STATISTICS

	Mean	S.D	Min	p50	Max	Obs
Regional GDP per capita	13,055.75	11,958.30	262.15	8,463.02	105,648.25	8,128
Growth in regional GDP per capita	0.02	0.03	-0.20	0.02	0.30	8,128
Country GDP per capita	14,094.16	11,525.30	690.66	9,157.66	64,198.29	8,128
# universities	9.60	23.71	0	2.00	461.00	8,128
Growth in # universities	0.02	0.03	0	0.0	0.28	8,128
Population (millions)	2.78	7.97	0.01	1.01	196.00	8,128
Growth in population	0.01	0.02	-0.14	0.01	0.25	8,128
Latitude	27.74	25.65	-54.33	37.75	69.95	8,128
Inverse distance to ocean	0.03	0.07	0	0.01	1.89	8,128
Malaria index	0.89	2.31	0	0.01	25.51	8,128
log(oil and gas production) 1950-2010	1.72	2.86	0	0.00	12.05	8,128
Dummy for capital in region	0.05	0.22	0	0	1.00	8,128
Distance to nearest region ('000km)	0.14	0.19	0.01	0.08	2.79	8,128
College share	0.07	0.07	0.00	0.04	0.45	5,744
Years of education	7.37	3.08	0.39	7.42	13.76	6,640

Notes. Each observation is region-year. *Source: WHED and Gennaioli et al. (2014) for regional economic data.*

Table 2: CROSS-SECTIONAL REGRESSIONS

Dependent variable: Regional GDP per capita	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln(# universities)	0.680***	0.214***	0.160***	0.056***	0.164***	0.074**	0.056**
	(0.124)	(0.042)	(0.039)	(0.021)	(0.048)	(0.031)	(0.022)
ln(population)	-0.468***	-0.105**	-0.112***	-0.069***	-0.100**	-0.054*	-0.123***
	(0.100)	(0.041)	(0.033)	(0.023)	(0.041)	(0.027)	(0.032)
Years of Education				0.292***		0.283***	0.237***
				(0.028)		(0.034)	(0.040)
ln(EPO Patent "stock")							0.081***
							(0.018)
Observations	1213	1213	1182	1182	619	619	619
# clusters	65	65	62	62	34	34	34
country dummies	no	yes	yes	yes	yes	yes	yes
region controls	no	no	yes	yes	yes	yes	yes

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. OLS estimates based on data in 2000. Standard errors clustered at the country level. Column (1) shows the relationship between universities and the natural log of GDP per capita, controlling for population. Column (2) includes country dummies. Column (3) includes regional controls (a dummy indicating whether the region contains a capital city, together with latitude, inverse distance to ocean, malaria ecology, log(oil and gas production) 1950-2010, these are not reported here). Column (4) includes years of education. Column (5) is the same specification as column (3) but restricts the sample to the regions for which OECD REGPAT patents are available. Column (6) includes years of education, and column (7) includes the natural log of the regional patent “stock”. We add one to the number of universities and to patents before taking logs.

Table 3: BASELINE RESULTS

Dependent variable: Regional Growth of GDP per capita	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Lagged growth in #universities	0.047***	0.036***	0.040***	0.046***	0.044***	0.045***	0.047***	0.047***	0.023**
	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)	(0.011)	(0.011)	(0.016)	(0.010)
Lagged level of regional GDP per capita				-0.015***	-0.013***	-0.058***	-0.078***	-0.078***	-0.077***
				(0.001)	(0.001)	(0.003)	(0.005)	(0.007)	(0.005)
Lagged level of country GDP per capita					-0.021***		0.038***	0.038**	
					(0.004)		(0.006)	(0.018)	
Lagged level of population /100		0.178***	-0.030	-0.076*	-0.086**	-1.095***	-0.850**	-0.850	-1.724***
		(0.032)	(0.035)	(0.040)	(0.039)	(0.333)	(0.352)	(0.720)	(0.476)
Lagged growth in population				-0.099**	-0.113***	-0.209***	-0.183***	-0.183***	-0.182***
				(0.038)	(0.039)	(0.045)	(0.045)	(0.068)	(0.050)
Dummy for capital in region				0.012***	0.011***				
				(0.002)	(0.002)				
Observations	8128	8128	8128	8128	8128	8128	8128	8128	8128
# clusters	1498	1498	1498	1498	1498	1498	1498	78	1498
clustering	Region	Region	Region	Region	Region	Region	Region	Country	Region
year dummies	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
country dummies	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
region controls	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
region trends	No	No	No	No	No	Yes	Yes	Yes	Yes
country by year dummies	No	No	No	No	No	No	No	No	Yes

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. OLS estimates, 78 countries. Column (1) is a simple correlation between regional GDP per capita growth and the lagged growth in university numbers. Column (2) controls for the lagged log of population. Column (3) includes country and year dummies. Column (4) controls for lagged regional GDP per capita, the lagged growth in population, the lagged log population level, a dummy for whether the region contains a capital city, together with latitude, inverse distance to ocean, malaria ecology, log(oil and gas production) 1950-2010 (not reported here). Column (5) adds lagged country GDP per capita. Column (6) includes regional fixed effects, and the time varying controls of column (4). Column (7) adds lagged country GDP per capita. Standard errors are clustered at the regional level except in column (8) where they are clustered at the country level. Levels of GDP per capita and population are in natural logs.

Table 4: DIFFERENCES IN UNIVERSITY QUALITY

Dependent variable: Regional Growth of GDP per capita	(1)	(2)	(3)	(4)	(5)
Panel A: Full sample					
Lagged growth in #universities	0.047***	0.051***	0.042***	0.050***	0.046***
	(0.011)	(0.012)	(0.013)	(0.013)	(0.014)
Lagged growth in PhD share		-0.003			-0.004
		(0.003)			(0.004)
Lagged growth in STEM share			0.002		0.005
			(0.003)		(0.003)
Lagged growth in professional share				-0.001	-0.002
				(0.003)	(0.004)
Observations	8128	8128	8128	8128	8128
Panel B: US, UK, FR, DE					
Lagged growth in #universities	0.051***	0.017	0.018	0.031*	0.014
	(0.016)	(0.016)	(0.018)	(0.017)	(0.017)
Lagged growth in PhD share		0.017***			0.015**
		(0.004)			(0.006)
Lagged growth in STEM share			0.015***		0.004
			(0.004)		(0.004)
Lagged growth in professional share				0.010**	-0.000
				(0.005)	(0.007)
Observations	1023	1023	1023	1023	1023
Panel C: All other countries					
Lagged growth in #universities	0.048***	0.054***	0.044***	0.052***	0.049***
	(0.011)	(0.013)	(0.013)	(0.014)	(0.015)
Lagged growth in PhD share		-0.004			-0.005
		(0.003)			(0.004)
Lagged growth in STEM share			0.002		0.005
			(0.003)		(0.003)
Lagged growth in professional share				-0.001	-0.002
				(0.003)	(0.004)
Observations	7105	7105	7105	7105	7105

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Panel A includes the full sample of countries, and Panel B restricts to the US, UK, France and West Germany. Within each panel, our core regression (Column (7) from Table 3) is replicated in column (1). Then in columns (2) to (4), the lagged growth of the shares of universities of different types are added as labelled.

Table 5: UNIVERSITY SPILLOVERS FROM OTHER REGIONS

Dependent variable: Regional Growth of GDP per capita	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lagged growth in #universities	0.047***	0.044***	0.044***	0.044***	0.044***	0.035***	0.037***
	(0.011)	(0.011)	(0.012)	(0.011)	(0.011)	(0.011)	(0.011)
Lagged growth in #universities, nearest region		0.012	0.022**	0.049***	0.049***		
		(0.011)	(0.011)	(0.017)	(0.017)		
Lagged growth in #universities X (dist near region/median dist near region in country)				-0.033***	-0.033***		
				(0.012)	(0.012)		
Lagged growth in #universities in other regions within country						0.059***	0.061***
						(0.013)	(0.013)
Observations	8128	8128	6544	8128	8128	8128	8128
# clusters	1498	1498	1257	1498	1498	1498	1498
Nearest / other region controls	No	No	No	No	Yes	No	Yes

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) replicates our core regression (column (7) from Table 3). Column (2) adds in the lagged growth in universities in the nearest region. Column (3) replicates column (2) but conditions the sample to regions whose nearest region is less than 200km away. Column (4) returns to the full sample, but adds an interaction term of universities with the ratio of the distance to nearest region to the median distance to nearest region in the country. Column (5) adds controls from the nearby region: namely the lagged population and population growth (not reported here). There were a small number of observations where the population in the nearest region was missing, relating to early years in the sample period. In this case, population was extrapolated back in time, using a log-linear trend, and a dummy variable included to indicate this. Column (6) includes the lagged growth in universities in all other regions of the country, and column (7) also adds the relevant controls from all other regions in the country: namely the lagged population and population growth (again with a dummy to indicate where the population in the rest of the country has been calculated with missing values for any regions that year).

Table 6: UNIVERSITIES AND SHARE OF EDUCATED WORKERS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ % college	Δ % college
Lagged growth in #universities	0.047***	0.084***	0.080***	0.081***	0.078***	0.078***	0.005***	0.004***
	(0.011)	(0.014)	(0.013)	(0.013)	(0.013)	(0.013)	(0.001)	(0.001)
Lagged growth in college share			2.237***		2.077***	2.075***		
			(0.362)		(0.323)	(0.326)		
Current growth in college share				0.847***	0.721***	0.722***		
				(0.148)	(0.130)	(0.132)		
Lagged level of college share						0.001		
						(0.023)		
Lagged level of regional GDP per capita	-0.078***	-0.093***	-0.094***	-0.093***	-0.094***	-0.094***		0.000
	(0.005)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)		(0.000)
Lagged level of country GDP per capita	0.038***	0.025***	0.027***	0.026***	0.028***	0.028***		-0.001***
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)		(0.000)
Lagged level of population/100	-0.850**	-2.136***	-2.226***	-2.289***	-2.350***	-2.348***		0.181***
	(0.352)	(0.452)	(0.451)	(0.456)	(0.456)	(0.457)		(0.038)
Lagged growth in population	-0.183***	-0.064	-0.065	-0.066	-0.066	-0.066		0.002
	(0.045)	(0.052)	(0.054)	(0.053)	(0.055)	(0.055)		(0.003)
Observations	8128	5118	5118	5118	5118	5118	5118	5118
# clusters	1498	1089	1089	1089	1089	1089	1089	1089

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Growth in college share is simply the percentage point difference: (college share (t) – college share (t-5))/5. Column (1) replicates Column (7) from Table 3. Column (2) restricts to the sample for which the change in college share is available. Column (3) drops the lagged growth in college share. Column (4) adds the contemporaneous change in college share. Column (5) includes both lagged and contemporaneous changes. Column (6) further adds the lagged level of college share (unlogged). Column (7) regresses the change in college share on the lagged growth in universities, with country dummies, but no other controls. Column (8) adds all the other controls.

Table 7: UNIVERSITIES AND INNOVATION

	(1)	(2)	(3)	(4)
Dependent Variable	Δ GDPpc	Δ GDPpc	Δ patents	Δ patents
Lagged growth in #universities	0.016	0.013	0.030	0.031
	(0.014)	(0.014)	(0.055)	(0.055)
Growth in EPO patent "stock"		0.054***		
		(0.006)		
Lagged level of regional GDP per capita	-0.096***	-0.096***		
	(0.007)	(0.007)		
Lagged level of country GDP per capita	0.073***	0.069***		
	(0.008)	(0.008)		
Lagged level of population/100	2.604***	2.151***		7.709***
	(0.766)	(0.740)		(2.271)
Lagged growth in population	-0.201***	-0.177***		-0.499***
	(0.061)	(0.059)		(0.158)
Observations	3559	3559	3559	3559
# clusters	757	757	757	757

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. The sample contains the countries for which regionalised EPO patents are available in OECD REGPAT (1978-2010). Column (1) replicates our core regression (column (7) from Table 3), but restricts to the relevant sample for patents data. Column (2) adds in the contemporaneous growth in cumulative patent "stock" to the regression. Column (3) regresses the growth in patent stock on the growth in universities as a raw correlation, with no other controls. Column (4) then adds the standard time varying controls (reported) and geographic controls (not reported).

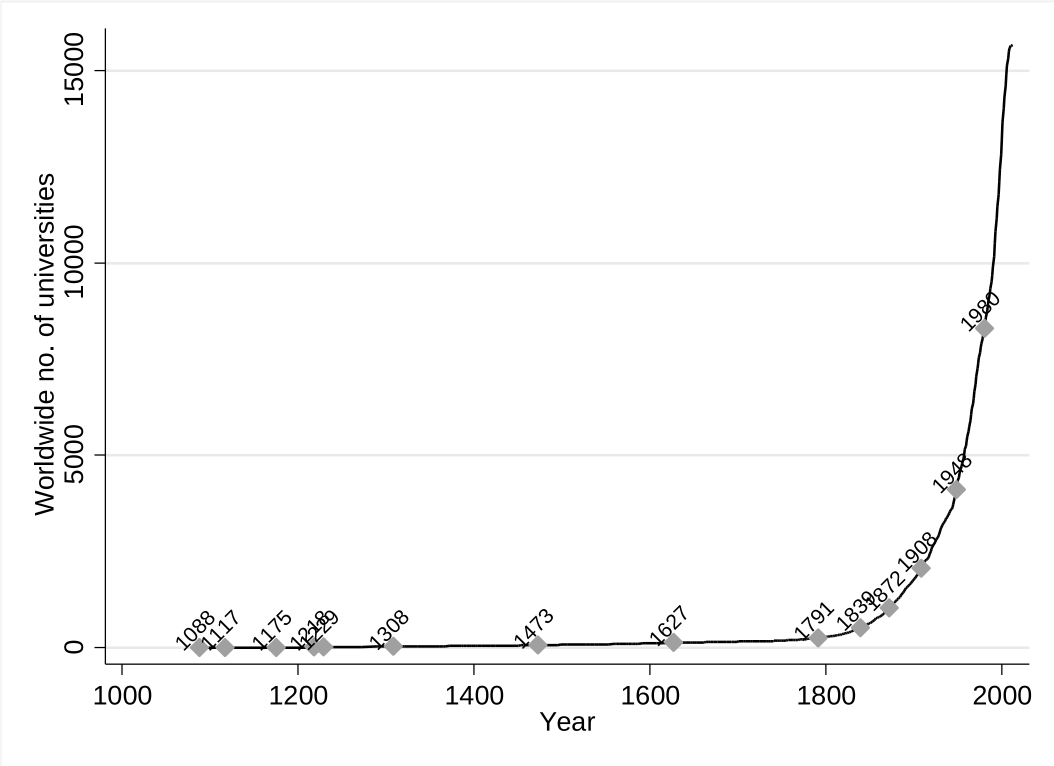
Table 8: UNIVERSITIES AND APPROVAL OF DEMOCRACY

Dependent variable: Approval of Democracy	(1)	(2)	(3)	(4)
15 year lagged ln(1+#universities per capita)	0.029***	0.026***	0.023**	0.023**
	(0.009)	(0.010)	(0.009)	(0.010)
Dummy for Male		0.038***	0.034***	0.034***
		(0.005)	(0.005)	(0.005)
Age (years)		0.002***	0.002***	0.002***
		(0.000)	(0.000)	(0.000)
Dummy for married		-0.001	-0.004***	-0.004***
		(0.001)	(0.001)	(0.001)
Children		-0.007***	-0.003*	-0.003*
		(0.002)	(0.002)	(0.002)
Employed (full, part time, self-employed)		0.017***	0.024***	0.024***
		(0.006)	(0.006)	(0.006)
Income scale		0.012***	0.005	0.006*
		(0.003)	(0.003)	(0.003)
Dummy for holds university degree			0.135***	0.135***
			(0.008)	(0.008)
Dummy for student			0.085***	0.086***
			(0.012)	(0.012)
Observations	138511	138511	138511	138511
Adjusted R-squared	0.075	0.079	0.085	0.085
# clusters	693	693	693	693
Country and year dummies	yes	yes	yes	yes
Geographic controls	no	no	no	yes

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. OLS estimates, 54 countries. Standard errors are clustered at the regional level. Region controls include latitude, inverse distance to ocean, malaria ecology, ln(oil and gas production) 1950-2010 and a dummy for if a region contains the country's capital city.

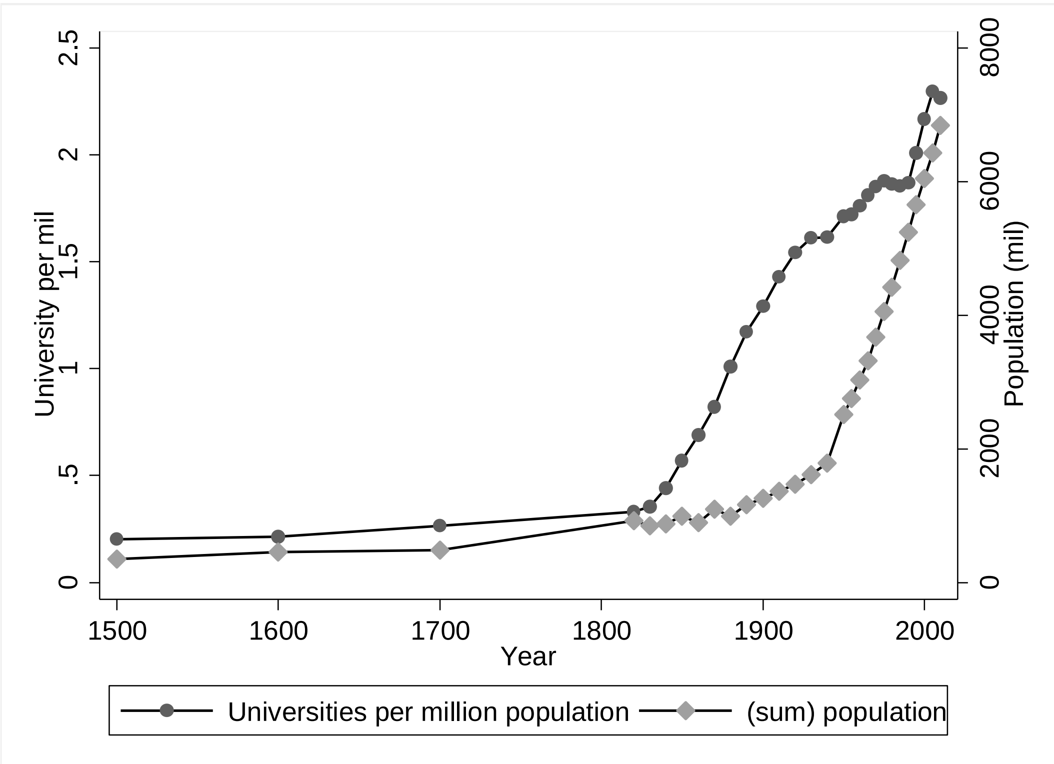
Figure 1: WORLDWIDE UNIVERSITIES OVER TIME

Panel A: University Count



Notes. The evolution of global universities over time; years where the total number doubled are marked. *Source: WHED.*

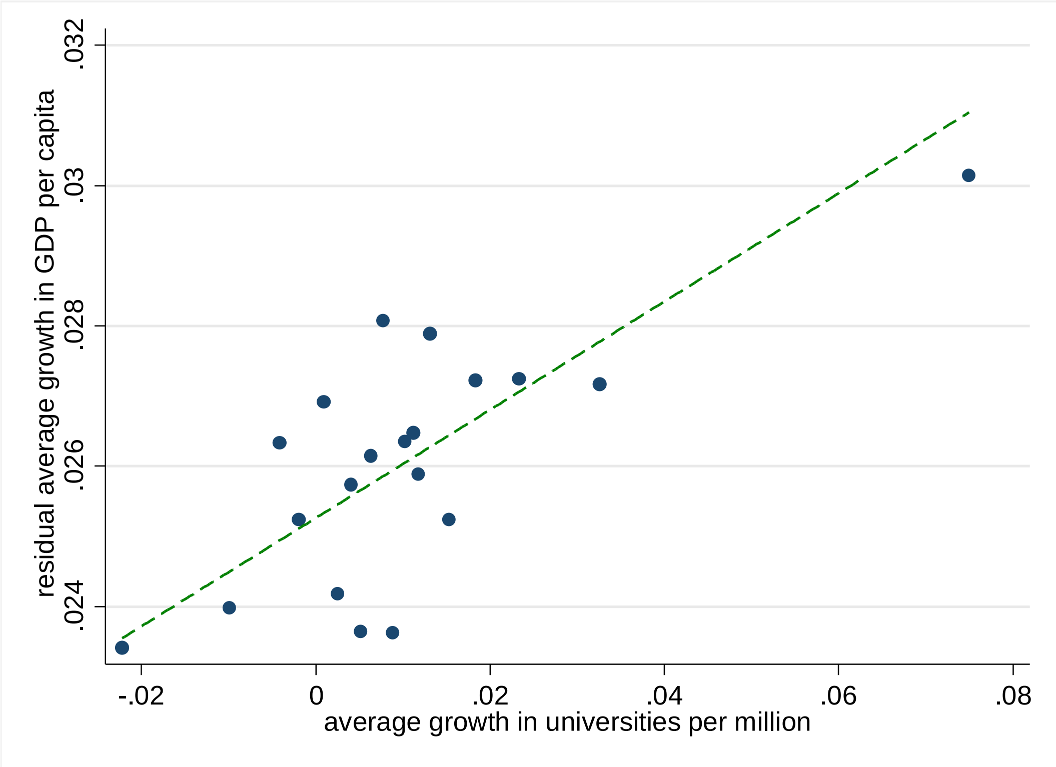
Panel B: University Density and Population



Notes. This chart shows the evolution of global university density (universities per million people) and population over time. *Source: WHED and Maddison population data.*

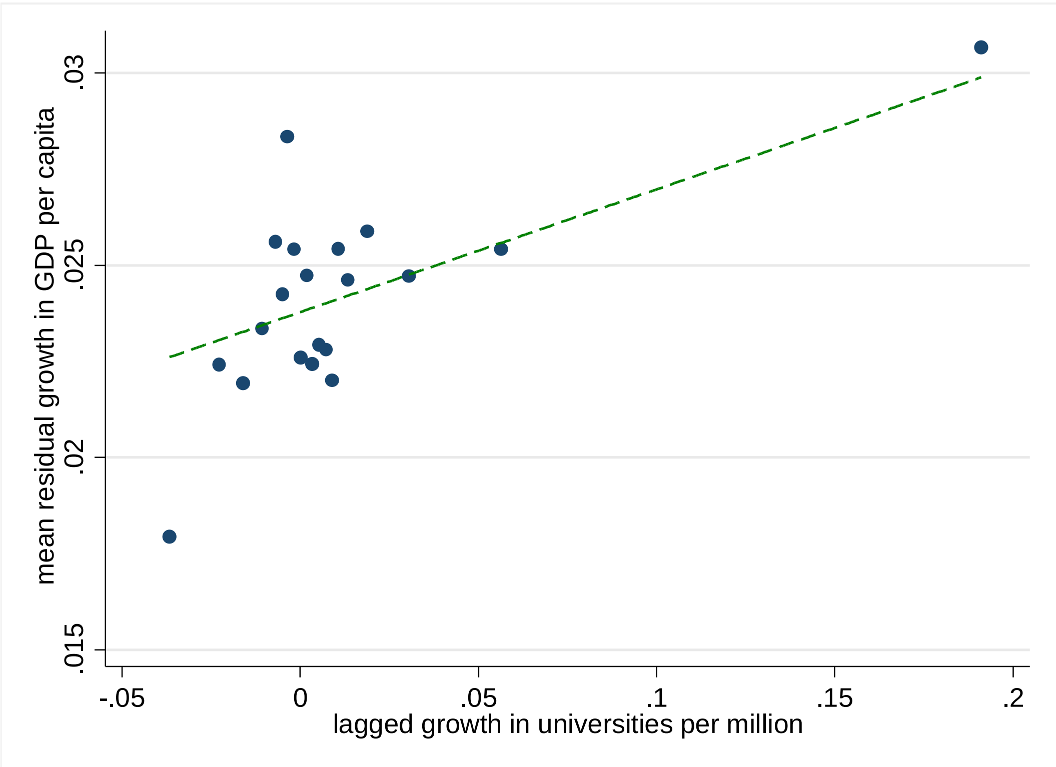
Figure 2: REGIONAL GDP PER CAPITA GROWTH AND UNIVERSITY GROWTH

Panel A: Average growth rates, one observation per region



Notes. 1,498 region observations are grouped equally into 20 bins, variation is within country. *Source:* WHED and Gennaioli et al. (2014) for regional GDP per capita and population

Panel B: Average growth rates, region-year observations



Notes. 8,128 region-year observations are grouped equally into 20 bins, variation is within country. *Source:* WHED and Gennaioli et al. (2014) for regional GDP per capita and population

APPENDICES: INTENDED ONLY FOR ONLINE PUBLICATION

APPENDIX A1: DATA APPENDIX

A1.1 WHED COVERAGE

WHED contains data on 185 countries (which includes 176 countries plus 9 administrative regions/dependencies: Hong Kong, Macao, Curaçao, French Guyana, French Polynesia, Guadeloupe, Martinique, New Caledonia and Reunion). We cross-check the 176 countries to a full list of independent states (from the US State Department, http://www.state.gov/s/inr/rls/4250.htm) and find that there are only 16 more independent states not included in the database. These are Antigua and Barbuda, Comoros, Djibouti, Dominica, Eritrea, Grenada, Kosovo, Micronesia, Nauru, Palau, Saint Lucia, Saint Vincent and the Grenadines, Sao Tome and Principe, Seychelles, Solomon Islands and South Sudan.

WHED contains information on higher education institutions that offer at least a post-graduate degree or a four year professional diploma. It therefore excludes, for example, further education institutions in the UK or community colleges in the US and may be thought of as a sample of "higher quality" universities.

We compare the country totals in WHED as at 2010 to data from "Webometrics" (http://www.webometrics.info/en/node/54), a source where higher education institutions (including ones that would not qualify for inclusion in WHED) are ranked by their "web presence". This source puts the total number of universities worldwide at 23,887 in 2015 (part of this difference will be due to growth over the 2010-2015 period). In the results section, we discuss a robustness check where we drop countries from our regressions with a very large divergence between the two sources.

A1.2 VALIDATING OUR APPROACH

Our approach for calculating university presence by region uses the founding dates of universities to determine the number of universities that were present at any particular date. We consider that a "university" is founded on this initial founding date, even if it was a smaller higher education institute or college at that date. This is often the case, but our approach is reasonable since only the better quality institutions are likely to subsequently become universities. Furthermore, there are many cases where a number of universities or higher education institutes were merged together into what is today recorded as one university in WHED. Our approach avoids the apparent reduction that would occur in such cases if we were merely counted the number of institutions present at any given date.

One key concern with this strategy is that it would not be suitable in a world where university exits are commonplace. Say a number of universities were present in the past and closed down before WHED 2010. A region could have actually seen a fall in universities, but our method would not capture this since it includes only surviving universities. Anecdotally we know that the period since the 1960s has been one of university growth across the globe, but we investigate this issue further in order to gain more comfort on the validity of our approach. We do this by obtaining historical records of the universities and higher education institutions present in the 1960s, and assess whether significant numbers of these are missing from WHED 2010.

The appropriate sources are the predecessors to WHED: "The International Handbook of Universities" (1959, published by the IAU annually); "American Universities and Colleges" (1960, published by The American Council on Education) and "The Yearbook of Universities of the Commonwealth" (1959, published by the Association of Universities of the British Commonwealth). As the name suggests, the "American Universities and Colleges" yearbook contains fully fledged universities, but also smaller colleges (including religious institutions), many of which would not be included in WHED today. The international handbook lists universities and other institutions not considered of "full university rank" separately. We include all of these institutions because the distinction is not consistent between countries – for example in France, these latter institutions contain all the grandes écoles which are considered to be of very high quality but are outside the framework of the French university system; and in China only one institution is listed as a full university while other institutions include a number of institutions with the name "university". The Commonwealth yearbook contains only fully fledged universities.

The main exercise we carry out is to name match between 1960 yearbooks and WHED 2010. There are 2,694 institutions listed across 110 countries in the three yearbooks in 1960, this compares with 5,372 institutions (in 132 countries) which according to WHED 2010 were founded pre 1960 – this is higher because WHED counts universities from the date they are founded, even if they are not founded as a fully-fledged university (as discussed above). The country level correlation of the number of universities present in 1960 in the two sources is 0.95. The matching process involves a number of iterations: exact matching, "fuzzy" matching, and manual matching. The process is complex because name changes and mergers are commonplace, therefore internet searches on Wikipedia or university websites were necessary. Where an institution was found to have been merged into a university that is present in WHED 2010 we considered it a match. The results of this process are summarised in Table A11. We find that university closure is extremely rare, and we only find evidence of this in the US, where 33 small (mostly religious) colleges are present in the 1960 yearbook and were found to have closed down, mainly due to bankruptcy. 155 institutions worldwide were found to still be in existence but not be listed in WHED. This was usually because they do not meet the WHED listing criteria (a university that offers at least a four year degree or postgraduate courses). Indeed, of the 155 institutions in this category, 115 were not considered fully fledged universities in 1960, and 33 of the remaining 40 were US colleges (mostly religious).

Based on these facts, we believe that it is reasonable to use the WHED founding dates as an (albeit imperfect) basis for a time series of university presence by region.

A1.3 DESCRIBING COUNTRY LEVEL UNIVERSITY GROWTH IN SELECTED COUNTRIES

This section gives an historical overview of the diffusion of universities from the 1880s in four advanced economies: France, Germany, the UK and US, and two emerging economies: India and China. We compare the timing of historical university expansions to growth and industrialisation (see Figure A5 for a measure of industrialisation over time in the UK, US, France and Germany sourced from Bairoch (1982)). This analysis provides a visual "sense-check" for the thesis developed by Mokyr (2002) that the building and dissemination of knowledge played a major role in the Industrial Revolution.

In the United Kingdom, universities have been established in waves: the "Ancient universities" starting with Oxford in 1100s were the first seven universities which were founded before 1800. Then a number of universities were chartered in the 19th Century, followed by the "Red Brick" universities before World War I. A large expansion occurred after World War II, around the time of the influential Robbins Report into Higher Education (1963). Former polytechnics were converted to universities in 1992, but in our data these higher education institutions are counted from when they opened in their original form. These waves can be seen in the university density line as shown in Figure A6, Panel A, which also plots national GDP per capita data (from Maddison), suggesting that the first expansions coincided with industrialisation in the 1800s (Figure A5 shows that industrialisation picked up from the 1830s in the UK). The raw university count trend is shown in Panel B.

In the US, the first university was Harvard, founded in 1636. By the time of the American Revolution there were nine colleges modelled on Oxford and Cambridge in England. However these were very small, exclusive and focused on religion and liberal arts. At that time, there were no law or medical schools, so one had to study these subjects in London. It was Thomas Jefferson who had a vision for state education, separate from religion, but this only took hold after the Civil War with the land grant colleges. This sharp rise in university density can be seen in Figure A7. Industrialisation in the US began to pick up in the 1860s (see Figure A5). University density reached much higher levels than in Britain: at 13 universities per million people in 1900 versus just over 2 in the UK. The difference is that in the US, density came down again as population growth outpaced the opening of new universities which continued to grow as shown in Panel B; though the downward trend did slow during the post war period (we can see the slight kick in university numbers from the 1950s in Panel B). However, the fall in university density must be considered in the context that over the same period, university size has also been increasing in the US and (this can be seen in Figure A8 and in our analysis on enrolments). Furthermore, there has been a sharp rise in "Community Colleges" in the US, which provide college access qualifications, and are not counted in our dataset.

In France, Figure A9 shows that university density really started picking up in the 1800s with the opening of the "Grande Écoles" which were established to support industry, commerce and science and technology in the late 19th Century. Indeed industrialisation in France was more gradual, and started picking up in the late 1880s, early 1900s. The next dramatic increase in universities numbers and density occurred in the 1960s during de Gaulle's reforms of the French economy.

Cantoni and Yuchtman (2014) discuss the opening of the first universities in Germany following the Papal schism in the late 14th Century. However, during the 1800s, Figure A10 shows that university density actually fell, as population growth outpaced the gradual increases in university numbers which can be seen in Panel B. Historically, Germany had a low share of college graduates as higher shares of the population were educated via the apprenticeship system. A deliberate push to expand university education began in the 1960s, with new public universities founded across the country (Jäeger, 2013). This was motivated by the need to compete in technology and science against the backdrop of the Cold War; but also social reasons, namely the notion that education is a civil right to be extended beyond the elites, and is crucial for democracy.

China and India saw much later expansions as shown in Figure A11 and Figure A12. China started opening up to Western advances in science in the 1800s, and followed Soviet influence in the 1950s with centrally planned education. We can see a sharp rise in university density from the 1900s to 1960. The spike in the 1960s is due to the Cultural Revolution, when higher education institutions were shut down for 6 years, and all research terminated. When the universities were reopened, they taught in line with Maoist thought. It was from the 1980s that institutions began to gain more autonomy and when China began its rapid growth trajectory, though so far growth in universities has not outpaced population growth. In India, expansion occurred after independence in 1947. During the colonial era, the upper classes would be sent to England for education. The British Raj oversaw the opening of universities and colleges from the late 1800s, but university density only started rising more rapidly after 1947 and recently has picked up pace again. We note that the in both countries, there are around 0.4 universities per million people, which is still a lot lower than in the UK or US.

Finally, we note that in general, expansions in university numbers have been accompanied by increases in university size. As we saw in Figure A8 (using UNESCO data that are only available from 1970), university students normalised by population have been growing overall in the US and the UK since the 1970s (with a dip in the late 1990s in the US) and more recently in China and India.

A1.4 CASE STUDIES OF UNIVERSITY EXPANSION IN SELECTED EUROPEAN COUNTRIES

As three case studies we consider European countries that undertook largescale expansions in the 1960s and 1970s, and where decisions over the geographical roll-out of universities appear to be unrelated with expectations of a region's economic growth prospects. First, the UK undertook a large expansion in the 1960s, around the time of the influential Robbins Report on Higher Education (Robbins, 1963). One key motivation was to develop UK science and technology in response to Soviet advances (Barr, 2014). The so-called 'plate glass' universities (Beloff, 1968) were created on greenfield sites outside small or medium-sized towns and away from large population or industrial centres. This was in contrast with previous universities which had typically emerged "bottom up", starting life as colleges to meet local needs (often founded by industrialists) and upgrading to university status later (Shattock, 2012). Students were recruited nationally and grants were also administered at the national level by the "University Grants Committee".

As a second case study, we look at West Germany (Rüegg, 2010) where a high number of university openings took place in the early 1970s. Here key objectives were to improve equality of opportunity and the modernisation and democratisation of society (Jäeger, 2014). Within the country, locational decisions were primarily driven by the objective of achieving an equal distribution of higher education. There was also a belated response to the rise of East Germany and the threat from what was perceived as rapid technological advances in the Soviet bloc.

Thirdly, in Finland, there was a large increase in the number of universities and their geographical spread in the 1960s and 1970s. The expansion of the university sector was closely linked with regional development policies (Rüegg, 2010), but locational decision-making processes were drawn out and uncertain, with committees split over favoured locations (Toivanen and Väänänen, 2016). It appears that decisions were primarily influenced by political forces rather than economic activity of different areas.

APPENDIX A2: FURTHER RESULTS

A2.1 SPECIFICATION AND SAMPLE CHECKS

In Table A3, we show that our regressions are robust to a series of checks. We perform these on columns (5) and (7) of Table 3. In row (2) we conservatively cluster standard errors at the country level, to account for correlation between the errors of regions within the same country over time. While the standard errors rise a little, the association between lagged university growth and GDP per capita growth remains significant at the 1% level.[52] In row (3) we weight the regression by the region's population as a share of total country population, in case low density regions (which might be outliers) are affecting the results. Again, this weighting has little effect on the university coefficient. In row (4) we include country-year dummies instead of lagged country-level GDP per capita, to control for time varying factors at the country level (including national income) that may affect both university growth and GDP per capita growth (for example a general increase in funding for higher education, or a change in national government). This does reduce the coefficient, but it is still highly significant. In row (5) we control for the current (as well as lagged) change in population to address the concern that the effect of the university is simply to pull in more people to the region, who spend or produce more and hence raise GDP per capita growth. Our university effect remains strong and therefore it does not appear to be driven by population growth. Row (6) uses growth in university density (universities per million people) instead of university count, with very similar results. We prefer to use the university count in our core analysis, with controls for population growth, as changes in university density can be driven either by the numerator (universities) or the denominator (population) and can be more difficult to interpret.

We then perform a few checks to see whether regions with no universities, or regions getting their first university are driving the results. Row (7) of Table A3 drops regions which never have a university in the sample period, and row (8) drops region-years with zero universities, and the coefficients remains unchanged. To make sure our results are not driven by extreme university growth observations we do two things. Row (9) drops region-year observations where a region opens its first university, and in row (10) we winsorise the top and bottom five per cent of university growth which both strengthen the results.[53] Row (11) uses similarly winsorised GDP per capita growth as the dependent variable, which dampens reduces our coefficient slightly but it still significant at the 1% level. In row (12) we show that the results are not sensitive to dropping observations where we have interpolated GDP per capita. To address measurement problems in terms of missing founding dates, in row (13) we include a dummy for regions where more than five percent of the universities have missing founding dates. Finally, we explore whether the definition of university in WHED (i.e. only institutions that offer four year courses or postgraduate degrees) may be a problem, in the sense that there may be some countries that have a larger share of institutions outside this category which could be important for growth. For this purpose, we compare the most recent university numbers in our database to an external source, Webometrics.[54] Row (14) shows that our results are robust

[52] We also estimate these regressions using Driscoll-Kraay standard errors (results available on request) to allow for cross-sectional dependence in a panel. The results are still highly significant (at the 1 per cent level) and given that such methods are not intended for panels with small T and large N (our core sample has T=13 and N=1,498) we prefer to stick with region-level clusters in our core specifications. We note that our results are robust also to clustering at the country level which is a more conservative specification as it allows the standard errors in one region-year to be correlated with standard errors in any other region-year within the same country.

[53] In further robustness checks (available on request) we also explore if there are any heterogeneous effects for regions opening their first universities by interacting the dummy with the university growth variable. The coefficients on both the dummy and interaction term are not significantly different from zero.

[54] http://www.webometrics.info/en/node/54

to dropping the 29 countries where there are more than double the number of institutions in Webometrics compared to the WHED listing.

A2.2 SIMULATION OF THE EFFECTS OF A NEW UNIVERSITY ON THE AVERAGE REGION'S HUMAN CAPITAL AND GDP

To assess the plausibility of the magnitudes identified in the main text we consider some quantitative calculations of university expansion.

To look at a representative case we take the average region in the dataset as summarised in Table 1: a population of just under 3 million, GDP per capita of $13,056 (and hence GDP of $39 billion), a college share of 7%, average years of education of 7.37, and just under 10 universities.

We assume that a new university with a capacity of 8,500 students is opened in the region. We believe that a university of 8,500 students a generous size for a new university, based on to average enrolments in our sample countries over the years where country level enrolments data are available.[55] The annual intake of students is 2,125, so the university is at capacity in four years. We assume it takes four years to graduate with a bachelors degree and a staff student ratio of 10,[56] so that there are 850 staff present at the university at full capacity. We assume that students enter the region to begin studying, and stay in the region post graduation, adding to its human capital stock. We keep the university size constant for the five year period following its opening. We assume that staff enter the region in the first year and remain there. We assume that the typical graduate has 18 years of education.

This experiment involves adding one university to an existing stock of 10 universities, which represents a 10% increase over a five year period, or an average of 2% per year. To compare to our regression results, which represent the impacts of a 1% increase in universities, we need to double the regression coefficients. Our core coefficient on universities in column (7) of Table 3 is 0.047. This implies that a 1% increase in the number of universities is associated with a 0.047% increase in GDP per capita in the subsequent 5 years. Therefore the implied increase in GDP per capita following a 2% change would be around 0.09%.

The impact of a 1% increase in universities in the previous period on college share from Table 6, column (8) is an increase in college share of 0.004, which represents 0.4 percentage points since college share is measured as a fraction. Therefore we double this to 0.008 to compare with the experiment. Similarly, the impact on years of education is a 0.02% increase, so we double this to 0.04%.

Using this simple example we generate impacts on college share and years of education growth in the next five year period and compare these to the predictions from our regressions.

---

[55] We obtained total tertiary education enrolments from UNESCO which is available since the 1970s, and divided by the number of universities in our data, to get the average number of universities by country in each year where the data are available. The average over the period is just under 8,200. Obviously, this will represent existing as well as new universities. Moreover, this is likely to be an overstatement since, as we previously discussed, not all tertiary institutions are included in WHED. The average growth rate in students per university implied by this country level data over the period is 2.5% per annum.

[56] This is a generous assumption. In the UK, for example, staff-student ratios range between 9 and 25 (see http://www.thecompleteuniversityguide.co.uk/league-tables/rankings?o=Student-Staff%20Ratio)

Our calculation involves a churning out of 2,125 new graduates per year and this results in an average annual rise in college share of 0.0006 (or 0.060 percentage points) in the next five year period. This is actually smaller than the 0.008 implied from our regressions, and could be due to more inward migration of skilled people following the opening of universities, which we do not capture controlling only for population changes. On the other hand the implied average annual rise in years of education is 0.09% which is more similar to the 0.04% implied by the regressions (which, as we noted are based on a different sample from the college share regressions).

While there are differences here, our simulation shows that the effects on human capital even with generous assumptions about the size of a new university, will be relatively small. This is in line with what we find in the regression analysis.

Demand effects of universities

Using this same example of the representative region, we can simulate the demand effects of university expansion. If the university is funded from outside the area then GDP may increase mechanically as demand from a university (e.g. rent, supplies, building and maintenance) and its staff and students boost the local economy.

We assume that the cost per student in our new university is $10,000 per year, which is likely to be an overestimate of the average university in our sample.[57] For a university of 8,500 students this implies total costs of $85 million. Since this represents annual costs, we assume that the transfer continues in each subsequent year. Therefore the uplift to GDP will be felt only in the *initial* years. Assuming that total enrolments stay fixed at 8,500 over the five years following university entry (which is the key period we use for our regressions), there would be *no* uplift to GDP per capita in that period. Alternatively, if we assume enrolments are growing by 5% per year[58] this would only account for around 15% of calculated effect of a 2% increase in universities implied by our baseline specification (0.09%).

A2.3 UNIVERSITIES AND DEMOCRATIC APPROVAL

Figure A3 Panel E shows that there is a positive and significant correlation between country level polity scores and university density, in the cross section (for 2000). Figure A13 also shows that there is a positive and significant correlation between the change in university density and change in polity scores over 1960-2000.

Table A10 reports a number of robustness tests around the regressions of approval of democracy on lagged university presence reported in Table 8. Column (1) repeats Table 8 column (4). Column (2) shows that this effect might be slightly stronger for OECD countries, as an interaction term between an OECD dummy and the lagged university presence is positive, but it is not significant at conventional levels. Column (3) shows that the main result is much smaller in magnitude and insignificant for 5 year lagged university presence, and actually

[57] In 2011 the OECD average tertiary education spending by educational institutions was $13,958 (see Education at a Glance 2014: OECD Indicators, Indicator B1). On average OECD countries spent 41% of GDP per capita per student in 2011. $10,000 represents 77% of GDP per capita in our average region-year ($13,056).

[58] The average growth rate in students per university implied by the UNESCO country level enrolments data over the period since the 1970s is 2.5% per annum.

negative for a 30 year lag. Column (5) shows that our main result can be closely replicated using a different survey measure for approval of democracy, “democracy is best” which asks respondents whether they agree with the statement that democracy is better than any other form of government. Column (6) does not include country fixed effects. This shows that the positive relationship we find between universities and approval of democracy is valid within countries. Across countries, factors not controlled for in these regressions (for example, levels of corruption) appear to influence the result. We investigated which countries appear to be driving this negative relationship and found, for example, that the Philippines (a country with high levels of corruption) has high university density but low approval of democracy. Column (7) clusters at the country level and significance holds. Column (8) weights by population, to account for the fact that some regions with low population may have less representative responses. Column (9) drops students and graduates and the main result gets stronger. Finally, column (10) shows that the results are robust to estimation using an ordered-probit model.

APPENDIX TABLES

Table A1: FULL RESULTS OF BASELINE SPECIFICATIONS

Dependent variable: Regional Growth of GDP per capita	
Lagged growth in #universities	0.044***
	(0.010)
Lagged level of regional GDP per capita	-0.013***
	(0.001)
Lagged level of country GDP per capita	-0.021***
	(0.004)
Lagged level of population	-0.086**
	(0.039)
Lagged growth in population/100	-0.113***
	(0.039)
Dummy for capital in region	0.011***
	(0.002)
Latitude	-0.000***
	(0.000)
Inverse distance to ocean	0.005
	(0.004)
Malaria ecology	0.001**
	(0.000)
log(oil and gas production) 1950-2010	0.000**
	(0.000)
Observations	8128
Adjusted R-squared	0.260
# clusters	1498

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. This table replicates Table 3, column (5) to show the geographic controls. Note, ln(oil and gas production) 1950-2010 is not normalised by population.

Table A2: DISTRIBUTED LAG SPECIFICATIONS

Dependent variable: **Regional Growth of GDP per capita**	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Full sample							
Current growth in #universities		-0.008	-0.005	-0.013	-0.013	-0.019	0.002
		(0.011)	(0.011)	(0.012)	(0.013)	(0.015)	(0.017)
5 year lagged growth in #universities	0.047***		0.045***	0.059***	0.054***	0.059***	0.086***
	(0.011)		(0.011)	(0.012)	(0.013)	(0.013)	(0.016)
10 year lagged growth in #universities				0.022**	0.026**	0.017	0.031*
				(0.011)	(0.012)	(0.014)	(0.017)
15 year lagged growth in #universities					0.006	-0.003	-0.006
					(0.011)	(0.013)	(0.018)
20 year lagged growth in #universities						0.006	0.009
						(0.015)	(0.019)
25 year lagged growth in #universities							0.025*
							(0.014)
Observations	8128	9246	8128	6863	5635	4604	3638

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) is replicates column (7) from Table 3. The subsequent columns add contemporaneous and further lagged growth in universities, and corresponding population growth. The level of population at the furthest lag is also controlled for.

Table A2: DISTRIBUTED LAG SPECIFICATIONS (CONTINUED)

Dependent variable: Regional Growth of GDP per capita	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel B: US, UK, FR, DE							
Current growth in #universities		0.001	0.017	0.047**	0.085***	0.027	-0.005
		(0.020)	(0.021)	(0.023)	(0.026)	(0.040)	(0.043)
5 year lagged growth in #universities	0.051***		0.057***	0.086***	0.104***	0.143***	0.132***
	(0.016)		(0.018)	(0.020)	(0.019)	(0.018)	(0.033)
10 year lagged growth in #universities				0.030	0.037*	0.061***	0.076***
				(0.019)	(0.021)	(0.022)	(0.023)
15 year lagged growth in #universities					0.013	0.027	0.027
					(0.026)	(0.029)	(0.026)
20 year lagged growth in #universities						0.047**	0.041**
						(0.022)	(0.018)
25 year lagged growth in #universities							0.017
							(0.019)
Observations	1023	1116	1023	930	837	744	651
Panel C: Rest							
Current growth in #universities		-0.007	-0.004	-0.015	-0.017	-0.015	0.016
		(0.012)	(0.012)	(0.013)	(0.014)	(0.016)	(0.017)
5 year lagged growth in #universities	0.048***		0.047***	0.062***	0.057***	0.061***	0.095***
	(0.011)		(0.011)	(0.013)	(0.014)	(0.014)	(0.016)
10 year lagged growth in #universities				0.021*	0.026**	0.019	0.039**
				(0.011)	(0.013)	(0.014)	(0.018)
15 year lagged growth in #universities					0.002	-0.007	-0.001
					(0.012)	(0.014)	(0.019)
20 year lagged growth in #universities						0.002	0.010
						(0.016)	(0.021)
25 year lagged growth in #universities							0.028*
							(0.015)
Observations	7105	8130	7105	5933	4798	3860	2987

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) replicates column (7) from Table 3 for the subsamples as indicated. The subsequent columns add contemporaneous and further lagged growth in universities, and corresponding population growth. The level of population at the furthest lag is also controlled for.

Table A3: SUMMARY OF ROBUSTNESS TESTS

		Coefficient on lagged University Growth		N
		Covariates	Region Trends	
(1)	Benchmark	0.044***	0.047***	8128
		(0.010)	(0.011)	
	A. Specification			
(2)	Cluster at country level (78 clusters)	0.044***	0.047***	8128
		(0.014)	(0.016)	
(3)	Population weights	0.041***	0.043***	8128
		(0.013)	(0.013)	
(4)	Country-year fixed effects	0.028***	0.023**	8128
		(0.010)	(0.010)	
(5)	Control for current population change	0.044***	0.045***	8128
		(0.010)	(0.011)	
(6)	University density	0.030***	0.029***	8128
		(0.009)	(0.009)	
	C. Sample issues			
(7)	Drop regions that never have a university	0.043***	0.047***	6642
		(0.011)	(0.011)	
(8)	Drop regions before they have a university	0.042***	0.045***	6041
		(0.011)	(0.011)	
(9)	Drop first university observations	0.051***	0.062***	7897
		(0.013)	(0.014)	
(10)	Winsorize university growth	0.061***	0.064***	8128
		(0.015)	(0.015)	
(11)	Winsorize GDP per capita growth	0.034***	0.036***	8128
		(0.008)	(0.008)	
(12)	Un-interpolated GDP per capita	0.049***	0.047***	5312
		(0.013)	(0.014)	
	D. Measurement issues			
(13)	Dummy for > 5% missing founding dates	0.042***	0.047***	8128
		(0.011)	(0.011)	
(14)	Country level total check (Webometrics)	0.053***	0.058***	5357
		(0.013)	(0.013)	

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Row (1) replicates column (5) and column (7) from Table 3.

Table A4: UNIVERSITY GROWTH AS DEPENDENT VARIABLE

Dependent variable: **Regional Growth in Number of Universities**	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Lagged growth in regional GDP per capita	-0.012	-0.006	-0.008	-0.010	-0.010	-0.030	-0.029
	(0.014)	(0.018)	(0.018)	(0.018)	(0.017)	(0.019)	(0.021)
Lagged growth in country GDP per capita		-0.017	-0.016	-0.013	-0.074***	-0.054**	-0.042
		(0.024)	(0.024)	(0.024)	(0.022)	(0.024)	(0.026)
Lagged growth in population			-0.057	-0.070	-0.101*	-0.114**	-0.137**
			(0.054)	(0.054)	(0.056)	(0.055)	(0.066)
Lagged level of population/100				-0.696**	1.970***	2.016***	2.562***
				(0.292)	(0.400)	(0.408)	(0.503)
Lagged #universities					-0.048***	-0.049***	-0.055***
					(0.003)	(0.003)	(0.004)
Lagged level of regional GDP per capita						0.009**	0.008
						(0.004)	(0.005)
Lagged level of country GDP per capita						-0.008*	-0.015**
						(0.005)	(0.006)
Lagged years of education							-0.003***
							(0.001)
Lagged growth in years of education							0.083**
							(0.033)
Observations	7746	7746	7746	7746	7746	7746	6506
# clusters	1489	1489	1489	1489	1489	1489	1458

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. All columns include region and year fixed effects, and standard errors clustered by region. Column (1) is simple correlation between regional growth in universities and the lagged growth in regional GDP per capita. Columns (2) to (6) include the additional variables shown. Column (7) includes the lagged level and lagged growth in years of education for the subsample where these measures are available. Levels of GDP per capita and population are in natural logs.

Table A5: HETEROGENEITY BY CONTINENT

Dependent variable: Regional growth in GDP per capita	(1)	(2)	(3)	(4)	(5)	(6)
Sample	All	US, UK, FR, DE	Other Europe, Canada	Latin America	Asia	Africa
Lagged growth in #universities	0.047***	0.051***	0.004	0.087***	0.034	0.116
	(0.011)	(0.016)	(0.011)	(0.020)	(0.026)	(0.093)
Lagged level of regional GDP per capita	-0.078***	-0.057***	-0.061***	-0.071***	-0.096***	-0.124***
	(0.005)	(0.008)	(0.006)	(0.008)	(0.009)	(0.022)
Lagged level of country GDP per capita	0.038***	-0.052***	0.019***	0.027**	0.059***	-0.065
	(0.006)	(0.010)	(0.007)	(0.012)	(0.010)	(0.044)
Lagged level of population	-0.850**	-0.179	-2.201***	-1.709**	-1.997**	-4.373***
	(0.352)	(0.368)	(0.669)	(0.812)	(0.933)	(1.581)
Lagged growth in population	-0.183***	-0.067	-0.527***	-0.189**	-0.139	0.108
	(0.045)	(0.089)	(0.091)	(0.092)	(0.091)	(0.102)
Observations	8128	1023	2792	1821	2249	243
# clusters	1498	93	581	295	462	67

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) replicates column (7) from Table 3. The other columns carry out an identical regression, but restricting to the sample continent as labelled. Levels of GDP per capita and population are in natural logs. Latin America contains Mexico, Central America and South America. Asia contains Australia.

Table A6: HETEROGENEITY BY TIME PERIODS FOR SELECTED COUNTRY GROUPINGS

Dependent variable: Regional growth in GDP per capita	(1)	(2)	(3)		(1)	(2)
		US, UK, FR, DE			Asia	
Sample	All	Pre-1990	Post-1990	All	Pre-1990	Post-1990
Lagged growth in #universities	0.051***	0.042**	0.080*	0.034	0.004	0.064*
	(0.016)	(0.018)	(0.041)	(0.026)	(0.026)	(0.035)
Lagged level of regional GDP per capita	-0.057***	-0.103***	-0.097***	-0.096***	-0.131***	-0.135***
	(0.008)	(0.012)	(0.018)	(0.009)	(0.013)	(0.011)
Lagged level of country GDP per capita	-0.052***	-0.017	0.022	0.059***	0.057***	0.081***
	(0.010)	(0.015)	(0.017)	(0.010)	(0.017)	(0.016)
Lagged level of population	-0.002	-0.002	-0.046***	-0.020**	-0.027*	-0.067***
	(0.004)	(0.005)	(0.010)	(0.009)	(0.014)	(0.021)
Lagged growth in population	-0.067	0.044	0.007	-0.139	-0.001	0.063
	(0.089)	(0.067)	(0.057)	(0.091)	(0.185)	(0.134)
Observations	1023	651	372	2249	841	1408
Adjusted R-squared	0.580	0.565	0.757	0.286	0.471	0.353
# clusters	93	93	93	462	297	462

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) carries out our core regression on the full sample for those countries. Columns (2) and (3) restrict to the time periods specified. Columns (4), (5) and (6) do similar for the Asian sample of countries (which includes Australia).

Table A7: BARRO REGRESSIONS WITH LAGGED UNIVERSITIES

Dependent variable: Regional Growth of GDP per capita	(1)	(2)	(3)	(4)
Lagged #universities			0.002***	0.002**
			(0.001)	(0.001)
Lagged level of population/100			-0.235***	-0.200***
			(0.068)	(0.067)
Lagged level of regional GDP per capita	-0.014***	-0.018***	-0.015***	-0.018***
	(0.001)	(0.002)	(0.001)	(0.002)
Lagged level of country GDP per capita	-0.036***	-0.032***	-0.036***	-0.032***
	(0.004)	(0.004)	(0.004)	(0.004)
Lagged level of population density	-0.001	-0.001**	-0.000	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Lagged years of education		0.004***		0.004***
		(0.001)		(0.001)
Observations	8010	8010	8010	8010
Adjusted R-squared	0.273	0.279	0.274	0.280
# clusters	1504	1504	1504	1504

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) replicates Gennaioli et al. (2014) Table (5), column (8), with geographic controls, year and country fixed effects, but omits years of education. There are more observations because we have interpolated GDP per capita in the sample (Gennaioli et al. only interpolate years of education and population). Column (2) adds years of education. Column (3) replicates column (1), but adds the five year lagged level of universities in a region, and lagged population. Column (4) then adds years of education to the specification in column (3). Standard errors are clustered at the regional level. The lagged number of universities is the natural log of 1 + the 5 year lagged number of universities. Levels of GDP per capita, population and population density are in natural logs. Years of schooling are not logged.

Table A8: LONGER DIFFERENCE BARRO REGRESSIONS

Dependent Variable: Average annual GDP per capita growth	50 year differences		40 year differences		30 year differences	
	(1)	(2)	(3)	(4)	(5)	(6)
Lagged #universities	-0.000	0.003**	-0.001**	0.002	0.000	0.002**
	(0.000)	(0.002)	(0.000)	(0.001)	(0.001)	(0.001)
Lagged level of regional GDP per capita		-0.013***		-0.006***		-0.013***
		(0.002)		(0.002)		(0.002)
Lagged level of population		-0.003*		-0.002*		-0.001
		(0.001)		(0.001)		(0.001)
Change in population		0.083		0.022		-0.063
		(0.064)		(0.056)		(0.071)
Observations	188	188	250	250	464	464
Country fixed effects	no	yes	no	yes	no	yes

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. This table shows long differences to 2000: so columns (1) to (2) show regressions for the sample where data are available for the period 1950-2000; columns (3)-(4) show regressions for the period 1960-2000; and columns (5)-(6) show regressions for the period 1970-2000. Column (1) is a simple correlation of the average annual growth in regional GDP per capita over 1950-2000 on the natural log of 1+ the number of universities in 1950. Column (2) adds country fixed effects, the 1950 natural log of the level of regional GDP per capita, the 1950 natural log of the level of population, the 1950-2000 change in population and country fixed effects. Columns (3) and (4) do the same for the 40 year difference to 2000. Columns (5) and (6) do the same for the 30 year difference to 2000. More data are available in later years, so the samples are larger for the shorter long differences. Robust standard errors are shown in parentheses.

Table A9: UNIVERSITIES AND YEARS OF EDUCATION

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ GDPpc	Δ Years Educ.	Δ Years Educ.
Lagged growth in #universities	0.047***	0.059***	0.057***	0.057***	0.056***	0.057***	0.053***	0.022**
	(0.011)	(0.013)	(0.012)	(0.012)	(0.012)	(0.012)	(0.014)	(0.009)
Lagged growth in years of education			0.073***		0.062***	0.062***		
			(0.026)		(0.024)	(0.024)		
Current growth in years of education				0.075*	0.055	0.082**		
				(0.042)	(0.039)	(0.040)		
Lagged years of education						0.002**		
						(0.001)		
Lagged level of regional GDP pc	-0.078***	-0.088***	-0.088***	-0.088***	-0.088***	-0.088***		-0.000
	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)		(0.003)
Lagged level of country GDP pc	0.038***	0.021***	0.019**	0.021***	0.020**	0.020**		0.002
	(0.006)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)		(0.003)
Lagged level of population/100	-0.850**	-2.090***	-2.094***	-1.946***	-1.988***	-2.132***		-1.916***
	(0.352)	(0.475)	(0.470)	(0.469)	(0.468)	(0.458)		(0.290)
Lagged growth in population	-0.183***	-0.045	-0.050	-0.045	-0.049	-0.044		-0.001
	(0.045)	(0.050)	(0.050)	(0.050)	(0.050)	(0.050)		(0.023)
Observations	8128	6117	6117	6117	6117	6117	6117	6117
# clusters	1498	1343	1343	1343	1343	1343	1343	1343

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Growth in years of education is the log difference. Column (1) replicates column (7) from Table 3. Column (2) restricts to the sample for which the change in years of education is available. Column (3) drops the lagged growth in years of education. Column (4) adds the contemporaneous change in years of education. Column (5) includes both lagged and contemporaneous changes. Column (6) further adds the lagged level of years of education (unlogged). Column (7) regresses the change in years of education on the lagged growth in universities, with country dummies, but no other controls. Column (8) adds all the other controls.

Table A10: ROBUSTNESS ON WORLD VALUES SURVEY ANALYSIS

Dependent Variable: View of democracy	(1) Approval	(2) Approval	(3) Approval	(4) Approval	(5) Best	(6) Approval	(7) Approval	(8) Approval	(9) Approval	(10) Approval
15 year lagged ln(1+#universities per capita)	0.023**	0.014			0.033**	-0.052***	0.023*	0.055**	0.029***	0.040**
	(0.010)	(0.012)			(0.016)	(0.016)	(0.012)	(0.022)	(0.011)	(0.016)
OECD dummy X 15 year lagged ln(1+#universities per capita)		0.025								
		(0.018)								
5 year lagged ln(1+#universities per capita)			0.013							
			(0.008)							
30 year lagged ln(1+#universities per capita)				-0.002						
				(0.009)						
Observations	138511	138511	138511	138511	48181	138511	138511	138511	100782	138511
Adjusted R-squared	0.085	0.085	0.085	0.085	0.099	0.018	0.085	0.071	0.083	
# clusters	693	693	693	693	335	693	58	693	691	693
Estimator	OLS	OLS	OLS	OLS	OLS	OLS	OLS	weighted OLS	OLS	Oprobit
Standard errors clustered at	region	region	region	region	region	region	country	region	region	region
Country and year dummies	yes	yes	yes	yes	yes	no	yes	yes	yes	yes
Sample	all	all	all	all	all	all	all	all	drop students, graduates	all

Notes. *** indicates significance at the 1% level, ** at the 5% level and * at the 10% level. Column (1) replicates column (4) from Table 8. Column (2) includes an OECD dummy (not reported) and interaction between this and lagged university density. Column (3) is identical to column (1), but uses the five year lagged university density. Column (4) uses the thirty year lagged university density. Column (5) has a different dependent variable: the view that democracy is "best". Column (6) omits country and year dummies. Column (7) clusters standard errors at the country level. Column (8) uses weighted OLS, weighting each region by its population as a share of the country's total population. Column (9) drops graduates and students from the sample. Column (10) is estimated using an Ordered Probit model.

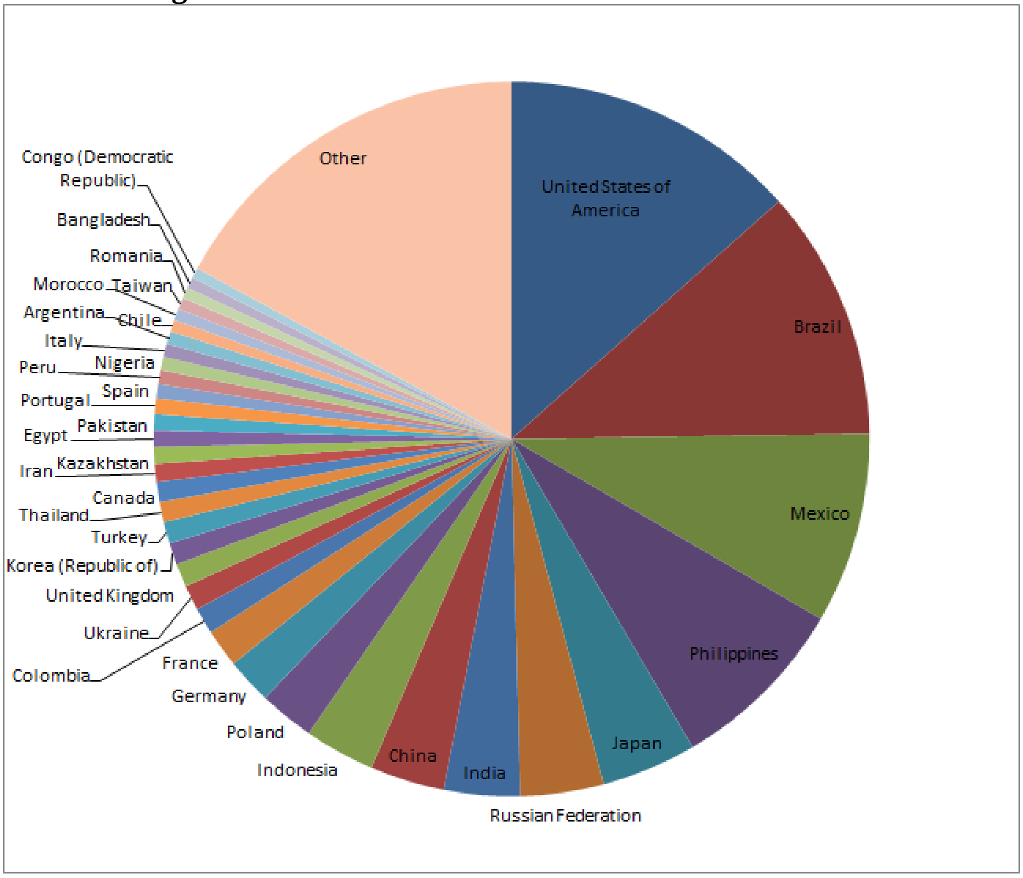
Table A11: MATCHING WHED AND 1960 YEARBOOKS

Outcome	"University"	Other	Total
Match - exact	570	65	635
Match - fuzzy	653	138	791
Match - manual	384	696	1080
Not in WHED 2010	40	115	155
Death	33	0	33
Total	1680	1014	2694

Notes. This table reports the outcome of the matching process between WHED and historical yearbooks, by universities and other types of institution.

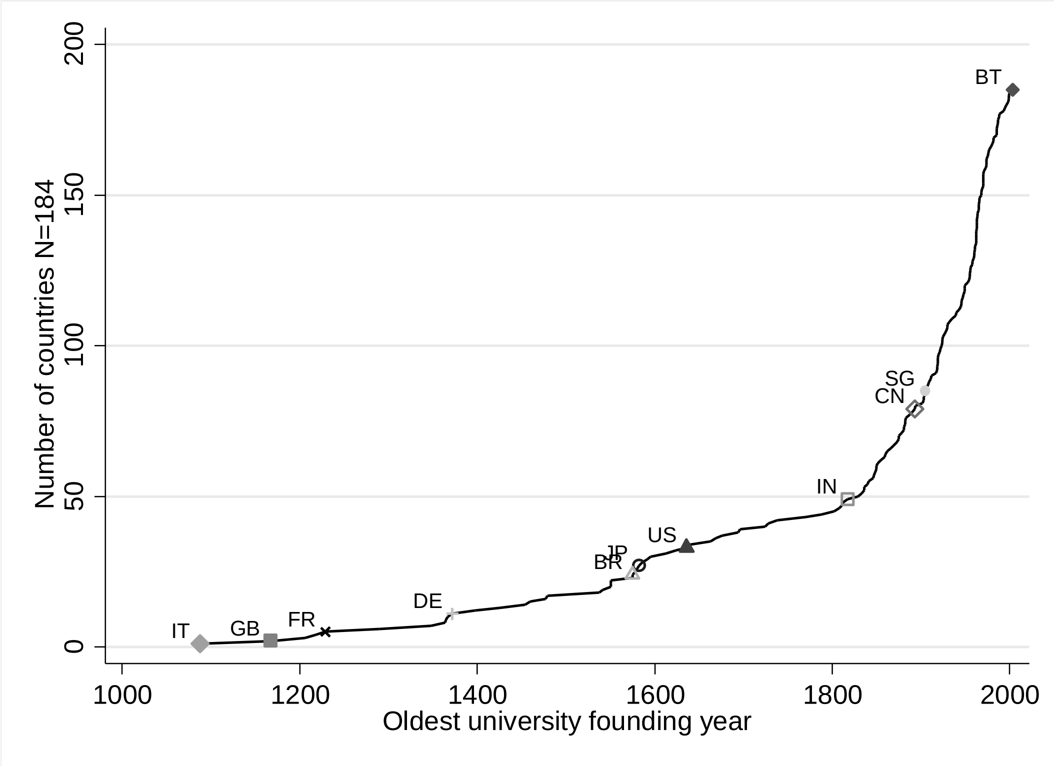
APPENDIX FIGURES

Figure A1: LOCATION OF UNIVERSITIES IN 2010



Notes. Pie chart shows the share of worldwide universities in each country, as at 2010. *Source: WHED.*

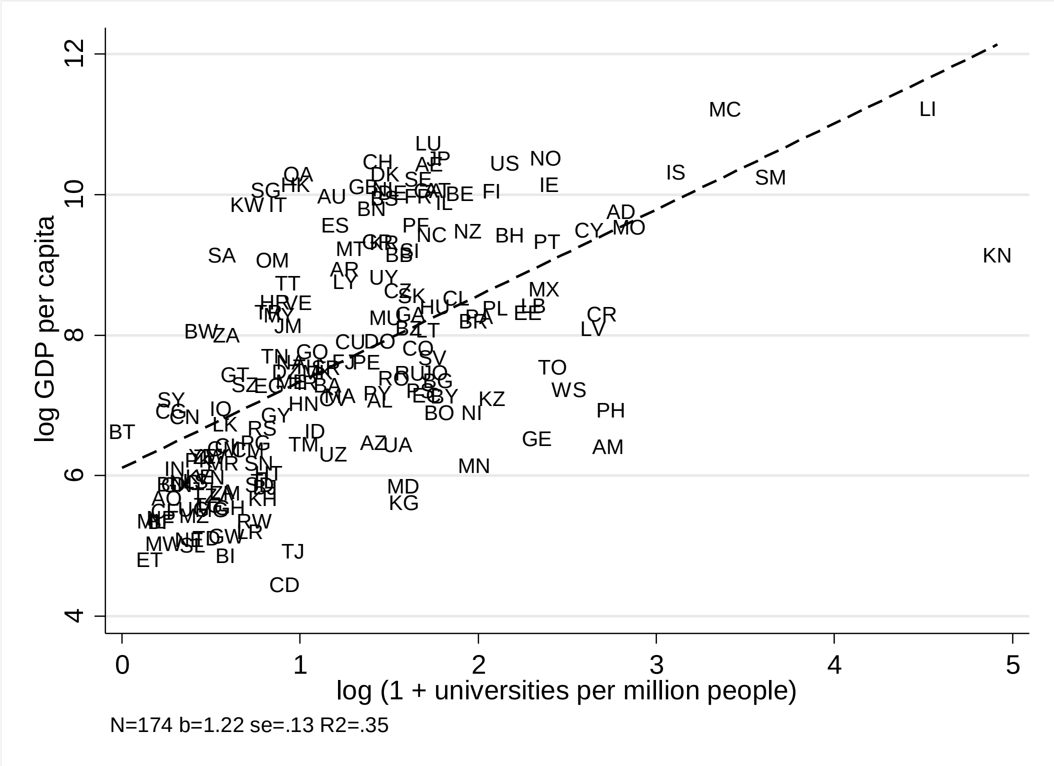
Figure A2: DIFFUSION OF UNIVERSITIES ACROSS COUNTRIES



Notes. This chart shows the total number of countries that have universities over time, with some key countries marked in the year they opened their first universities marked. *Source: WHED.*

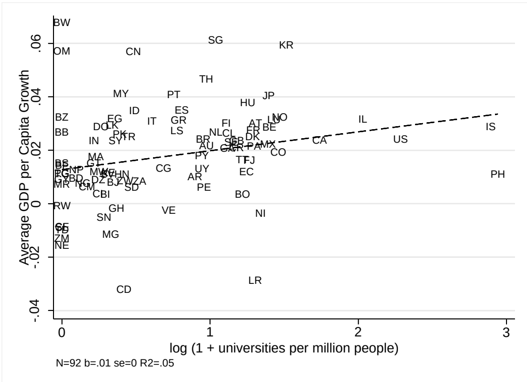
Figure A3: SCATTER PLOTS AT COUNTRY LEVEL, CROSS SECTION IN 2000

Panel A: Universities and income in 2000



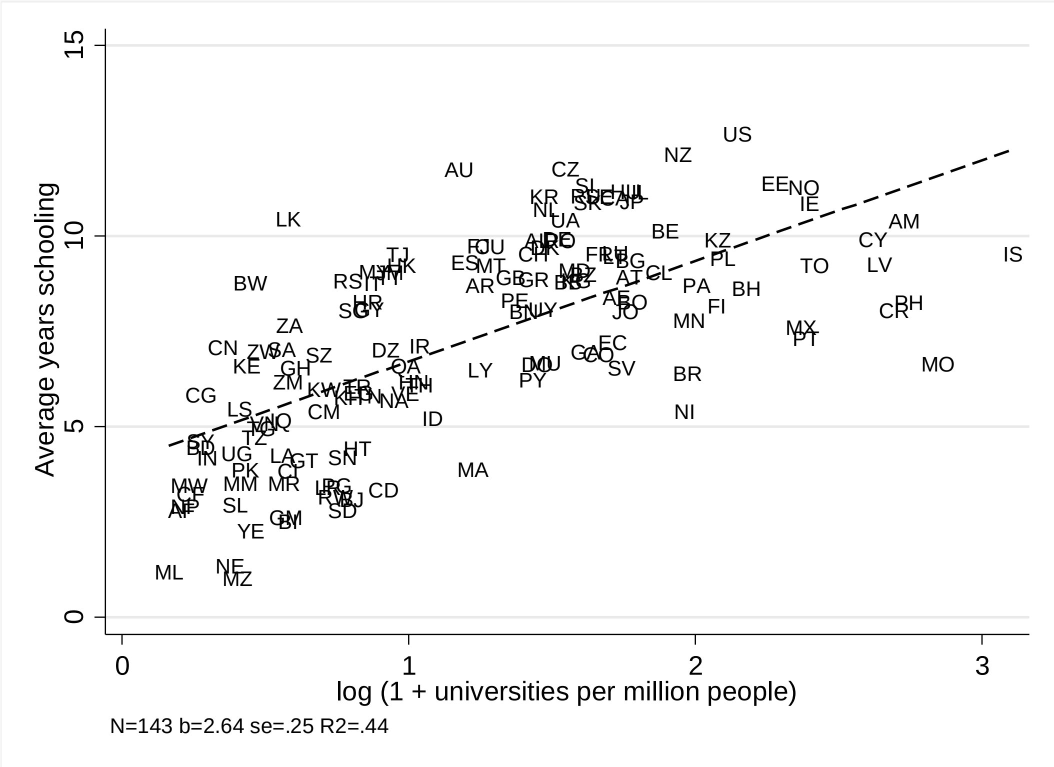
Notes. Each observation is a country in 2000. *Source: WHED and World Bank GDP per capita*

Panel B: Universities in 1960 and GDP per capita growth (1960-2000)



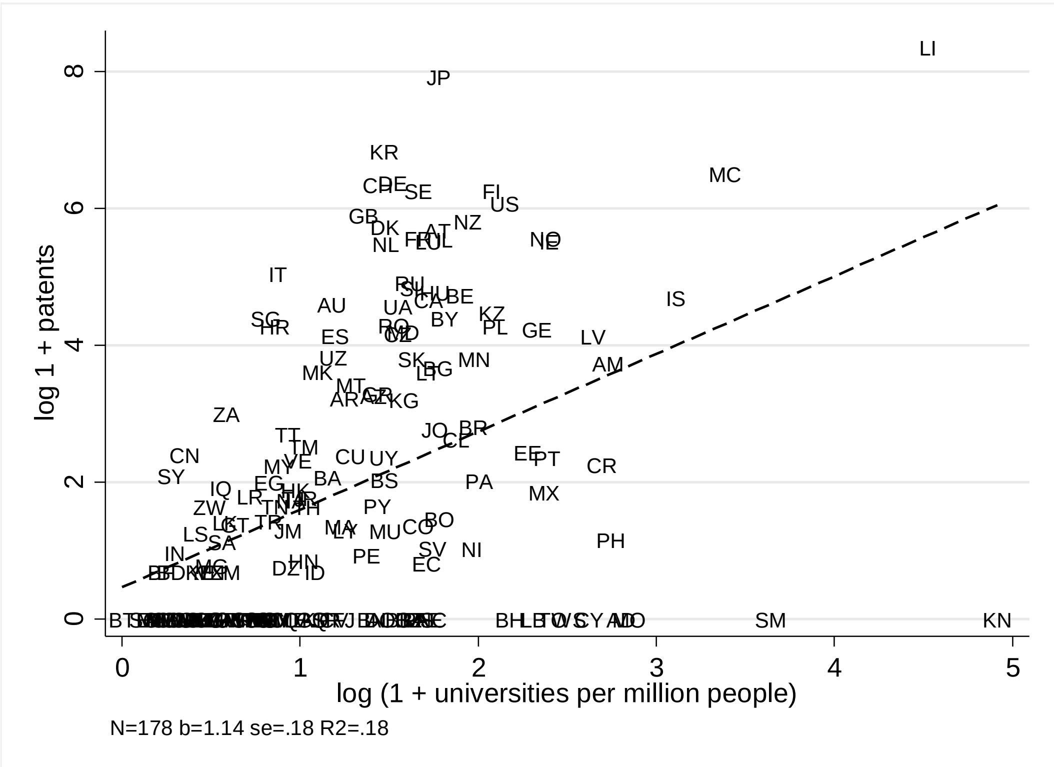
Notes. Each observation is a country. Average annual growth rates over the period 1960-2000 on the y axis. *Source: WHED and World Bank GDP per capita*

Panel C: Universities and average years of schooling in 2000



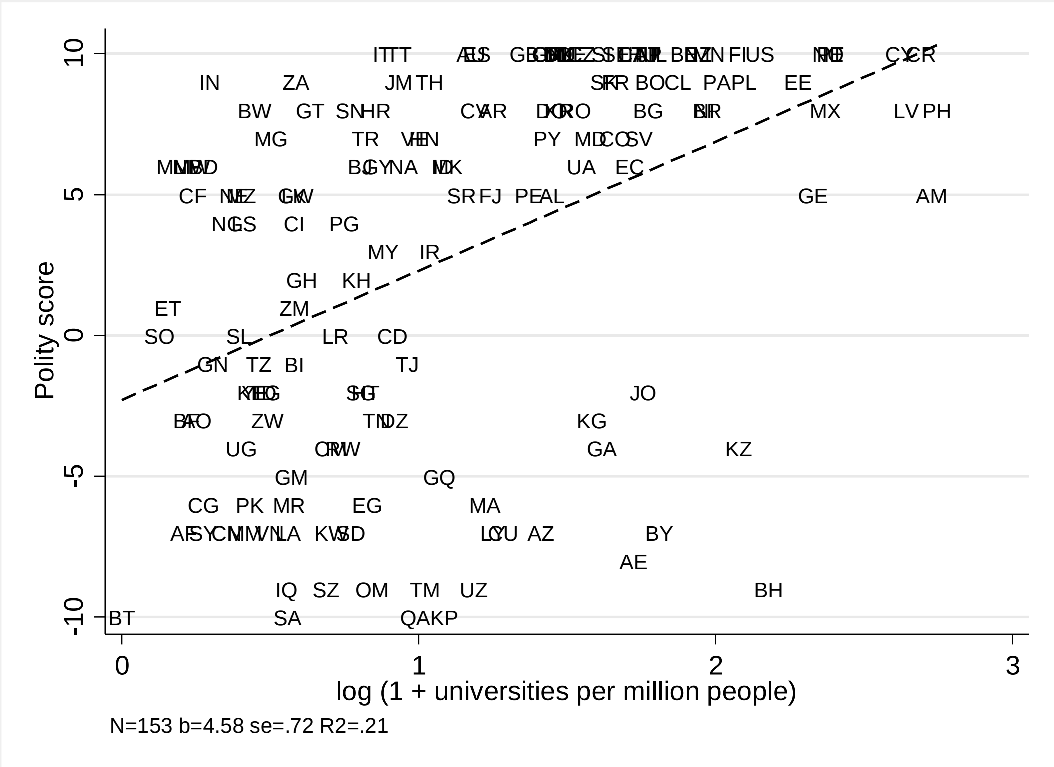
Notes. Each observation is a country in 2000. *Source: WHED and years of schooling obtained from Barro-Lee dataset*

Panel D: Universities and patents in 2000



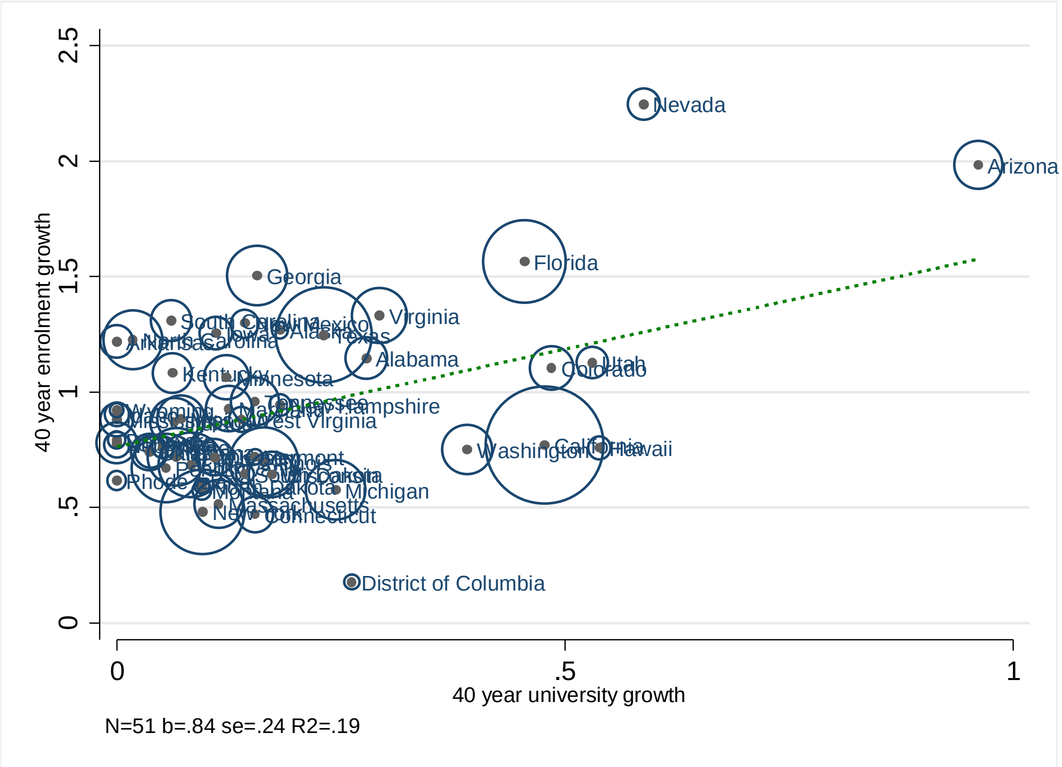
Notes. Each observation is a country in 2000. *Source: WHED and patents from WIPO*

Panel E: Universities and democracy in 2000



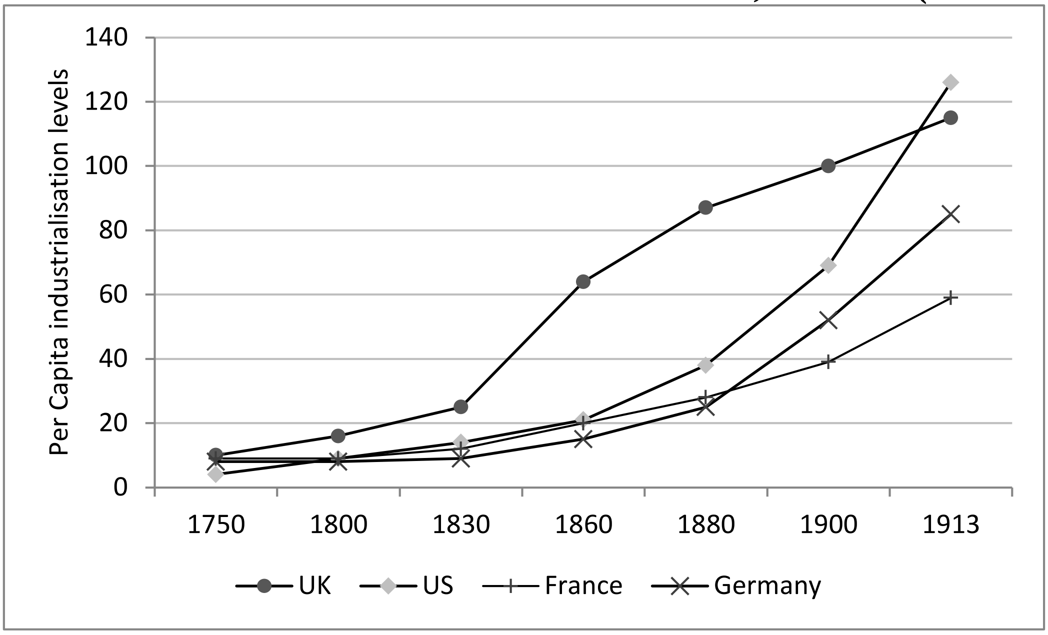
Notes. Each observation is a country in 2000. *Source: WHED and Polity2 scores from Polity IV project*

Figure A4: GROWTH IN US ENROLMENTS VS GROWTH IN UNIVERSITIES



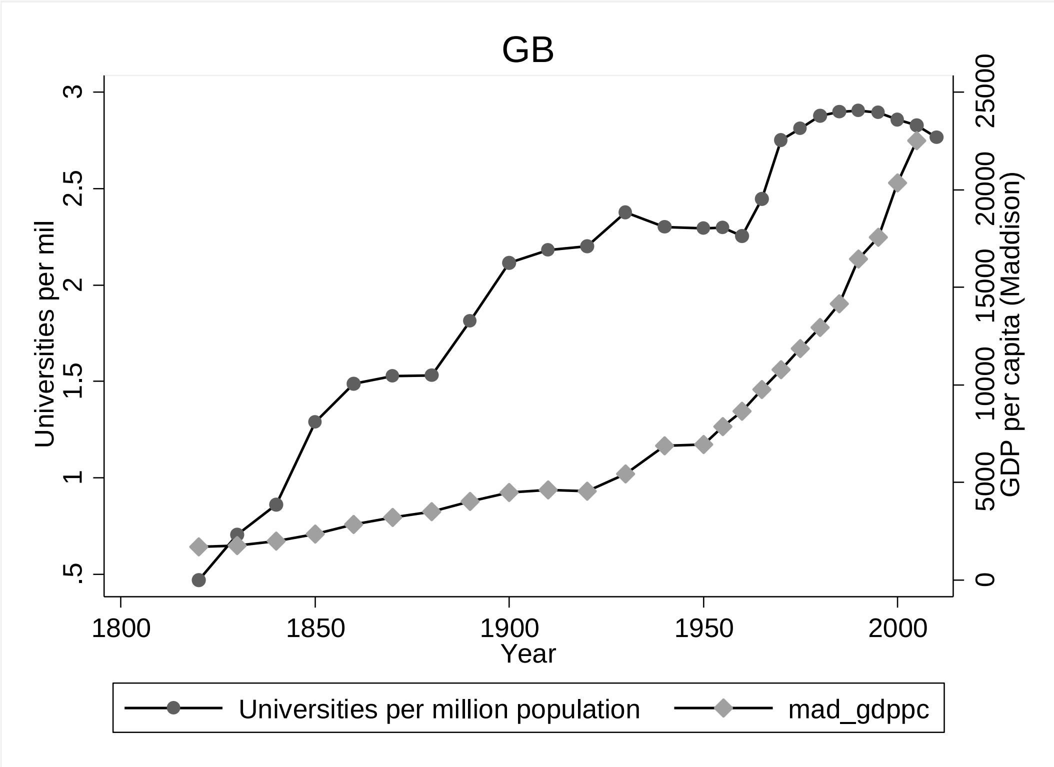
Notes. Each observation is a region (US state), weighted by the region's share in total US population in 2010. 40 year growth relates to the period 1970-2010. Dropping Arizona, b=0.62 and se=0.28. *Source: WHED and NCES.*

Figure A5: PER CAPITA INDUSTRIALISATION LEVELS, 1959-1913 (UK 1900=100)



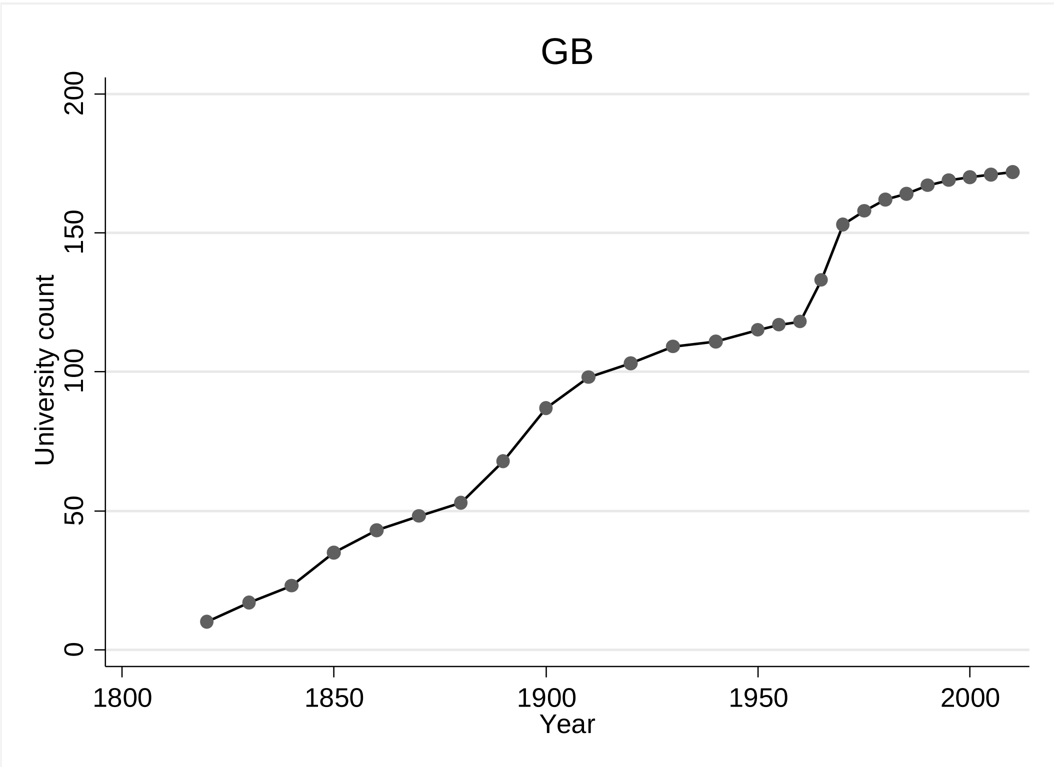
Notes. Graph based on Table 9, Bairoch (1982); taken from Baldwin (2012)

Figure A6: UNIVERSITIES AND INDUSTRIALISATION IN THE UK
Panel A: University density and GDP per capita trends



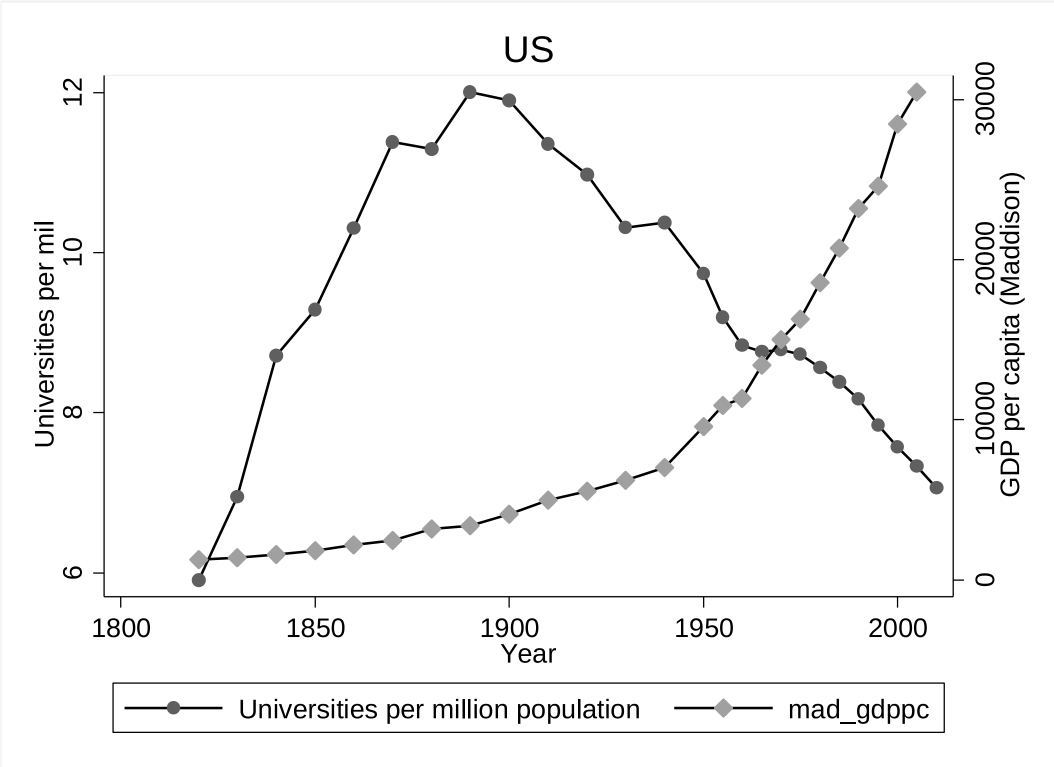
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



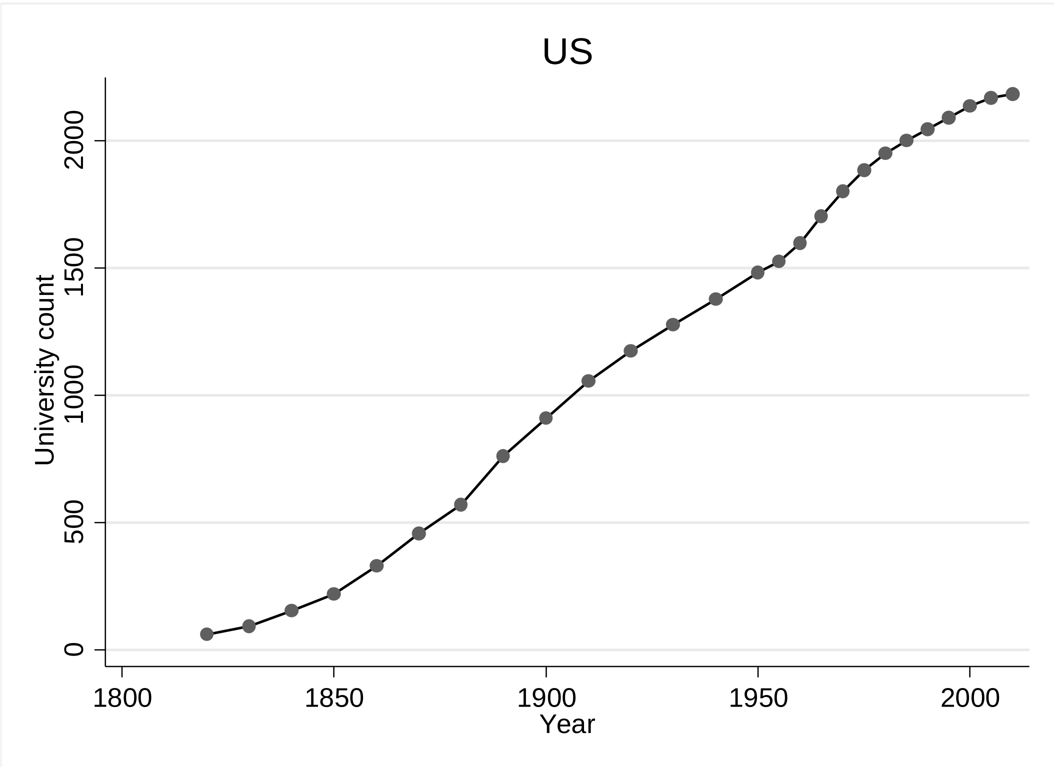
Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A7: UNIVERSITIES AND INDUSTRIALISATION IN THE US
Panel A: University density and GDP per capita trends



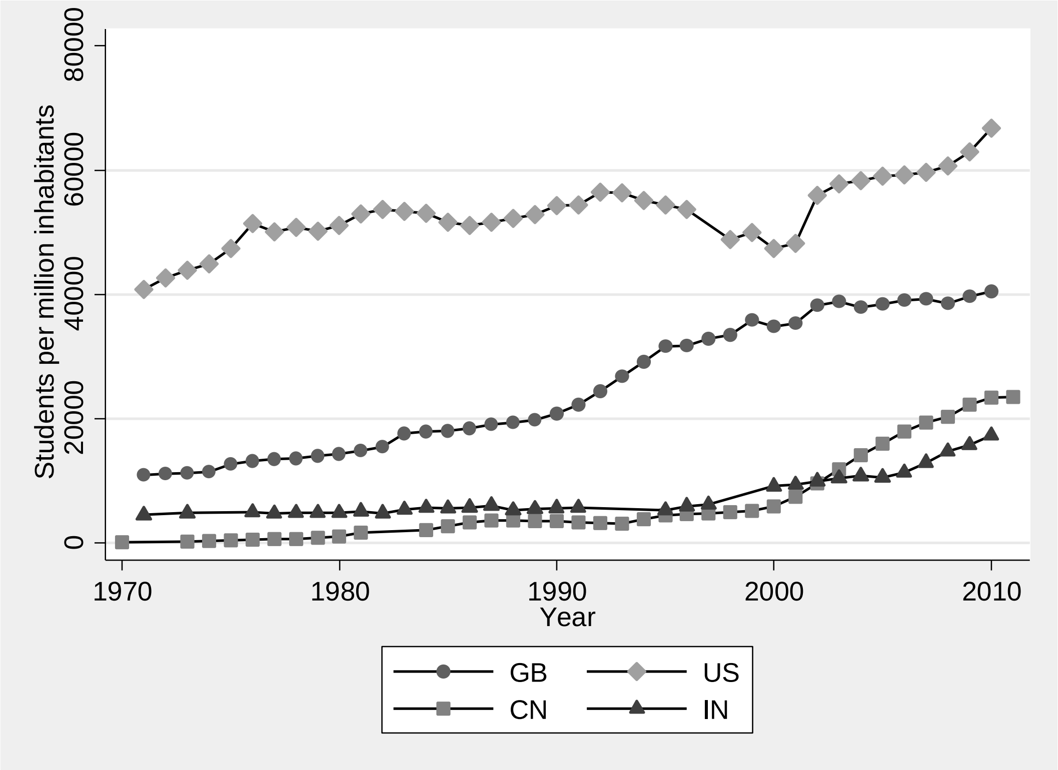
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



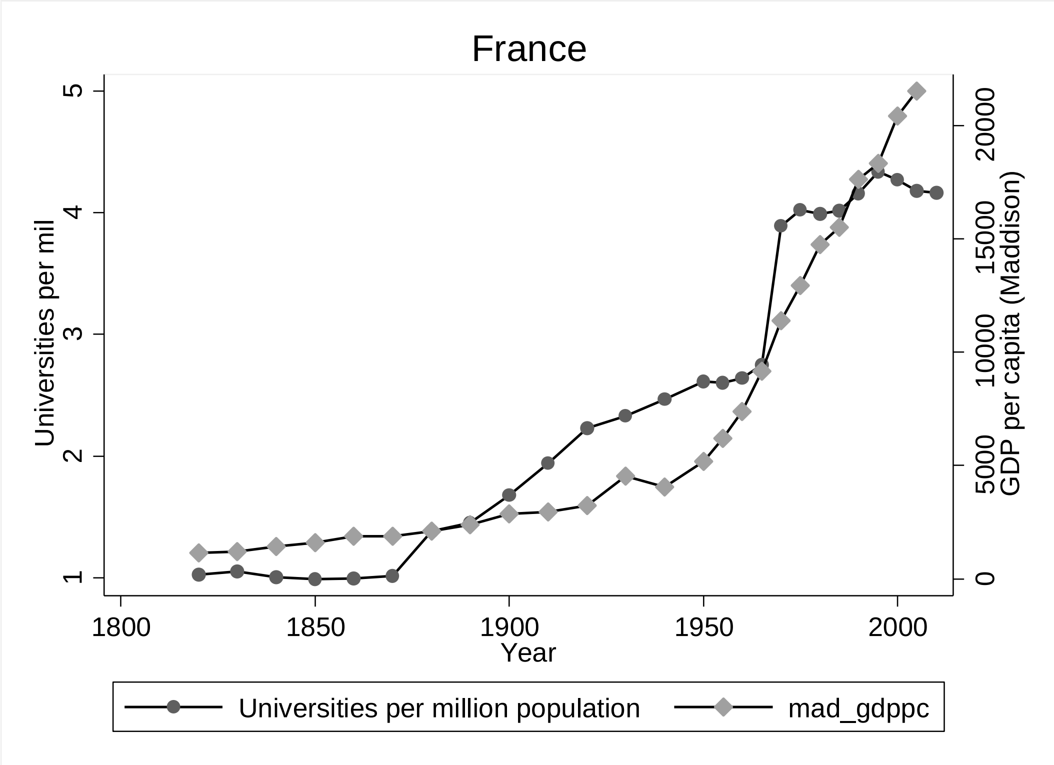
Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A8: TRENDS IN STUDENT NUMBERS NORMALISED BY POPULATION



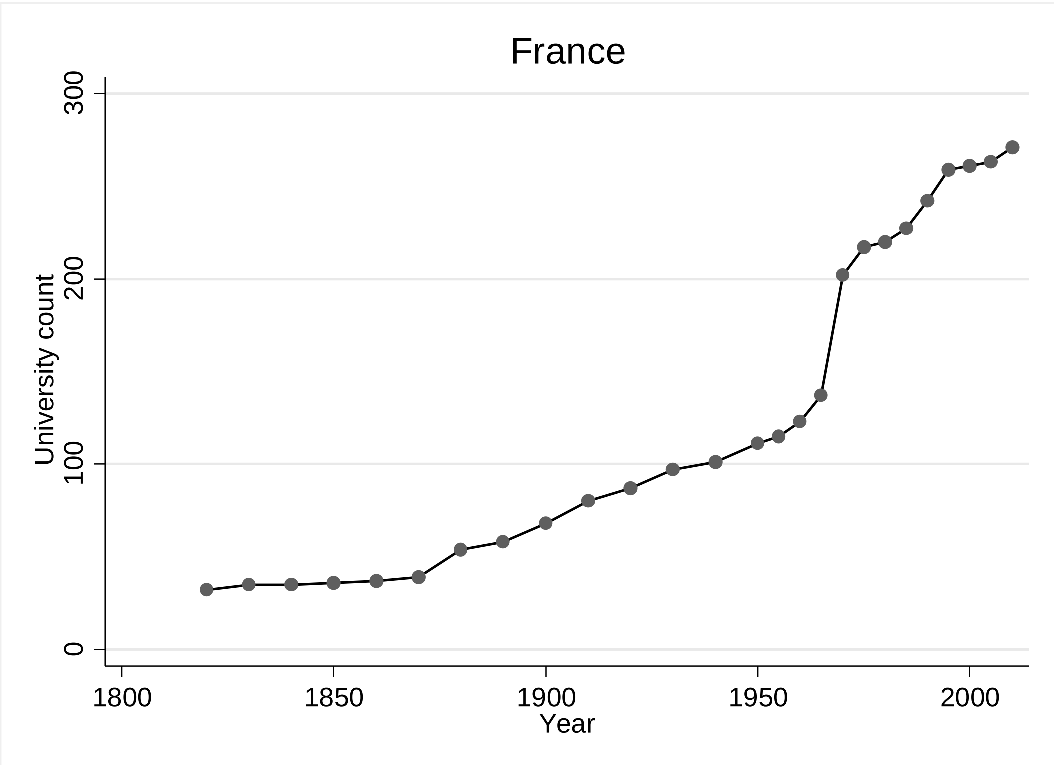
Notes. Number of students in tertiary education per million inhabitants. *Source: UNESCO*

Figure A9: UNIVERSITIES AND INDUSTRIALISATION IN FRANCE
Panel A: University density and GDP per capita trends



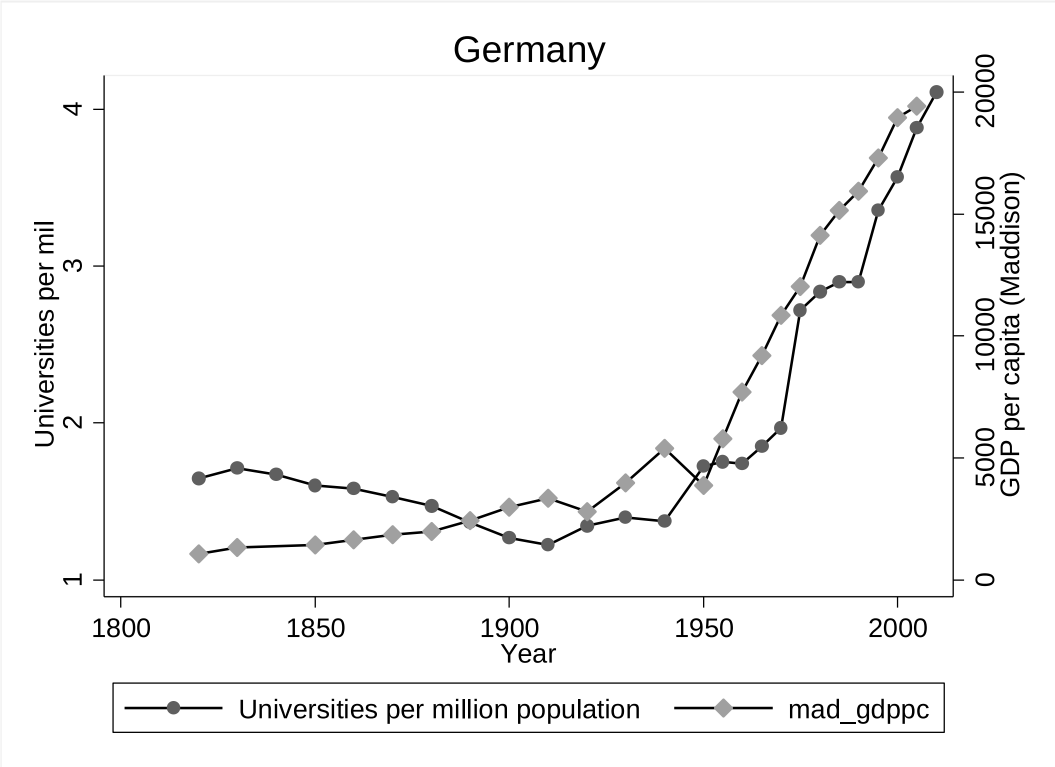
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



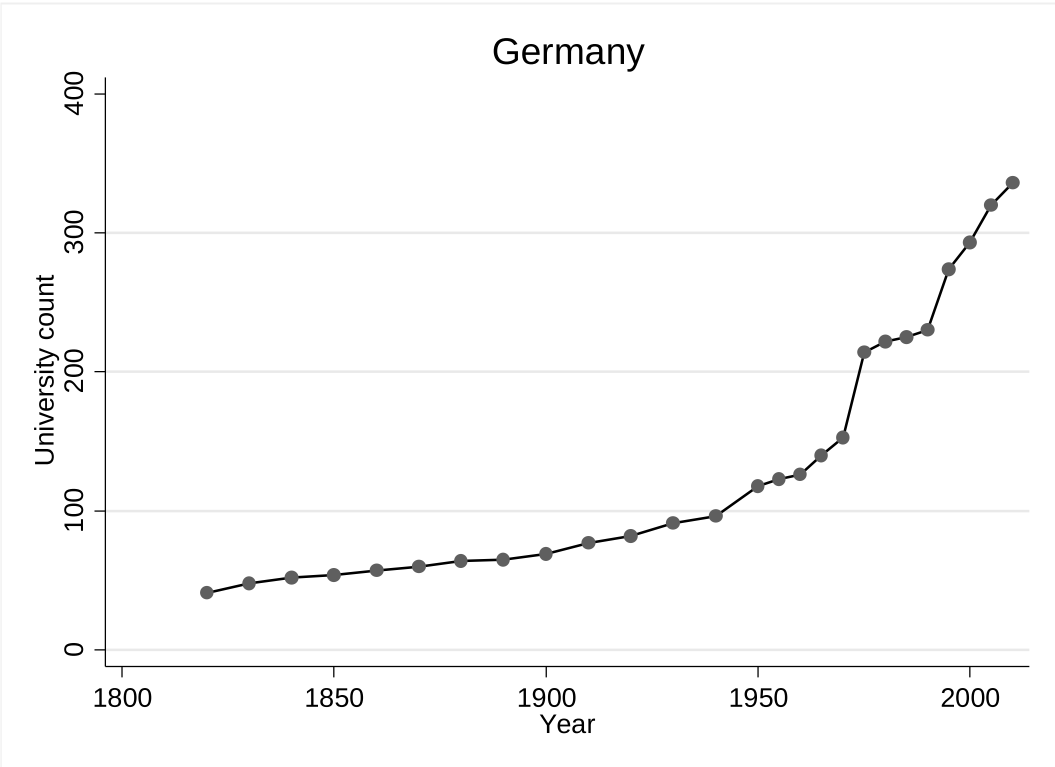
Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A10: UNIVERSITIES AND INDUSTRIALISATION IN GERMANY
Panel A: University density and GDP per capita trends



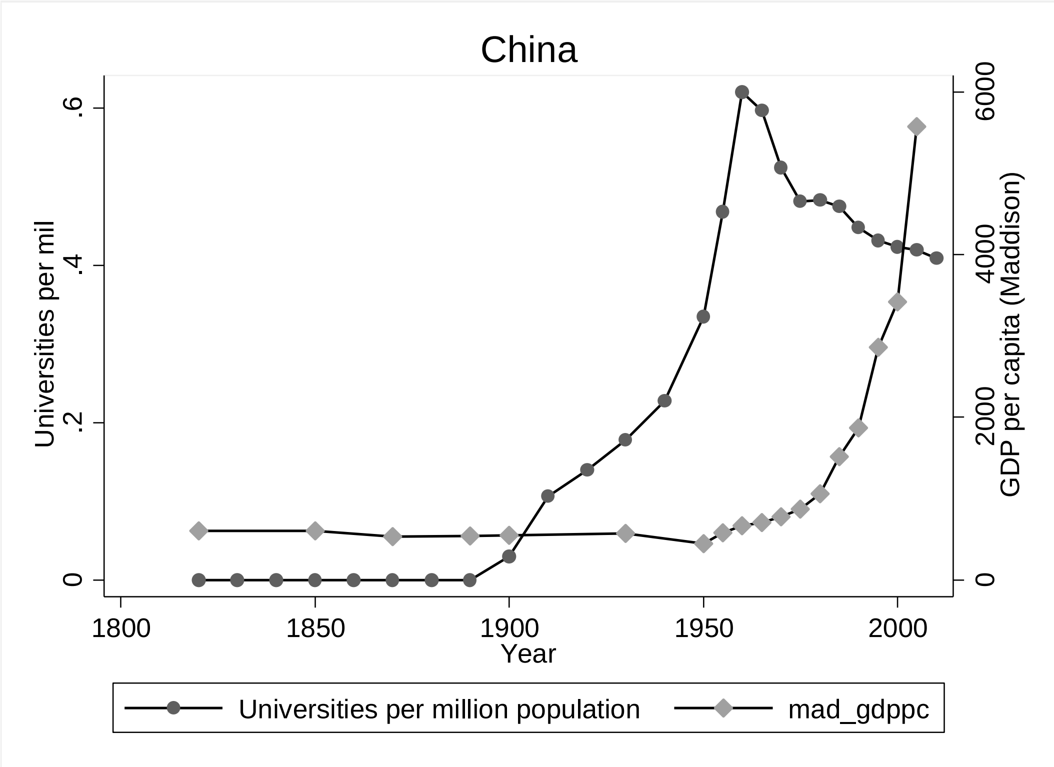
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



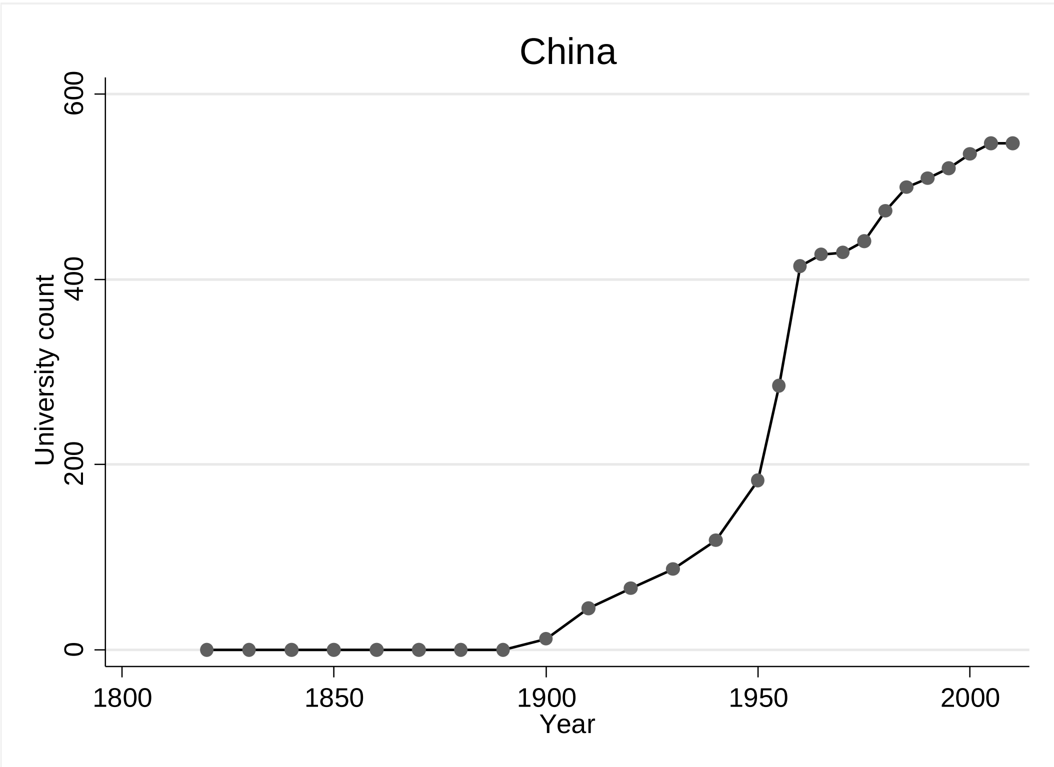
Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A11: UNIVERSITIES AND INDUSTRIALISATION IN CHINA
Panel A: University density and GDP per capita trends



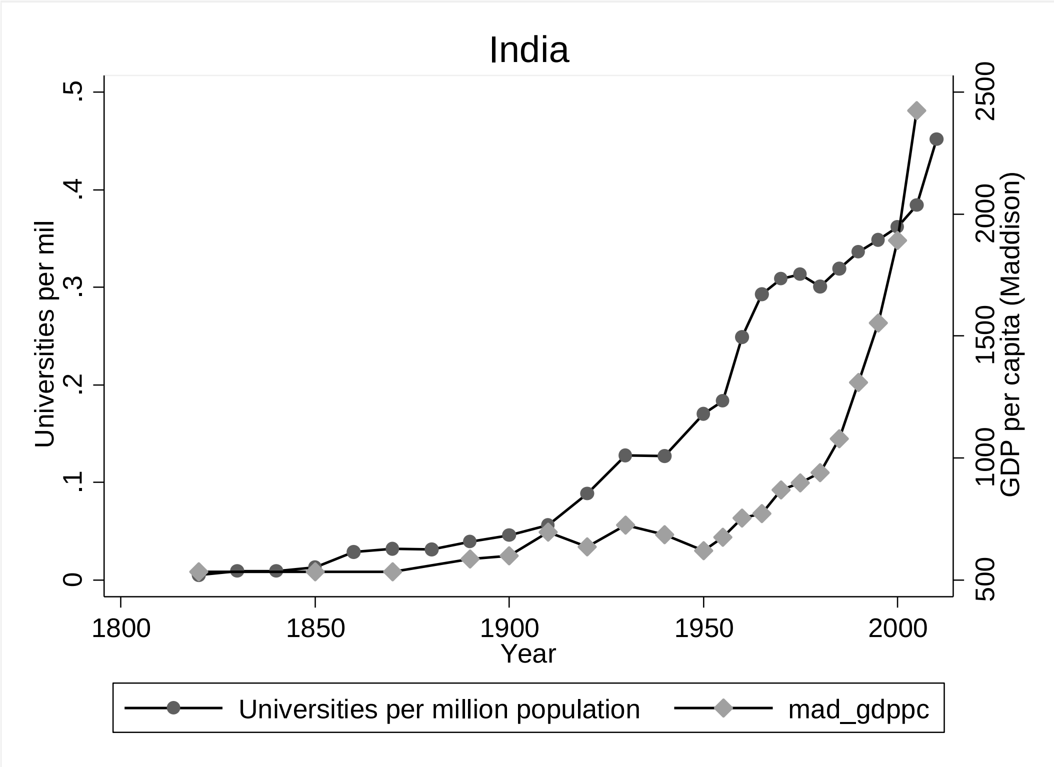
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



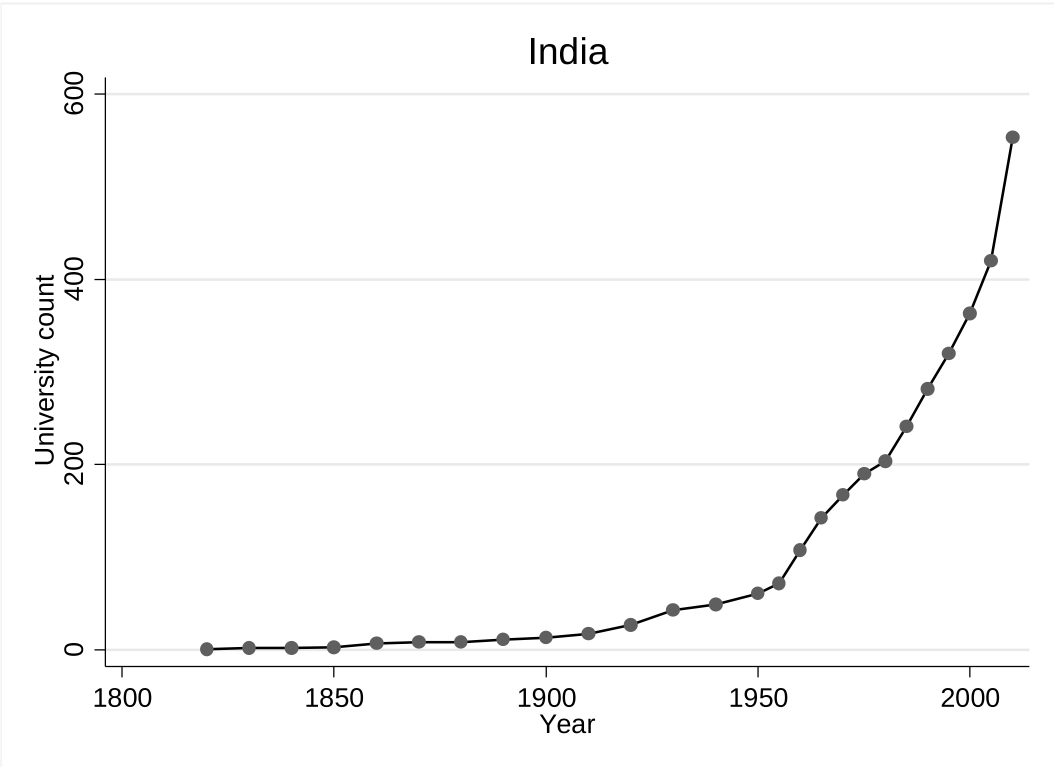
Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A12: UNIVERSITIES AND INDUSTRIALISATION IN INDIA
Panel A: University density and GDP per capita trends



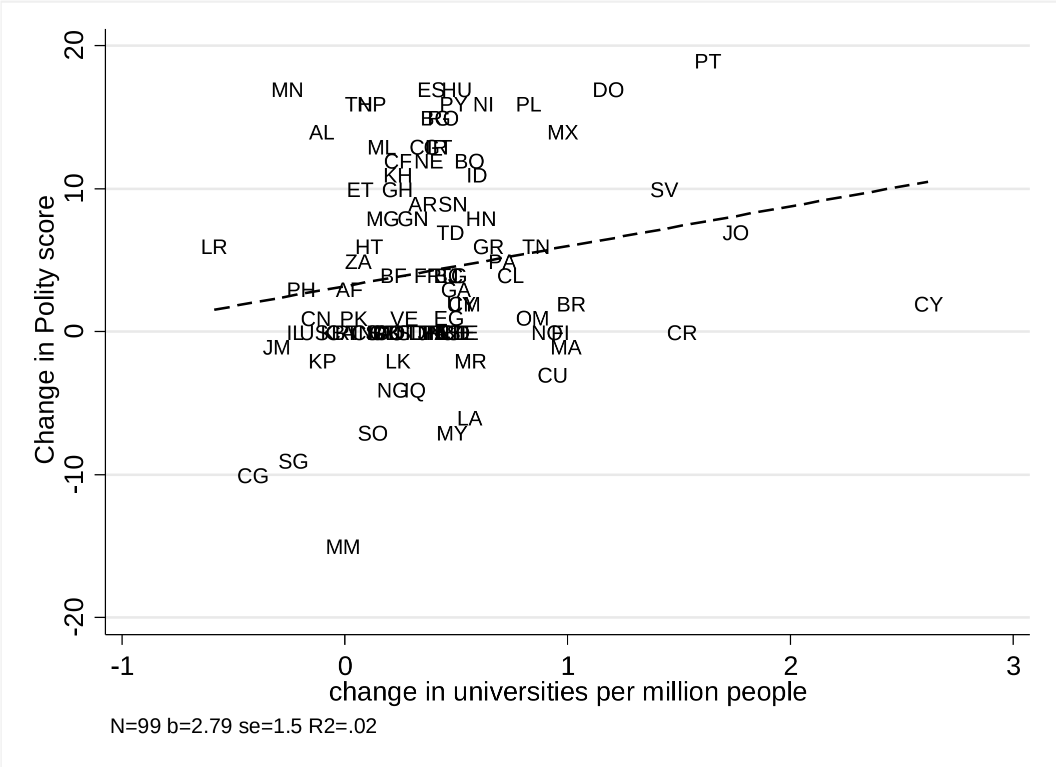
Notes. This chart shows the evolution of university density (universities per million people) and GDP per capita over time. *Source: WHED and Maddison GDP per capita data.*

Panel B: University count trend



Notes. This chart shows the evolution of university count over time. *Source: WHED*

Figure A13: CHANGE IN UNIVERSITIES AND CHANGE IN DEMOCRACY



Notes. Each observation is a country in 2000. *Source: WHED and Polity 2 variable from Polity IV*

CENTRE FOR ECONOMIC PERFORMANCE
Recent Discussion Papers

1443	Marta De Philippis	STEM Graduates and Secondary School Curriculum: Does Early Exposure to Science Matter?
1442	Thierry Mayer Marc J. Melitz Gianmarco I.P. Ottaviano	Product Mix and Firm Productivity Responses to Trade Competition
1441	Paul Dolan Georgios Kavetsos Christian Krekel Dimitris Mavridis Robert Metcalfe Claudia Senik Stefan Szymanski Nicolas R. Ziebarth	The Host with the Most? The Effects of the Olympic Games on Happiness
1440	Jörn-Steffen Pischke	Wage Flexibility and Employment Fluctuations: Evidence from the Housing Sector
1439	Brian Bell John Van Reenen	CEO Pay and the Rise of Relative Performance Contracts: A Question of Governance
1438	Fadi Hassan Paolo Lucchino	Powering Education
1437	Evangelia Leda Pateli	Local and Sectoral Import Spillovers in Sweden
1436	Laura Kudrna Georgios Kavetsos Chloe Foy Paul Dolan	Without My Medal on My Mind: Counterfactual Thinking and Other Determinants of Athlete Emotions
1435	Andrew B. Bernard Andreas Moxnes Yukiko U. Saito	Production Networks, Geography and Firm Performance

1434	Zack Cooper Stephen Gibbons Matthew Skellern	Does Competition from Private Surgical Centres Improve Public Hospitals' Performance? Evidence from the English National Health Service
1433	Nicholas Bloom Raffaella Sadun John Van Reenen	Management as a Technology?
1432	Andrew B. Bernard Toshihiro Okubo	Product Switching and the Business Cycle
1431	Fabrice Defever Alejandro Riaño	Protectionism through Exporting: Subsidies with Export Share Requirements in China
1430	Andrew B. Bernard Renzo Massari Jose-Daniel Reyes Daria Taglioni	Exporter Dynamics and Partial-Year Effects
1429	Cletus C. Coughlin Dennis Novy	Estimating Border Effects: The Impact of Spatial Aggregation
1428	Alan Manning	The Elusive Employment Effect of the Minimum Wage
1427	Decio Coviello Andrea Guglielmo Giancarlo Spagnolo	The Effect of Discretion on Procurement Performance
1426	Andrew B. Bernard Andreas Moxnes and Karen Helene Ulltveit-Moe	Two-sided Heterogeneity and Trade
1425	Stephen Machin Sandra McNally Martina Viarengo	"Teaching to Teach" Literacy

The Centre for Economic Performance Publications Unit
Tel 020 7955 7673 Fax 020 7404 0612
Email info@cep.lse.ac.uk Web site http://cep.lse.ac.uk