Universities as engines for regional growth? Using the synthetic control method to analyze the effects of research universities

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Abstract

Are research universities important for regional growth and development? We study the impact on the regional economy of granting research university status to two former university colleges in two different regions in Sweden. We analyze the development in the treated regions compared to a set of control regions that are created using the synthetic control method. We find small or no effects on the regional economy. Our findings cast doubt on the effectiveness of research universities in fostering regional growth and development. We contribute to the existing research by using a more credible identification strategy in assessing the effects of universities on the regional economy compared to what has usually been used in previous studies.

Keywords: Higher education, Local economy, Regional development, Research, University

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1. Introduction

Is a research university an important and significant engine for regional innovation, growth, and development? Among policymakers and to some degree in the university community there is a strong tendency to consider universities as essential in fostering regional innovation and growth. This hypothesized link is frequently used in context to attract and motivate increases in public and private grants and expenditure on research universities (cf. Ducker and Goldsten, 2007; Power and Malmberg, 2008). Among economists, regional economic development has attracted substantial interest following the seminal work by Krugman (1991). One active area of research in this theme has concerned the effects of universities on the local and regional economy (see Ducker and Goldstein, 2007, for an overview). In the present paper, we investigate the effects on the regional economy of granting research university privileges to two Swedish University Colleges in 1999, using the synthetic control method (SCM).

Universities play a central role for knowledge accumulation, not only as producers of basic research, but also by creating human capital in the form of highly skilled labor. Locally and regionally universities may influence the economy via a number of mechanisms, which are not mutually exclusive. Drucker and Goldstein (2007) summarized these activities and mechanisms in: (1) creation of knowledge, (2) human-capital creation, (3), transfer of existing know-how, (4) technological innovation, (5) capital investment, (6) regional leadership, (7) knowledge infrastructure production, and (8) influence on regional milieu.

For example, knowledge spillovers and human capital development may be important locational attractors for private sector research and development and high technology production. Specifically, some research findings may be difficult to transfer to industry without frequent face-to-face contact between university and industry. This aspect of knowledge transfer encourages commercial startups to locate in the vicinity of university research centers. Additionally, there is a tendency for graduates with advanced degrees to remain and work in the local area, which is a potential important mechanism for increasing local and regional human capital. Scientists and engineers who stay in the area help to transfer university research findings to local firms, or they may work in industrial labs. But while universities contribute to innovation, it is less clear if they contribute specifically to regional innovation. As pointed out by Power and Malmberg (2008), there are few reasons to assume that innovation in one region will make that same region the site for economic exploitation of the innovation. Furthermore, standard models of spatial equilibrium suggest that mobile workers and firms will arbitrage the benefits associated with local policies and we should thus not expect large effects of local policy (Rosen 1979, Roback 1982).

Empirically, recent models of local multipliers suggest that there may be positive effects of, for example, firm placement on the local economy, indicating important regional economic effects of universities (Moretti 2010, 2011). However, there are a number of conflicting results in the literature. Anselin et al. (1997) find a link between university research and innovative activity in the US using cross-sectional data from 1982. Woodward et al. (2006) find a small positive relationship between university research and plant localization using US data from 1997–2000. Goldstein and Renault (2004) find no support for a relationship between universities and regional economic development in the US (1969–1998). For the period 1986–1998 they do, however, find that average earnings tend to increase somewhat more in areas where a research university is located. Using a similar approach, Drucker (2015) studied the relationship of US higher education activities and regional economic performance 2001–2011, finding a weak relationship to regional economic development. Using German panel data, Schubert and Kroll (2014) study the effects of higher education institutions in 2000–2011 using fixed effects as well as spatial lags, and find very large effects on regional GDP per capita and unemployment. Using instrumental variables and fixed effects estimations, Anderson et al. (2004, 2009) find that increases in the number of employed researchers in a region increased regional output in Sweden, 1985–1998. In a review of the literature, including case studies, studies based on knowledge production functions, and cross sectional studies, Drucker and Goldstein (2007) find that the evidence is mixed, but that there may be some evidence that regional economic development is improved by higher education institutions, even though the strength of the evidence-base is not particularly high. A general empirical challenge in the above cited studies concerns issues of endogeneity, specifically that there are unobservable characteristics that influence both regional economic development and the establishment of new research universities and/or substantial increases in research funding.

The aim in our paper is thus to use the synthetic control method (SCM) to address the issue of endogeneity and attempt to estimate the causal effect on regional economic effects of universities and other higher education institutions. To our knowledge, the only existing study using credible techniques for causal inference is Shimeng (2015). Using the SCM and event study methods, Shimeng (2015) find negligible effects of US universities on local output in 10 years, but clear increases in productivity over an 80-year period. Our goal here is to estimate the effects of two Swedish universities, which were granted university rights in 1999, on regional GDP per capita. Sweden is subdivided into 21 central executive administrative divisions (we will refer to these as regions for the remainder of the paper). Exploiting this regional division will allow us to study the regional effects of the 1999 university reform intervention by comparing treated regions (where new research universities were established) to unaffected control regions. To credibly identify the effects of the research universities, we use the SCM developed by Abadie et al. (2010), which presents a way to systematically choose comparable comparison units in comparative studies. For unbiased effect estimation, conventional panel data estimators require strong assumptions of either time invariant confounding or common trends in the outcome of interest between treated regions and their comparison units. Finding a single comparison unit or a set of controls that are not in violation of these assumptions can be difficult, especially in small samples. In contrast, SCM allows for the relaxation of the assumption of time invariant confounding, and by the construction of a synthetic control region from a set of potential controls, it also increases the probability that the common trends assumption holds. This is achieved by selecting a donor pool of potential controls and constructing the synthetic control region based on its (weighted average) comparability to the treated region in terms of pre-intervention outcome trajectory and covariates.

Our main objective is to study the effects on regional economic development. To do this we first study the effects of gaining university status on intermediate university-related outcomes such as region-specific awarded doctoral degrees and number of professors. We consider these intermediate outcomes as potential causal mechanisms from the intervention to the end-point effects on the regional economy measured as growth in regional GDP per capita. We find robust evidence that the transition to research university status increased the number of awarded doctoral degrees and the number of professors in the regions. Following the arguments in Drucker and Goldstein (2007) we thus find support for two of the factors argued to be important for the regional economy: (1) creation of knowledge and (2) human-capital creation. This suggests that the university status had an actual effect on the research possibilities in the treated regions. We also studied whether giving the two university colleges research university status had an effect on intermediate entrepreneurial outcomes that could affect the regional economy (local patent applications and firm startups). Here we find no or very minor evidence of an effect on these outcomes. Thus, in terms of the mechanisms suggested Drucker and Goldstein (2007) we find no effects on (4) technological innovation. Lastly, we move on to investigating the primary outcome measure, regional GDP per capita, where we find no robust evidence of an effect of the two interventions during the 13-year follow-up period.

To some extent, these findings contradict previous research that has generally found small but positive effects of research universities on regional economic growth and development. One reason for this discrepancy might be that we, by using the synthetic control method, are able to control for confounding factors that previous studies have not been able to eliminate. Another possibility is that while we study the effect of being granted research university status and the consequent influx of research competence, previous studies have often focused on the influx of students in the local area. Thus, while there may be an effect on the local economy of an influx of students, we find no effect of an influx of research competence, at least not in the time period studied here.

In the next section we describe the Swedish university system in general and the universities in the focus of our study in more detail. In section three we describe the synthetic control method, the data that we use, and how we implement the method. In section four we present the results of our analysis, and section five concludes the paper with a discussion of our findings.

2. The Intervention: The Swedish 1999 university reform

The Nordic countries, including Sweden, spend a relatively large amount on higher education and the cost per student at the university level was estimated at around 21,000 USD in year 2011. This can be compared to the OECD average of 14,000 USD and the top figures in the US at 26,000 USD (UKÄ, 2015). Higher education in Sweden is conducted at 16 public universities and 19 university colleges as well as another set of art and theological institutions. Formally, the main difference between a research university and a university college is that the former have formal rights to award two-year master's degrees and PhDs, whereas the latter may be allowed to do this for a restricted number of subjects and only after a specific application and review by the Swedish Higher Education Authority. The oldest university in Sweden is Uppsala University, which was founded in 1477; the youngest universities include those of Karlstad, Örebro, and Linneaus (given university rights in 1999) and Mid Sweden (founded in 2005). A small fraction of the universities and university colleges are organized as private foundations, although these are similar to other universities in that they still operate under the same laws, are publicly tax-funded, and have no tuition fees for domestic students or students from the European Union.

This paper focuses primarily on the regional economic effects of being granted research university status using the 1999 university reform as a natural experiment. In the 1999 university reform the government awarded university rights to the colleges in Karlstad, Örebro, and Växjö (Linneaus). For the analysis we focus on the effects of the establishments of universities in Örebro and Karlstad and exclude Linneaus University. The reason for excluding Linneaus University is that it has a campus spread over multiple regions that has also changed over time. The university in Karlstad, situated in the city of Karlstad, which is the regional capital of the Värmland region with a total population of around 312,000, was founded as a university college in 1977. Today, the university has about 8,000 full-time-equivalent students and 1,000 full-time-equivalent employees. Örebro University is slightly larger with approximately 9,000 full-time-equivalent students, and is situated in the city of Örebro, which is the regional capital of the Örebro region with a total population of around 290,000. The former Örebro University College was founded in 1977.

The universities in Örebro and Karlstad started the application process to become research universities (from the former status as university colleges) at the end of the 1980s. The Swedish Higher Education Authority (under its former name) reviewed and evaluated the universities during the 1990s and recommended the Swedish government to grant research university rights to Karlstad University College but not to Örebro University College. Despite this recommendation, the government decided to promote both Örebro and Karlstad to full universities in the 1999 University Reform and they were officially founded on January 1, 1999 (VR, 2008).

A main reason for granting the former university colleges' research university status was that the government wanted a university in each Swedish region to function as a catalyst for regional innovation and growth. The regional growth program, as initiated by the Swedish government, is the main policy-steering document for regional innovation and growth issues and from 1999 onwards included the two universities as the key focal point in this work. The influx of research grants were to a substantial degree focused on sectors that was deemed especially important for the regions, e.g. for Karlstad University (the Värmland region) this included (i) paper and pulp, (ii) packaging, (iii) steel and engineering (van Vught et al., 2006).

As stated above, the main difference between a research university and a university college is that the former has a formal right to award two-year master's degrees and PhDs, whereas the latter may be allowed to do this for a restricted number of subjects and only after a specific application and review by the Swedish Higher Education Authority. Research university status also enabled the former colleges to advance with a number of expansions, including e.g. civil engineering programs (Karlstad University) and medical doctor programs (Örebro University). But maybe the most important difference is the higher government block research funding provided to research universities (UKÄ, 2015). Of the total governmental funding received by the 16 universities and 19 university colleges, approximately 86 percent is allocated to the universities. The funding mainly goes to the older and larger universities, but it has also substantially improved the research allocation to the universities in Örebro and Karlstad.

3. Empirical approach and data

3.1 The synthetic control method

To identify the effects of research universities on the regional economy we use the synthetic control method developed by Abadie and Gardeazabal (2003) and Abadie et al. (2010, 2015). The method builds on the idea that a weighted average of comparison units is a better control than any single unit or the average of all potential units. The selection of comparison regions is very important since using inappropriate control regions may lead to wrong conclusions (Abadie et al., 2015). To describe the synthetic control method we follow Abadie et al. (2010) closely. Let J+1 be the number of regions, indexed by j, and let j=1 be the treated region. The regions in the sample are observed for time periods t=1,2,...,T, where T_0 is the number of pretreatment periods. Next we define two potential outcomes: Y_{jt}^{I} is the outcome when region j in time t is exposed to treatment, and Y_{jt}^{N} the unobserved outcome in region j in time t if the region would not be exposed to treatment. The goal of the analysis is to measure the post-treatment effect in region j=1, defined as $\alpha_{1t} = Y_{1t}^{I} - Y_{1t}^{N}$. Since Y_{1t}^{N} is unobserved we have to construct it using the synthetic control method.

The synthetic control region is constructed as a weighted average of control regions j=2,...,J+1 from the donor pool of control regions, and represented by a vector of weights $W=(w_2,...,w_{J+1})'$ with $0 \leq w_j \leq 1$ and $w_2 + \cdot\cdot\cdot + w_{J+1} = 1$. Each choice of W gives a set of weights and characterizes a possible synthetic control. We want the synthetic control to reproduce the trajectory of the outcome variable and to be similar to the treated region on pre-treatment predictors of the outcome variable. Hence, let Z_j denote the vector of observed predictors for each unit in the sample. Now suppose that we find $W=W^*=(w_2^*,...,w_{J+1}^*)$ such that for the pre-treatment period $t \leq T_0$, then we can use $\hat{\alpha}_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt}$ as an estimator for α_{1t}.

Mathematically, the weights $\mathbf{W}^*$ are chosen such that the resulting synthetic region best approximates the region exposed to the intervention with respect to the pre-intervention outcome predictors (Z_j) and a linear combination of pre-intervention outcomes defined by the vectors $\mathbf{K}_1$, ..., $\mathbf{K}_M$. More precisely, if $\mathbf{X}_1$ is defined as a vector of pre-treatment variables for the treated unit $(\mathbf{Z}_1', \bar{Y}_1^{\boldsymbol{K}_1}, \dots, \bar{Y}_1^{\boldsymbol{K}_M})$ and $\mathbf{X}_0$ is defined as the corresponding matrix of these variables for the possible control units, the weight matrix is chosen to minimize $\|\mathbf{X}_1 - \mathbf{X}_0\mathbf{W}\|\mathbf{v} = \sqrt{(\mathbf{X}_1 - \mathbf{X}_0)'\mathbf{V}(\mathbf{X}_1 - \mathbf{X}_0\mathbf{W})}$, where $\mathbf{V}$ is a diagonal matrix introduced to allow different weights to the variables in $\mathbf{X}_0$ and $\mathbf{X}_1$ depending on their predictive power on the outcome (for more details, see Abadie and Gardeazabal, 2003; Abadie et al., 2010; 2014).

3.2 Data

For the main economic analysis, we use annual regional-level panel data for the period 1993–2011 covering all 21 Swedish regions (defined in Eurostat's Nomenclature of Territorial Units for Statistics [NUTS] as level 3 regions). Thus we have six years of pre-intervention data and 13 years of post-intervention data. Our sample period begins in 1993 since it is the first year for which data on the main variable is available (regional GDP/capita) and runs to 2011 (more recent data not fully available for all variables of interest). For the intermediate university-related outcomes measures, data for a longer pre-intervention period were available (back to 1977), and in these cases the pre-intervention period was extended. For the number of startups, data was available from 1994. We use data from Statistics Sweden (regional GDP/capita, investments, population, educated), the Swedish Higher Education Authority (number of students, number of doctoral degrees, number of professors), the Swedish Patent and Registration Office (patent applications), and Growth Analysis (startups). All variables are described in Table A1.

The unit of analysis in the present study is the region, and all variables are measured on the regional level. In some cases, more than one university is located in a region; in those cases, the variables are summed within each region. Following the arguments in Drucker and Goldstein (2007), we focus on three sets of outcome variables: 1) university-specific outcomes (number of students, number of doctoral degrees, and number of professors), 2) entrepreneurial outcomes (patent applications and startups), and 3) economic outcomes (regional GDP/capita). The variables included in the vector of pre-intervention characteristics are investments, population, and educated (share of population with at least some university education), in addition to values on the dependent variable for the years 1994, 1996, and 1998. For the outcomes number of doctoral degrees and number of professors there was no variation in the outcome variable between any of regions in the sample at some of these time points (e.g. they were 0 in all regions in 1994 and 1996). Thus, we simply matched these on the average of the pre-treatment outcomes instead.

3.3 Implementing the synthetic control method

Taking into account that Värmland and Örebro constitute the treated units, the set of units which were not exposed to the treatment and which may constitute the reservoir of potential comparison units must be established from the 19 remaining regions. First, we excluded the regions Jämtland and Västernorrland since they share a university college between them (that became a research university in 2005). Second, we excluded the regions Kalmar and Kronoberg. As described above, Kronoberg acquired a research university in 1999; however, in 2010 this was merged with a university college in the neighboring region Kalmar and is therefore not included in the analysis. Third, we exclude Norrbotten, which gained a research university in 1997. We also excluded those regions that have had research universities for a long time (Stockholm, Uppsala, Östergötland, Skåne, Västra Götaland, and Västerbotten), leaving us with a donor pool of eight Swedish regions (Södermanland, Jönköping, Gotland, Blekinge, Halland, Västmanland, Dalarna, and Gävleborg). We present the treated regions and the donor pool in Figure 1. Results from analysis including the regions with older research universities in the donor pool are very similar to the results presented here (available upon request).

The synthetic control regions, for Värmland and for Örebro, with respect to each outcome variable were assembled so that they best reproduced the most relevant characteristics of the two regions prior to the policy intervention. To this end, the following statistics were employed: (1) a set of observed covariates for each region to use as predictors of each variable outcomes above mentioned; (2) some linear combinations of pre-intervention outcome to control for unobserved common factors whose effects vary over time; and (3) a set of weights for each treated regions chosen to be positive and sum to one. Each particular value of the vector **W** represented a potential synthetic control; that is, a particular weighted average of control regions. Consequently, the resulting synthetic regions coincided with the weighted average of those units selected from the corresponding donor pool because they were associated with positive weights. So, for instance, the synthetic Örebro corresponded to weighted averages of available control units that best reproduced the most relevant characteristics of that region prior to 1999.

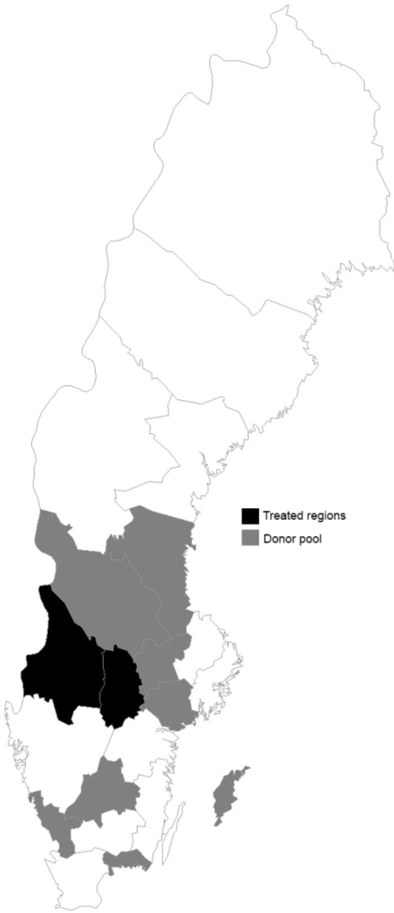

Figure 1. A map of Sweden with regional administrative divisions, highlighting the two treated regions and the donor pool

While all weights utilized to construct the synthetic control groups are presented in Table A3, some further details must be provided in relation to points (1) and (2). Starting from point (1), the set of predictors of the outcome variables are population size, education level, and per capita investments, which are some of the determinants of economic growth as suggested by e.g. Barro (1997). All three predictors are used in the estimations of economic effects, while investments are not used as a predictor for education outcomes at the university level. Data availability for Swedish regions makes the predictors list rather short. Consequently, if not controlled for, other confounders may certainly have biased the estimation. However, using a linear factor model – as prescribed by point (2) – this problem can be sufficiently overcome. In fact, matching on pre-intervention values of the outcome controls for unobserved factors and for the heterogeneity of the effect of the observed and unobserved factors on the outcome of interest. In fact, if units are alike in both observed and unobserved determinants of the outcome variable as well as in the effect of those determinants on the outcome variable, they will produce similar trajectories of the outcome variable over extended periods of time (Abadie et al., 2010; 2014). To this end, specific values of the outcome variables in the pre-intervention period were used as predictors (1994, 1996, 1998). Further exercises, not reported here, were performed by using different time points without obtaining substantively different results. Hence, the credibility of the synthetic Värmland and Örebro has been measured with respect to their ability to track the treated unit's outcomes trajectories as well as the predictor values in the 1994–1998 period. That being done, the discrepancy between the outcome trajectories for the treated units and the synthetic ones in the post-intervention period can be interpreted as the impact of the Research University policy.

The final step of the empirical strategy are robustness checks based on placebo techniques. According to Abadie and Gardeazabal (2003) and Abadie et al. (2010; 2015), placebo techniques must be employed under the assumption of the principle of permutation inference. This implies that the synthetic control procedure is iteratively applied to every potential control unit. Specifically, in each iteration the treatment policy here examined was reassigned to one of the units of that control group. Then, the effect associated with each placebo was computed in order to construct a distribution of estimated impacts for the untreated regions. By so doing, the effect, respectively estimated for Värmland and Örebro could be contrasted with those estimated for a region chosen at random. Hence, if the placebo results showed gaps wider than those estimated for the Värmland and Örebro outcomes, no significant evidence would support the impact estimated for these same regions.

4. Results

We construct synthetic control regions that best reproduces the values of the predictors for each outcome variable of interest in the pre-intervention period. We estimate the effect of gaining research university rights on the outcome variables as the difference between each outcome variable in each treated region and its synthetic versions in the years after the 1999 intervention. In tables A2 and A3 we present the predictor balance and regional weights for all analyses in the paper. In Figure A1 we present placebo analyses.

4.1 Intermediate university-related outcomes

As a first step we will look at the university-related outcomes (number of students, number of doctoral degrees, number of professors) for both treated regions. This will give us a better understanding of what happened when the treated regions went from only having university colleges to having research universities. Figure 2 presents the results for the two treated regions.

Regarding the number of students, the synthetic controls do not closely match the treated regions in the pre-intervention period, except for a few years in close proximity to intervention. For the number of doctoral degrees and professors, however, the pre-intervention period is very similar between the treated regions and their corresponding synthetic controls. Predictor balance (Table A2) in the pre-intervention period is also reasonably similar in the treated regions and the synthetic versions for the pre-treatment control variables (population and educated). Thus, the treated regions and their synthetic counterparts are comparable in the pre-intervention period (weights on donor pool regions are presented in Table A3). In both treated regions we see clear effects on number of doctoral degrees and number of professors, but not on the number of students. In the placebo studies (Figure A1) we can also see that these effects are large compared to the effects in the non-treated regions. These results illustrate the reform clearly: it did not cause an increase in the total number of students in the two regions, but rather an influx of resources for research.

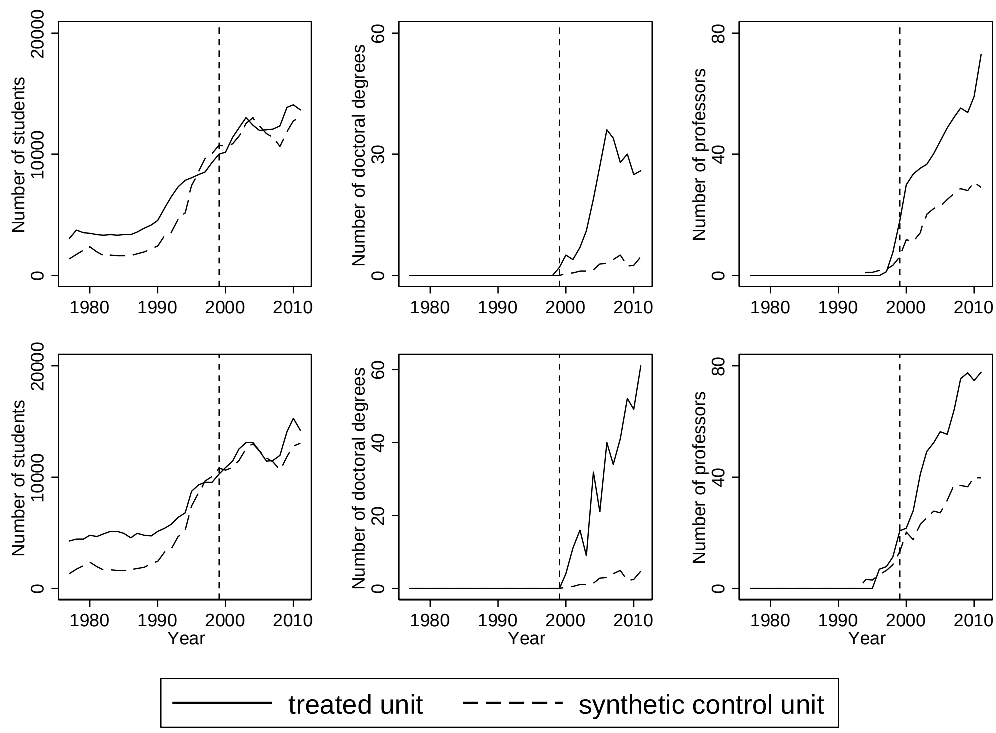

Figure 2. Effects of becoming a research university on intermediate university-related outcomes, Värmland (top panel) and Örebro (bottom panel)

4.2 Intermediate entrepreneurial outcomes

In Figure 3 we present findings regarding a set of intermediate entrepreneurial outcomes for Värmland (top panel) and Örebro (bottom panel). We find no effect on patent applications in Värmland, but in Örebro there seems to have been a positive effect on this outcome, which is still evident when considering the placebo graphs in Figure A1. However, the relatively bad pre-fit (probably due to much variation in these variables in the pre-period) calls for caution in interpreting this finding. Regarding the number of startups, we have a somewhat better pre-treatment fit and the results show no effect on the number of startups in either region.

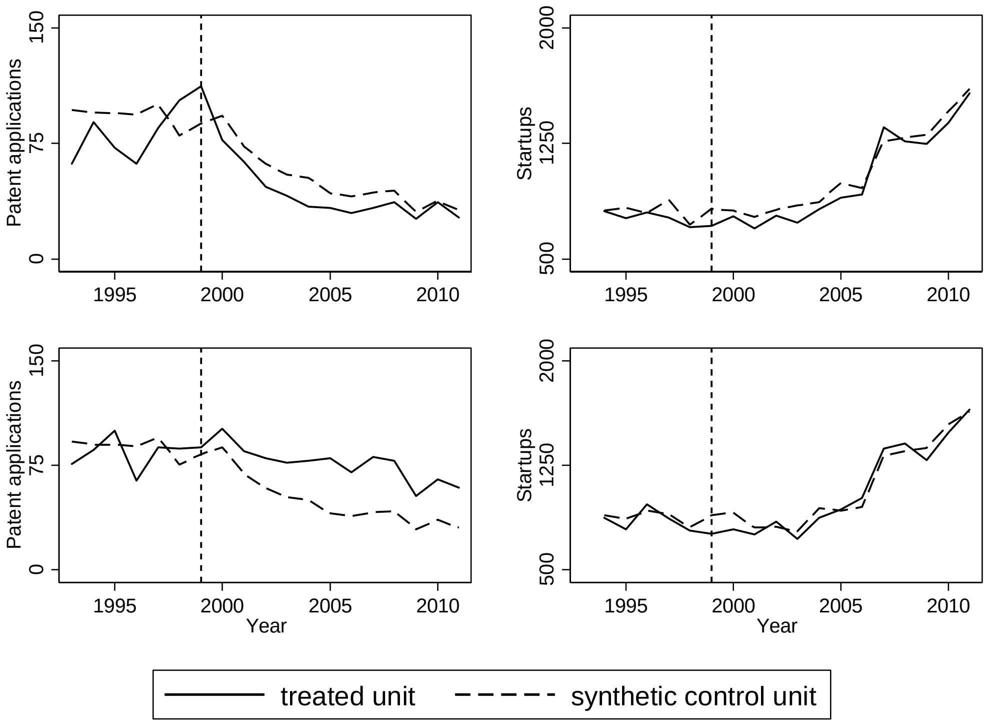

Figure 3. Effects on intermediate entrepreneurial factors of getting a research university in Värmland (top panel) and Örebro (bottom panel)

4.3 Economic outcomes

Finally, we study the effects on the primary outcome measure. In Figure 4 we present findings regarding economic outcomes for Värmland (left) and Örebro (right). As for the university-specific outcomes, the synthetic controls reasonably track the treated regions in the pre-treatment period, and the predictor balance (Table A2) in the pre-intervention period is also reasonably similar in the treated regions and the synthetic versions. As is evident from the near-perfect fit between the synthetic controls and the treated units during the entire post-intervention period in both regions, we find no evidence of an effect of the interventions on regional GDP per capita.

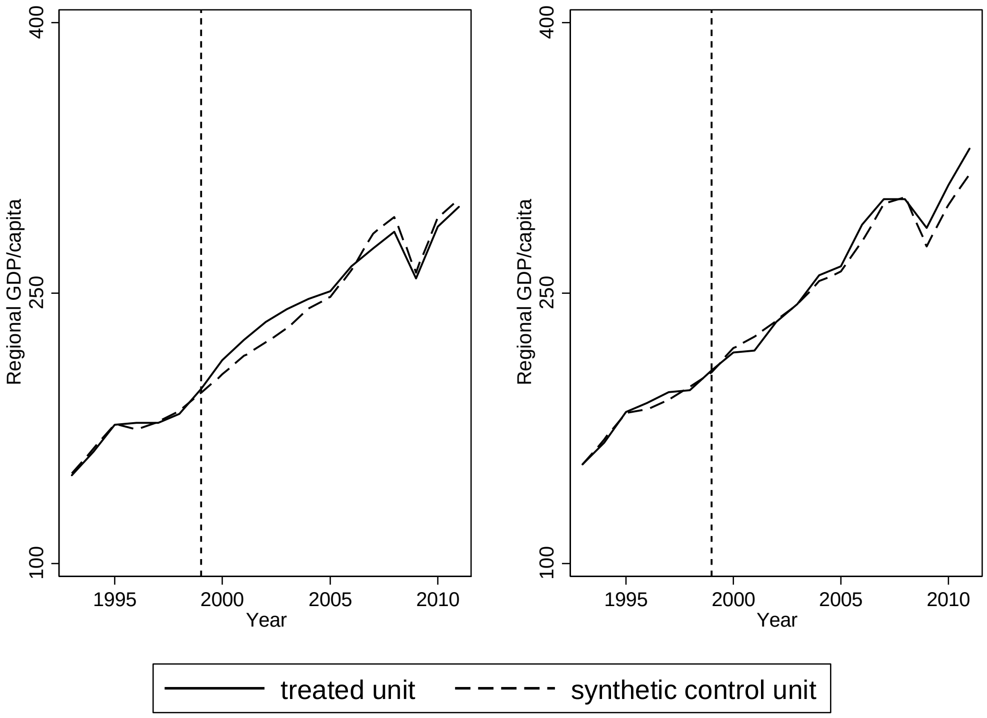

Figure 5. Economic effects of getting a research university, Värmland (left) and Örebro (right)

5. Concluding discussion

Our study finds no effects of granting research university status to university colleges on the regional economy. In our analysis of intermediate factors, we find robust evidence that the intervention caused a research competence (in the form of awarded PhDs and professorships), whereas the number of students, patent applications, and firm startups appear unaffected. This suggests that the increases in research funding and formal competence (and potentially human capital) did not have any detectable effects on the regional economies over the 13-year post-intervention period. Given that some previous studies find at least some modest positive regional effects of higher education institutions (see e.g. Drucker and Goldstein 2007 for a review) and a Swedish study of more distant increases in research personnel finds positive impacts on regional economies (Anderson et al. 2004, 2009), the question must be: why might our results be different?

One possibility could be that we use a more credible identification technique than other studies, thus being better able to identify the true causal effect. Furthermore, we do not study the effects of higher education institutions per se, but the effects of more advanced degrees and research in the local region. As clearly shown in the intermediate analyses, we do not study the effects of an increase in the number of students in the region on the regional economy. Thus, while there may be effects on the local economy of an influx of students, we find no effects of an influx of more research. Another possibility is that a 13-year period is not long enough for the benefits to be evident, as suggested by Shimeng (2015). Further, the fields of specialization of research universities may also be important for regional economic effects. The universities of both Karlstad and Örebro are dominated by research in the social sciences (48–52 percent of PhDs awarded are in the social sciences), which contrasts with the relatively greater focus on sciences, technology, and medical science of some of the older universities in Sweden.

The lack of effects on the regional economy does not mean that higher education does not benefit the economy as a whole. As argued by Drucker (2015), interregional migration may be a reason for small or no regional economic effects of universities, making the benefits of universities not region specific. In a recent report on student choice in Sweden, Pokarzhevskaya and Regnér (2015), find that at most universities only about 30 percent of the students still live in the region where they studied 10 years after initiating their university studies. Thus, even though student quality may increase, this does not necessarily benefit the region. This is something that may explain our findings of no regional economic effects.

In sum, and to the extent that our findings can be generalized, our findings cast some doubt on the potential of universities to contribute to regional innovation and regional economic growth. Even though universities increase knowledge production, new scientific results, innovations, and skilled workers, it is not clear that the benefits are regional. As argued by Power and Malmberg (2008: 243): "The role of the university in regional economic development is more related to the fact that a world class university will bring manifold material and immaterial advantages to its host region than to some systemic logic according to which we should expect the world-class research carried out in universities to result in innovations that get exploited as economic activities in precisely that region. In this sense, therefore, the problem at hand might not be regional after all, and policy should perhaps focus more on promoting global excellence in each of the three spheres of research, innovation and value creation than on fine-tuning their local interplay."

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Appendix

Table A1. Variable description

Variable	Description	Source
University-specific outcomes		
Number of students	Number of enrolled students	The Swedish Higher Education Authority
Number of doctoral degrees	Number of awarded doctoral degrees	
Number of professors	Number of full professors	
Economic outcomes		
Regional GDP/capita	Regional Gross Domestic Product, current prices, SEK millions	Statistics Sweden
Entrepreneurial outcomes		
Patent applications	Number of patent applications	The Swedish Patent and Registration Office
Startups	Number of started firms	Growth Analysis
Control variables		
Investments	Per capita industrial investments, SEK	Statistics Sweden, processed by Regionfakta
Population	Number of inhabitants	Statistics Sweden
Educated	Number of inhabitants with at least some university education	

Note: All variables are aggregated on the regional level (NUTS3).

Table A2. Predictor balance

	Synthetic control by outcome variable							
	Real treated unit	**Average in donor pool**	**Number of students**	**Number of doctoral degrees**	**Number of professors**	**Regional GDP/capita**	**Patent applications**	**Startups**
Panel A: Värmland								
Population	283	236	246	223	219	259	261	283
Educated	14095	11582	13579	11127	11130	12784	12681	14095
Investments	8180	5350	.	.	.	4361	5523	6257
Panel B: Örebro								
Population	276	236	246	223	285	270	251	276
Educated	14357	11582	13579	11127	13676	12662	12208	13226
Investments	5184	5350	.	.	.	4674	5346	6138

Table A3. Region weights for synthetic control groups

	Number of students	Number of doctoral degrees	Number of professors	Regional GDP/capita	Patent applications	Startups
Värmland						
Södermanland	0	.143	.018	.648	0	0
Jönköping	0	0	.186	.098	0	.033
Gotland	0	.143	.006	.042	.082	0
Blekinge	0	.143	.008	0	0	0
Halland	0	.143	.442	.212	0	0
Västmanland	1	.143	.015	0	.213	.279
Dalarna	0	.143	.024	0	.705	.04
Gävleborg	0	.143	.300	0	0	.648
Örebro						
Södermanland	0	.143	0	.27	0	0
Jönköping	0	0	.617	.299	0	0
Gotland	0	.143	0	.096	.126	0
Blekinge	0	.143	.173	0	0	.091
Halland	0	.143	.21	0	0	0
Västmanland	1	.143	0	0	.197	0
Dalarna	0	.143	0	.335	.676	.909
Gävleborg	0	.143	0	0	0	0

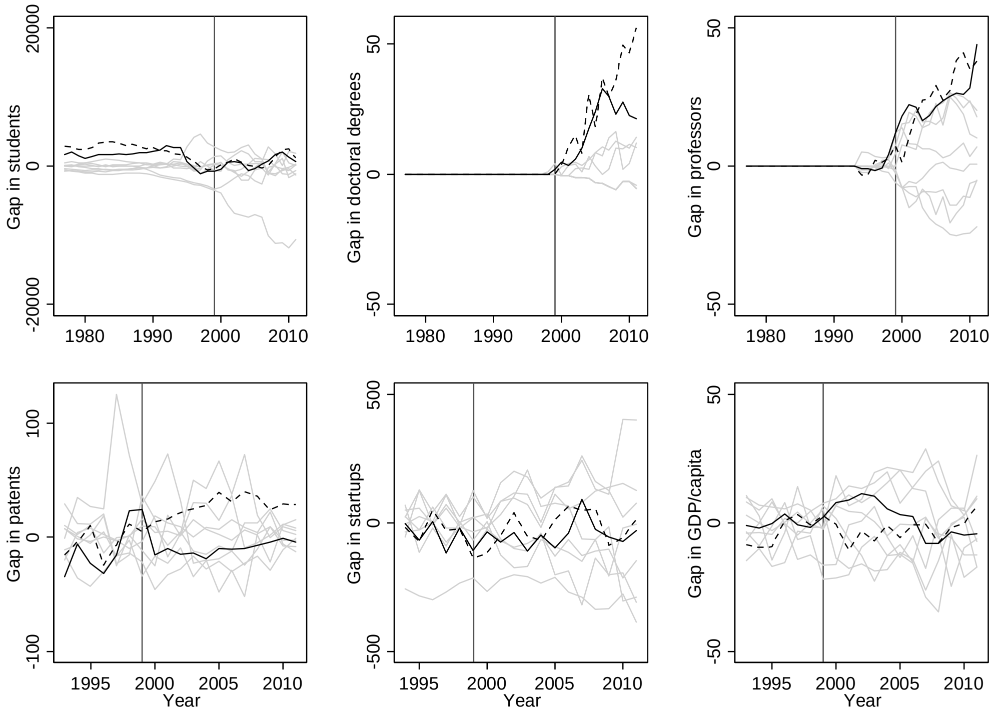

Figure A1. Gaps in Värmland (black) and Örebro (dash), and placebo gaps (grey)