Motu

# Higher education institutions and regional growth: The case of New Zealand

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**Abstract**

We examine the relationship between the presence of Higher Education Institutions (HEIs) and local growth, using a sample of 57 New Zealand Territorial Local Authorities (TLAs) between 1986 and 2013. Our models include a large set of controls, including past growth. An innovation of our approach is that we include official population projections as a control to account for growth-related factors that were perceived at the time by policy makers, but are otherwise unobservable to the econometrician. Holding all else equal, we find that a greater university share of Equivalent Full Time Students (EFTS) to working-age population raises population and employment growth. At the means, a one percentage point increase in university EFTS share is associated with a 0.19 (0.14) percentage point increase in the annual average population (employment) growth rate. This relationship holds under all alternative specifications, including different HEI activity definitions, samples, and specifications. On the other hand, growth related to polytechnic activity was estimated less precisely, and is much smaller. While our results suggest a positive association between university activity and growth, we find no evidence for complementarities between HEI activity and several indicators of urbanisation and innovation, nor do we find evidence that HEI presence affected the industrial (sectoral) structure of the local economy.

**JEL codes**

I25, J11, R11

**Keywords**

Universities; Polytechnics; Regional Growth, Patent Activity; Skilled Workforce

**Summary haiku**

Universities

Bring extra population

And more employment

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# 1 Introduction

Can Higher Education Institutions (HEIs), such as universities and polytechnics, bring about better economic outcomes in their hosting areas? This possibility is of interest to national policy makers who consider strategies for promoting local development, and for local policy makers wishing to attract people and jobs to their local area. We provide new information that helps to answer this question by estimating the relationship between the presence of Higher Education Institutions (HEIs) and local growth, using a sample of 57 New Zealand Territorial Local Authorities (TLAs) between 1986 and 2013. We find that, holding all else equal, TLAs with a higher ratio of university Equivalent Full Time Students (EFTS) to working-age population experience faster population and employment growth. We estimate growth using demographic rather than monetary variables, reflecting the idea that a well-performing area is one that is consistently able to attract and retain population and workers.

We test this relationship using various specifications, including alternative samples, HEI variable definitions, and estimation techniques, including Ordinary Least Squares (OLS), Weighted Least Squares (WLS), and difference Generalised Method of Moments (GMM). Within these specifications, we control for local time-invariant factors, national and local time-variant factors, and for lagged growth, with the latter included to control for the possibility of reverse causality (i.e. growth leading to increased HEI activity). In an innovative approach to capture unobserved, local time-variant factors, we also include the five, ten and twenty year official (medium) population projections that were publicly available in each period. We use these projections to control for the possibility that variation in HEI activity could be driven by perceived future potential (rather than current, past, or long term performance) of the area, noting that official projections often play a role in shaping strategies and actions taken by policy makers. Across all specifications, we find a positive and non-linear (concave) relationship between the relative size of the university EFTS population and local growth. At the means, a one percentage point increase in the university EFTS share is associated with a 0.19 (0.14) percentage point increase in the annual average population (employment) growth rate. We find similar patterns for increases in polytechnic EFTS shares, although these were weaker and estimated far less precisely.

Next, we investigate whether the effect of HEI activity varies across large and small metropolitan areas. We remove the two smaller, university-dominated TLAs (Palmerston North and Dunedin Cities) from the sample. We estimate a similar linear relationship where a one percentage point increase in the university EFTS share is associated with a 0.13 (0.09) percentage point increase in the annual average population (employment) growth rate. We further investigate complementarities by testing a number of specifications which interact HEI activity with various proxies for local urbanisation and innovative activity. We find no evidence for such growth-related complementarities, or that HEI activity influences the local industrial employment shares.

Our results can be interpreted in the context of endogenous growth models (Romer, 1986; Lucas, 1988; S. T. Rebelo, 1991; S. Rebelo, 1998). In these models, HEIs can contribute positively to growth by increasing the local stock of knowledge and human capital (Mankiw et al., 1992; Glaeser et al., 1992; Glaeser et al., 1995; Doppelhofer et al., 2000; Barro, 2001; Gregorio and Lee, 2002). For example, research and development (R&D), training of workers, or linking graduates to business can all improve the economic performance of an area. Furthermore, HEIs may enhance quality of life by improving the local stock of civic amenities (e.g. theatre halls, galleries, etc.) and natural amenities (through conservation projects).

Spillovers from HEIs to their hosting areas may occur if the (growth-relevant) output produced is *tacit* (Jacobs 1969); that is, if benefits produced are geographically-bounded, i.e. agents located near HEIs can more cheaply and easily utilise their intellectual output (Jovanovic and Rob, 1989; Jaffe, 1989; Jaffe et al., 1993; Glaeser, 1999; Deltas and Karkalakos, 2013). Holding all else equal, the productivity of these local agents can be expected to increase, leading to faster overall growth in these areas (Karlsson and Andersson, 2007; Wang, 2010[1]).

However, it is possible that geographical proximity is insufficient to promote growth if other local conditions (e.g. political, social, institutional, etc.) are unfavourable (Fagerberg 1987; Nelson and Phelps 1966; Benhabib and Spiegel, 1994; Fagerberg et al., 1997; Asheim and Gertler, 2006; Ascani et al., 2012; Rodríguez-Pose, 1999). For example, several studies examining sub-national regions across Europe have found that, while the rate of return to education was similar across all regions, returns to R&D investment were only positive and significant in less peripheral regions which had a large pre-existing proportion of educated workers and high patent density (Crescenzi, 2005; Sterlacchini, 2008; Rodríguez-Pose and Crescenzi, 2008, Duch et al, 2011).

Our study builds on this prior work and is organised as follows. Section 2 provides an outline of New Zealand's tertiary education system. Section 3 describes our estimation strategy and sample. Section 4 provides descriptive statistics. The main results of the analysis are discussed in section 5. Finally, section 6 summarises and discusses our main findings.

[1] Wang found that fastest growth was recorded for counties hosting HEIs that offered business degrees and Master/Doctoral level qualifications.

# 2 Tertiary education in New Zealand

The New Zealand tertiary education system ranges from foundation studies and industry training up to doctoral (PhD) degree qualifications (Ministry of Education, 2006). Tertiary education services are provided by a variety of publicly funded (e.g. universities, polytechnics, institutes of technology, colleges of education, wānanga[2]) and privately funded tertiary institutions. In 2016, there were 8 universities,[3] 16 polytechnics,[4] 3 wānanga,[5] and several hundred private training establishments operating in New Zealand (NZQA 2016).

New Zealand universities, like those in most OECD countries, focus on advanced training and research. New Zealand colleges of education specialise in training teachers, whereas polytechnics and institutes of technology place greater focus on vocational training. Private training establishments provide a wide variety of courses (mostly below bachelor degree level), while wānanga deliver an array of qualifications in a Māori cultural context.

Historically, this categorisation of institutions was more defined, with universities being the only type of institution legally empowered to train at bachelor degree level or above. Furthermore, universities were the only type of institution obliged to conduct research in exchange for receiving public funding (Taonga, 2015). However, reforms in the Education Act (New Zealand Parliament, 1989) removed these restrictions, enabling all tertiary providers to offer courses at all levels, provided they satisfy certain criteria.

Despite these regulatory changes, universities retain a stronger focus on training at higher levels. For example, between 2007 and 2014, 95% of all university Equivalent Full Time Students (EFTS) were studying towards a bachelor degree qualification or above.[6] This contrasts with only approximately a quarter of all polytechnics EFTS (including institutes of technology) and under a tenth of all wānanga and private training establishments students (MoE, 2015). Universities also remain dominant in R&D, accounting for approximately half of New Zealand's research staff (Hughes, 2012), and almost all PhD students (MoE, 2015).

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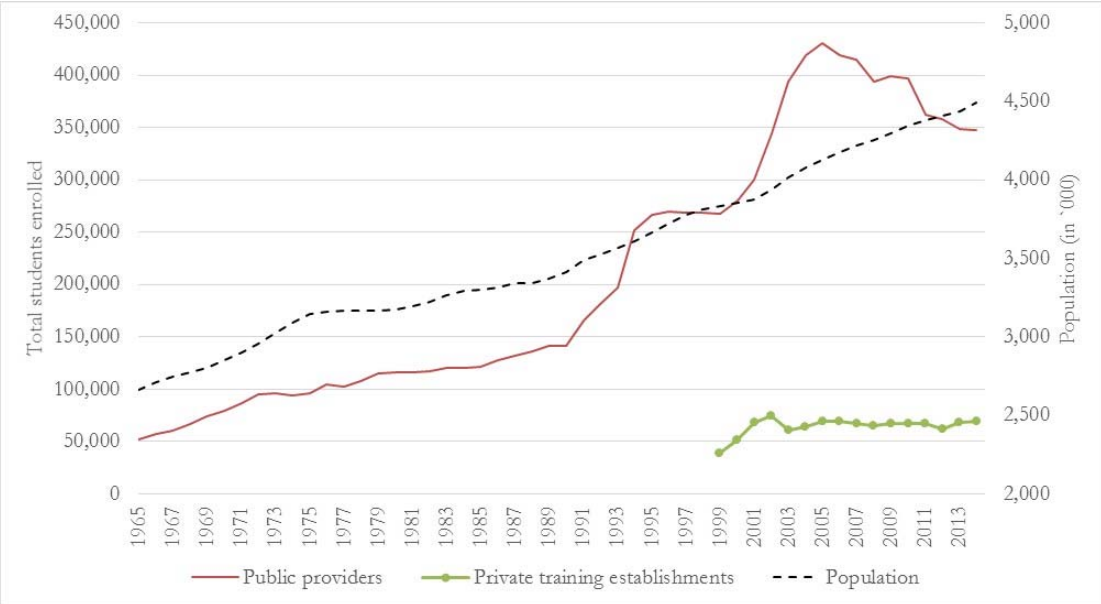
2 A wānanga is a tertiary educational institution that delivers (mostly non-degree) qualifications in a Māori (indigenous) cultural context.
3 University of Auckland, Auckland University of Technology, University of Waikato, Victoria University of Wellington, Massey University, University of Canterbury, Lincoln University, and the University of Otago.
4 Ara institute of Canterbury, Christchurch Polytechnic Institute of Technology, Eastern Institute of Technology, Manukau Institute of Technology, Nelson Marlborough Institute of Technology, Northland Polytechnic, Otago Polytechnic, Southern Institute of Technology, Tai Poutini Polytechnic, The Open Polytechnic of New Zealand, Unitec New Zealand, Universal College of Learning, Waiariki Institute of Technology, Waikato Institute of Technology, Wellington Institute of Technology, Western Institute of Technology Taranaki, and the Whitireia Community Polytechnic.
5 Te Wānanga o Raukawa, Te Whare Wānanga o Awanuiārangi, and Te Wānanga o Aotearoa.
6 The Tertiary Education Commission decides if a course is either full-time or part-time by applying what is called an EFTS value to each course. The EFTS value is a measure of the amount of study or the workload involved in undertaking a course. A year of full-time study is usually between 0.8 EFTS and 1.2 EFTS. For more information see: http://www.studylink.govt.nz/about-studylink/glossary/efts-general-definition.html

One change evident in New Zealand's tertiary education institutes following the 1989 reforms was an increase in mergers (e.g. by 2007, all colleges of education had amalgamated with universities) and expansions (achieved primarily by establishing satellite campuses).[7]

Overall, in 2014 there were more than 360,000 domestic students, about a tenth of the working age population (MoE, 2015), participating in formal tertiary education. Figure 1 shows the total number of students enrolled in tertiary courses and the total population between 1965 and 2014.[8]

Figure 1: Students in formal tertiary education and population, 1965-2014




**Notes**: Student numbers are sourced from the Ministry of Education (2015). Population data are sourced from Statistics New Zealand's (2015) long term series (1965-1990) and official population estimates (1991-2014).

# 3 Estimation and sample

## 3.1 Estimation

Our approach for estimating the contributions of HEIs to their hosting area is based on insights from spatial equilibrium literature (Rosen 1979; Roback 1982; Overman et al., 2010; Grimes, 2014). We consider HEIs as a form of infrastructure, with the potential to improve both productivity and/or the stock of amenities in the hosting area.

For example, assume that a positive productivity shock is experienced in a hosting area following the establishment of a new HEI, or as a result of some growth-relevant output being

7 However, the vast majority of students still train at a main campus For example, between 2000 and 2012, 82-87% of the internal EFTS that were enrolled in tertiary education were trained at the main campus of a university or polytechnic (Ministry of Education, 2013).
8 Enrolment data from private training establishments was first collected by the Ministry of Education in 1999.

generated by an existing HEI. This shock increases the productivity of local firms, enabling them to pay greater wages to workers and/or to increase employment.[9] At the same time, local living costs initially remain unchanged. This incentivises individuals and firms to relocate to the area, increasing the local population and workforce. Eventually, migration flows increase the local cost of living, especially for non-tradable goods (e.g. land prices), so the benefits relative to the costs of locating in the area are fully exhausted, with no further incentive for others to migrate.[10] However, if agglomeration forces are sufficiently strong (Krugman, 1991), migration itself could lead to additional (positive) productivity shocks, in turn attracting more migrants. Thus the initial productivity shock could generate a self-reinforcing feedback loop (i.e. between migration, productivity, and economic growth). If these forces are sufficiently strong, long term differences in the rates of growth could arise between areas hosting HEIs and those that do not.

Reflecting the process just described, we estimate the benefits generated from HEIs in terms of population and employment growth; thus we evaluate the success of an area by its ability to attract and retain individuals and firms. Therefore, we estimate local growth over time as a function of local level characteristics in each initial period *t*:

$$\left(\frac{1}{s}\right)\ln\left(\frac{y_{j,t+s}}{y_{j,t}}\right) = \beta HEI_{j,t} + \lambda X_{j,t} + \zeta_j + \eta_t + \varepsilon_{j,t}, \quad \varepsilon_{j,t} \sim N(0, \delta^2); \quad s > 0 \tag{1}$$

For area *j* in period *t,* growth is defined by the annual average growth rate in population and employment between periods *t* and *t+s*. Growth is estimated as function of the degree to which HEIs ($HEI_{j,t}$) are present in the area, a set of time-variant local and surrounding area specific controls ($X_{j,t}$), time invariant area effects ($\zeta_j$), period effects ($\eta_t$), and an idiosyncratic error term ($\varepsilon_{j,t}$).

Universities (and most polytechnics) were established before the first year that we can observe (1986), and closures are rare. In addition, most institutions that were officially established after 1986 have evolved from smaller institutions (e.g. community colleges) previously operating in the area. Due to this low variation, simply including an indicator capturing whether an institution is physically present in the area is not likely to reveal meaningful relationships. To maximise the variability of the data, we instead capture the level of HEI 'presence' in an area by calculating the ratio of local EFTS to local working age population (i.e. aged 15 or above). We hypothesise that, holding all else equal, a greater share of EFTS population is associated with greater accumulation of knowledge and human capital, leading to a faster rate of growth. We capture differences in the relationship between different types of HEIs and growth by including these ratios separately for universities (including teacher's

9 Assuming that the benefits are (at least to some extent) tacit.
10 That is, changes in the cost of non-tradable goods is the balancing mechanism of this process.

colleges) and polytechnics (including institutes of technology). Finally, we include a quadratic term in order to capture non-linearities in relationships.

To isolate the effect of HEIs on local growth from other factors, we include period and area fixed effects to control for macroeconomic shocks and for time-invariant area specific features (e.g. climate, historical factors, etc.), respectively. In addition, we control for a number of local time variant demographic and labour market characteristics, as well as agricultural price shocks, and innovative activity at the (greater) regional level.

As the decision of where to establish an HEI is likely to be non-random, OLS estimates will be biased if other unobserved local characteristics correlate both with our HEI variables and with growth. We attempt to control for these biases by focusing on two aspects that may affect our results.

First, we recognise that the decision to establish (or expand the activity of) an HEI may reflect the local area's perceived growth potential.[11] We control for this possibility by including the official five, ten, and twenty year (medium) population projections produced by Statistics New Zealand, publicly available in each period $t$ (Statistics New Zealand, various years). Including these projections accounts for some of the factors that may have shaped the expectations (and thus unobserved actions) that policy makers had regarding the future performance of areas. These projections may also account for additional growth-relevant factors that were used to construct the projections that are not included in our model.

Second, we recognise the possibility of reverse causality between HEI presence and growth; that is, that the performance of the area may lead to changes in HEI activity. To help control for this possibility, we include the lagged dependent variable as an additional control, estimating the relationship between the presence of an HEI in the area and growth, conditional on local growth in the previous period:

$$\left(\frac{1}{S}\right)\ln\left(\frac{y_{j,t+s}}{y_{j,t}}\right) = \left(\frac{1}{S}\right)\ln\left(\frac{y_{j,t}}{y_{j,t-S}}\right) + \beta HEI_{j,t} + \lambda X_{j,t} + \zeta_j + \eta_t + \varepsilon_{j,t} \quad (2)$$

To correct for dynamic panel bias (Nickell, 1981), we use the difference GMM approach (Anderson and Hsiao, 1981; 1982), instrumenting the (differenced) lagged dependent variable with its twice lagged level (Arellano, 1989).

[11] For example, when Massey University was established in Albany (1993), the local population constituted fewer than 700 residents. However, it was known prior to the establishment that major expansions were planned for the area. Between the 1996 and 2013 census, the population grew on average by 9.4% each year, compared with 0.9% for New Zealand as a whole.

Our final specification explores heterogeneity in the relationship between HEIs and growth, arising from differences in local characteristics (Fagerberg, 1987). To account for such differences, we interact the HEI variables with other local characteristics:

$$\left(\frac{1}{S}\right)\ln\left(\frac{y_{j,t+s}}{y_{j,t}}\right) = \left(\frac{1}{S}\right)\ln\left(\frac{y_{j,t}}{y_{j,t-S}}\right) + \beta HEI_{j,t} + +\mu[HEI_{j,t} * Z_{j,t}] + \lambda X_{j,t} + \zeta_j + \eta_t + \varepsilon_{j,t} \qquad (3)$$

The interaction term, $\mu[HEI_{j,t} * Z_{j,t}]$, estimates the influence that hosting an HEI has on the area's future growth, given different levels of certain local characteristics ($Z_{j,t}$). This subset of local characteristics captures different aspects of 'urbanisation' (thousand inhabitants per $Km^2$, full time employment share in the Finance and Insurance industry) and 'innovation' (patent applications per 10,000 inhabitants; share of working age population with a bachelor degree or above).

## 3.2 Sample

Our sample consists of six waves of census data between 1986 and 2013,[12] aggregated to 57 Territorial Local Authorities (TLAs).[13] A TLA is an administrative/political, rather than an economic boundary. Therefore, studies that use these boundaries may suffer from measurement errors and/or spatial autocorrelation (Glaeser et al., 1995). Because of data limitations, we cannot test alternative geographic boundaries sometimes used in New Zealand regional studies, and our sample size limits our ability to apply spatial models. Instead, we remedy potential biases by amalgamating proximate urban TLAs. We do so where adjacent TLAs each contain sizeable urban populations – forming a cohesive economic unit in which individuals commute within our amalgamated TLA boundaries.

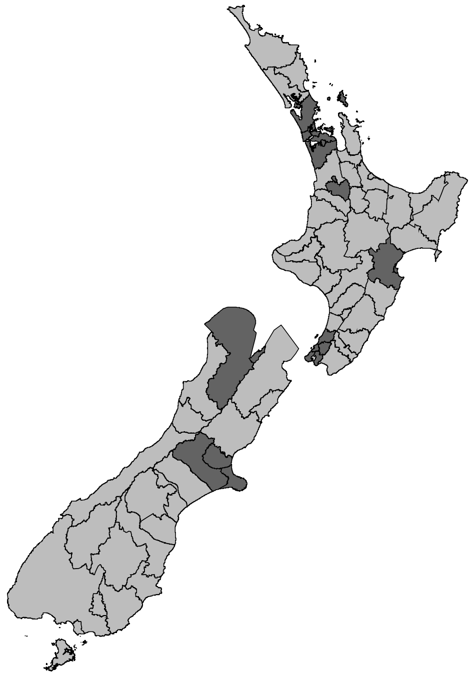
This procedure results in six amalgamated TLAs: Auckland (amalgamation of all TLAs within the former Auckland Regional Council area), Greater Hamilton (amalgamation of Hamilton City with Waipa District), Napier-Hastings (amalgamation of Napier City and Hastings District), Greater Wellington (amalgamation of Kapiti Coast District, Porirua, Upper Hutt, Lower Hutt, and Wellington Cities), Nelson-Tasman (amalgamation of Nelson City and Tasman District) and Greater Christchurch (amalgamation of Christchurch City, Banks Peninsula, Waimakariri, and Selwyn Districts).[14] Figure 2 maps the various New Zealand TLAs, highlighting the amalgamated areas in dark grey.

12 We use census population from 1981 in order to generate a lagged dependent variable in the first period (i.e. average annual growth rate between 1981 and 1986) in the difference GMM estimations. Unfortunately, we do not have employment figures from 1981, thus the estimation of employment growth (using difference GMM) is one period shorter.

13 A Territorial Local Authority is defined as a city council or district council. For more information, see Statistics New Zealand (2015).

14 We remove the Chatham Island Unitary Territory and Area Outside Territorial Authority from the sample as these are very small and different from all other TLAs. The Chatham Island Unitary Territory comprises a small group of islands over 700 Km Southeast of New Zealand's main islands, while the Area Outside Territorial Authority is a residual category for all values not allocated elsewhere.

Figure 2: New Zealand's Territorial Local Authorities (TLAs)



**Notes**: Amalgamated TLAs are in dark grey. From north to south, these are: Auckland, Greater Hamilton, Napier-Hastings, Greater Wellington, Nelson-Tasman, and Greater Christchurch.

Because of limitations in the information available on EFTS counts in wānanga and private training establishments in earlier periods, we do not include data from these institutions in the sample. We do not expect this exclusion to significantly affect our results, since the institutions that we do include account for over three quarters of the overall EFTS population over the sample. More importantly, they include almost the entire EFTS population enrolled towards qualifications at the bachelor degree level or above, and the vast majority of R&D produced by all HEIs.

We create the HEI variables by combining administrative data from the Ministry of Education (MoE), HEIs' own annual reports, and census data from Statistics New Zealand. From these sources, we collect data on the number of Equivalent Full Time Students (EFTS) enrolled in long term courses in each TLA $j$, in each period $t$.[15]

Between 1996 and 2006, we use MoE tables that record the number of EFTS in each TLA receiving educational services from each institution. These tables may include double counting. This may occur for example, when the same student is enrolled in more than one TLA, or in more than one institution in the same year. However, aggregating all EFTS yields results very similar to the official counts, suggesting that instances of double counting account for only a

15 Unfortunately, the data are not sufficiently detailed to allow for a consistent decomposition across institutions by field of study.

very small percentage of the overall EFTS population. In the earlier period, we gather the spatial distribution of the EFTS population of each institution from their own annual reports.[16]

Next, we standardise the data by converting the counts to percentages (i.e. EFTS count in period *t*, area *j*, and institution *k* as a percentage of the total of EFTS across all areas serviced by institution *k* in period *t*). We then convert the percentages back to EFTS counts by multiplying these by the official EFTS count of each institution (MoE, 1988; 1992; 1997; 2002; 2015). We aggregate total university (including Teacher College) and polytechnic (including institute of technology) EFTS counts up to the TLA level. Finally, we convert these counts into a share of the TLA working age population (i.e. census usually resident population at age 15 or above), sourced from the census.[17]

Population projection data are sourced from the 1986, 1991, 1995, 2001, and 2006 demographic trends publications (Statistics New Zealand, various years).[18] Median house prices and land values are sourced from Quotable Value Ltd (QV). Data for the commodity price indices are sourced from the ANZ's Commodity Price Index, weighted by local commodity production.[19] Finally, local innovation is proxied by the number of patent applications (per 10,000 inhabitants) submitted to the Patent Cooperation Treaty (PCT) and the European Patent Office (EPO), and is sourced from the OECD patent database.[20] Data for all other controls are sourced from the 1981 to 2013 census.

# 4 Descriptive Statistics

Between 1986 and 2013, the unweighted average TLA population grew at an annual rate of 0.3% (figure 3). Fastest growth was recorded between 1991 and 1996 (0.8%), and slowest growth in the period following.[21] Over the full period, unweighted employment growth rate was almost twice as great (0.6%). As before, the fastest average growth rate was recorded between 1991 and 1996 (2.2%), while the slowest was between 2006 and 2013 (-0.3%), a period that included the Global Financial Crisis.

16 When EFTS data are not available (i.e. where we have only full and part time student counts), we approximate the EFTS count in each campus by the institution's EFTS-to-total student ratio in the next available period. Furthermore, when institutions with a satellite campus did not report EFTS count by location, we approximated the count using the campus size relative to the overall institution (in terms of EFTS) from the most recent year with that data available. We do not expect these approximations to have a great impact on the estimation since these were rarely needed. In addition, regarding the second approximation, the MoE tables from most recent years show that even after more than two decades of expansions via satellite campuses and inter-HEI cooperation, the vast majority of EFTS training is conducted within a main campus.

17 Figures A1 and A2 in appendix 1 map these shares across TLAs in 1986 and in 2006.

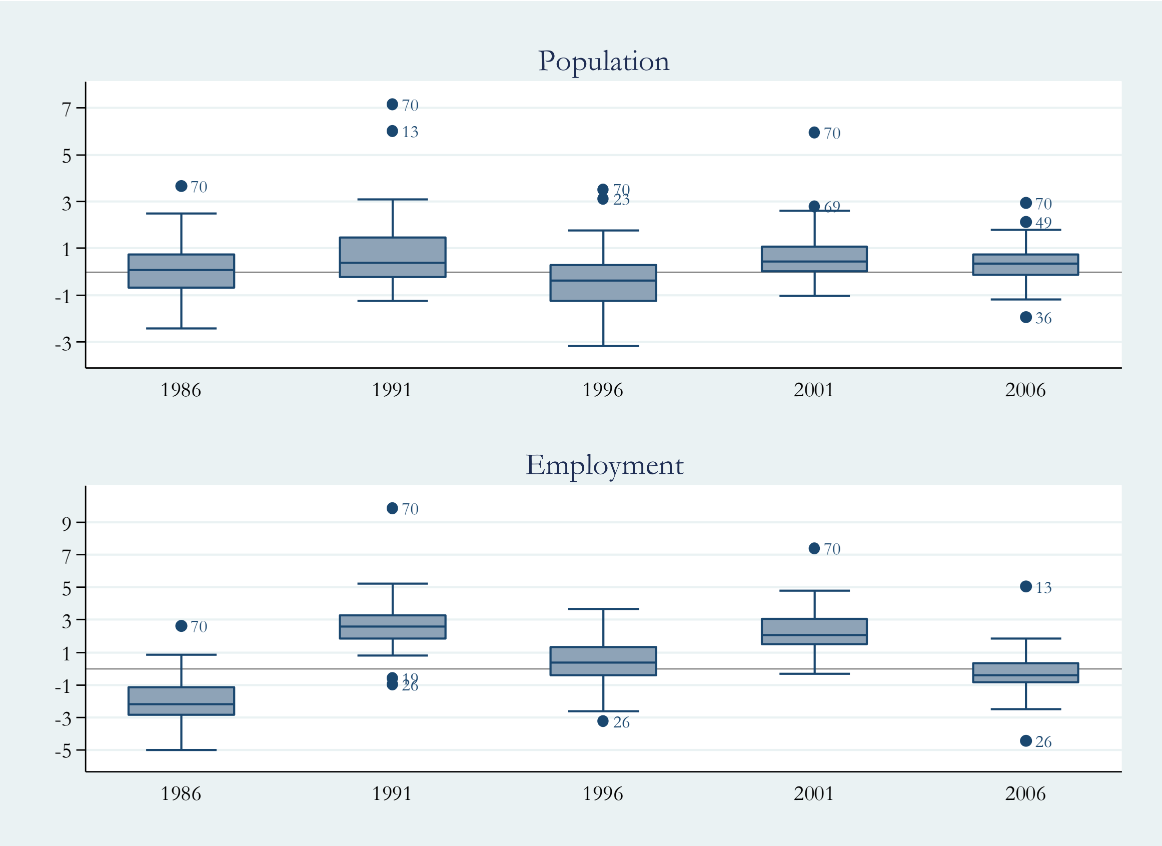
18 These were chosen based on having their publication date closest to each census year.

19 See Grimes and Hyland (2013) for more information on constructing this variable.

20 For more information about the variables used see appendix 2.

21 Official population estimates shows similar trends. Between 1991 and 1996, New Zealand's population grew at an annual average rate of 1.4%. Growth was slowest (0.8%) between 1996 and 2001 (Statistics New Zealand, 2016).

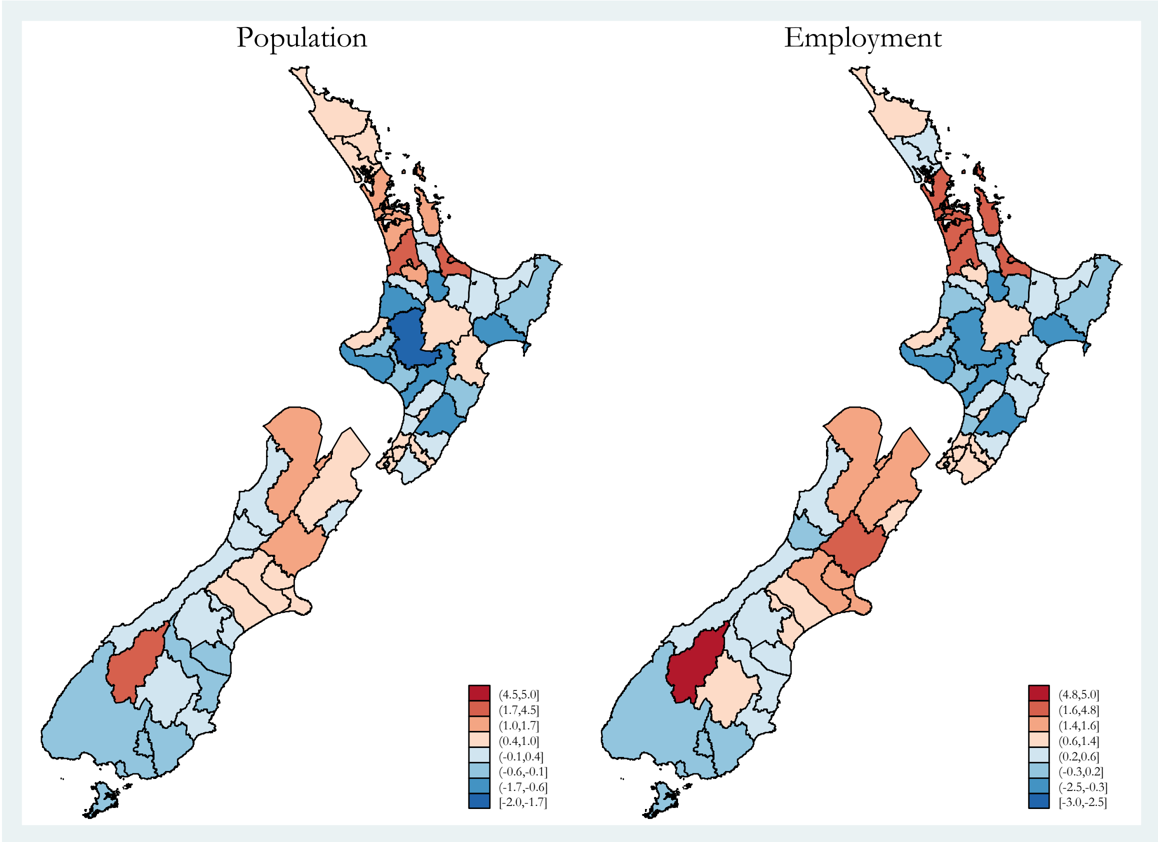
Figure 3: Intercensal average annual growth rates, 1986-2013




**Notes**: Annual growth in % is measured on the vertical axis. Growth is between the year shown in the horizontal axis and the following census period. TLAs with extreme growth rates are presented using the following code: Waikato District (13), South Waikato District (19), Tauranga City (23), Kawerau District (26), Ruapehu District (36), Carterton District (49), Central Otago District (69), and Queenstown-Lakes District (70).

Spatially, growth in both population and employment tended to be centred in and near the three largest metropolitan centres (figure 4). One exception is the Queenstown-Lakes District, which recorded the fastest growth overall (4.6%), as well as in each intercensal period (3-7%). This TLA is almost 500Km road distance away from the nearest large city (Christchurch City). On the other hand, growth in most other small and remote TLAs was negative. s

Figure 4: Annual average growth rates by TLA, 1986-2013

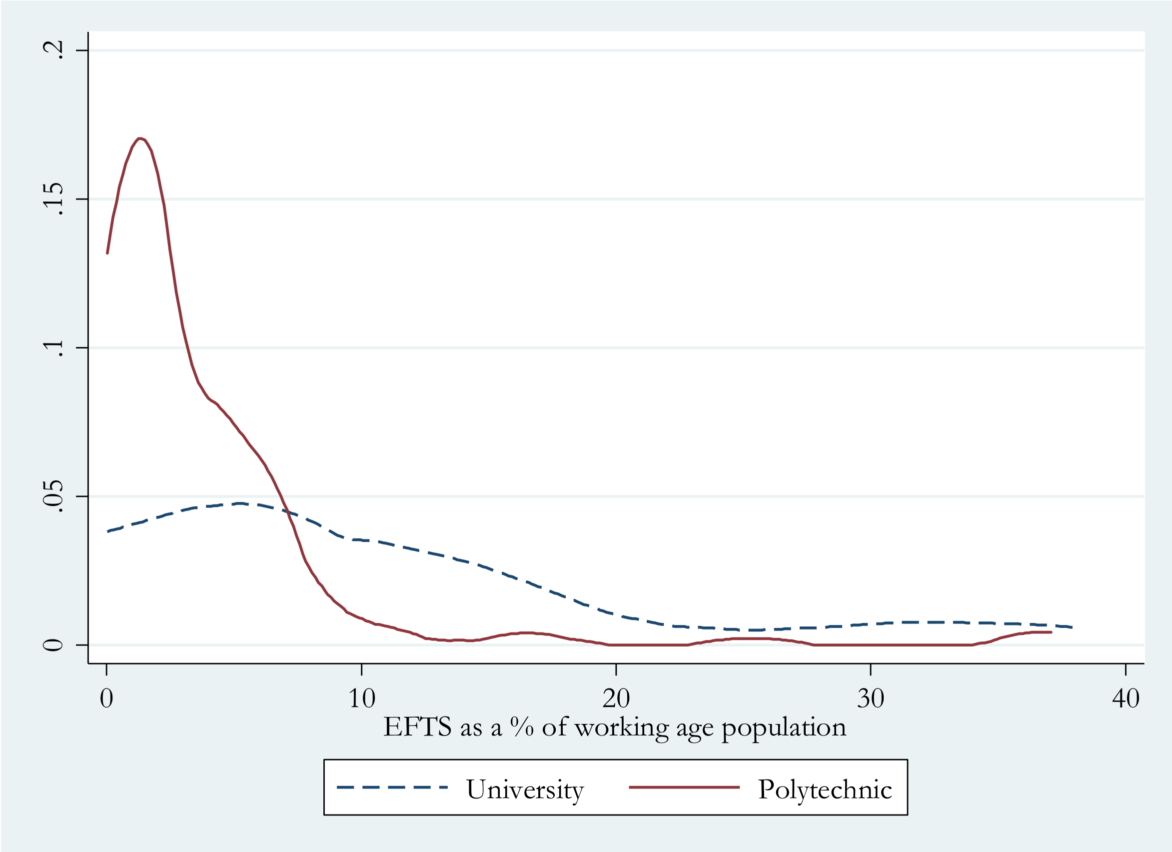



**Notes:** Growth rate is averaged over the entire 1986 to 2013 period.

The kernel density of EFTS shares for TLAs with a share greater than zero is presented in figure 5. For polytechnics, the majority of observations depict shares under 10%. For universities, most TLAs record EFTS shares below 20%. A small peak appears at just over 30%, reflecting the shares of Palmerston North and Dunedin Cities - New Zealand's only true 'university towns' (hosting the main campus of Massey University the University of Otago respectively). These cities are relatively small compared with other areas hosting universities, jointly accounting for less than 5% of the national population.[22]

22 As compared with Auckland, Greater Hamilton, Greater Wellington, and Greater Christchurch, accounting for 34%, 5%, 7%, and 10% of the national population, respectively (Statistics New Zealand, 2016)

Figure 5: Density of EFTS shares for TLAs with shares greater than zero

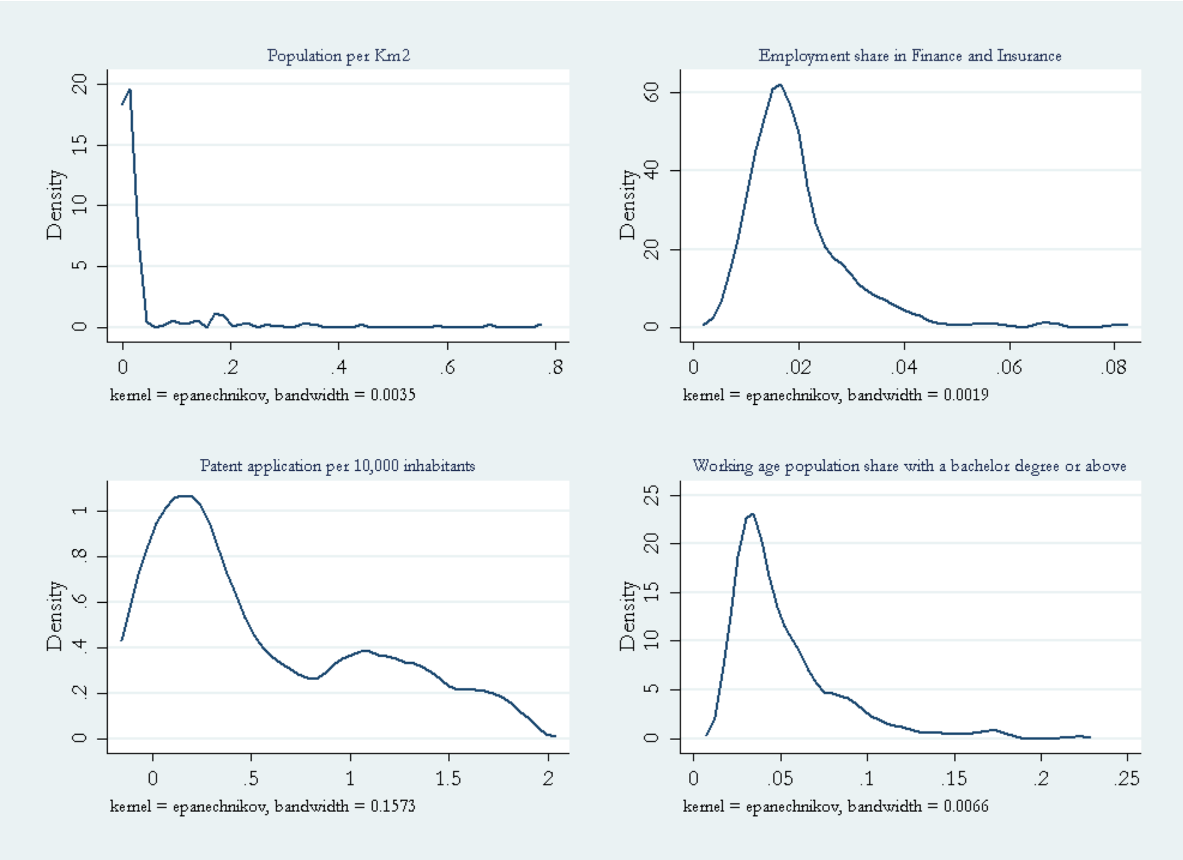



**Notes**: Vertical axis plots the density of observations. Horizontal axis shows the share of Equivalent Full Time Students (EFTS) in each TLA as a share of the working age population.

As some of our specifications include interactions between the EFTS shares and specific TLA characteristics, we plot the distribution of these characteristics' variables in Figure 6. The figure shows that population density is low in most TLAs, with 94% of the observations having fewer than 200 inhabitants per $Km^2$, and 60% fewer than 100 (mean of 4). The distribution of employment share in the finance and insurance industry resembles more of a skewed bell curve, with a sample mean of about 2%. Patent applications are heavily right skewed, with most TLAs having fewer than 0.5 applications per 10,000 inhabitants. Finally, the share of working age population with a bachelor degree or above as highest qualification is highly concentrated at around 5% of the local workforce.

To better understand some differences between TLAs that host HEIs and those that do not, the mean and standard deviation of the variables used are summarised in table 1. The first column summarises the data across all TLAs hosting a university (which in all cases also host polytechnics). The second column summarises the data of TLAs that host only a polytechnic, while the third column summarises the data for the TLAs that do not host universities or polytechnics. The last column presents the p-value for a T-test for the difference in means between each pair of groups.

Figure 6: Density plots for various controls




**Notes**: Vertical axis plots the density of observations. Horizontal axis plots the range in values of each variable. Population density is calculated as population ('000) per Km$^2$.

The table suggests that TLAs hosting a university record much faster population growth rates on average (0.96%) than other TLAs, and that their populations were also projected to grow faster (0.61-0.80%). In addition, they have more of an urban profile, with significantly greater representation of working age population holding a bachelor degree or above as highest qualification, population between the ages of 15 and 64, foreign born population, and employment in services. Furthermore, these areas tend to have a greater house price to income ratio and population density. Interestingly, their patent density is only greater compared with TLAs not hosting HEIs.[23] On the other hand, TLAs hosting universities have lower shares of agricultural employment and population from the Māori ethnic group.

TLAs hosting only a polytechnic and those not hosting an HEI show similar rates of population, employment, and projected population growth. Both show similar shares of Māori

[23] This lack of statistical difference between the two groups of HEI hosting TLAs may results from the fact that patent density is measured at the (greater) regional council level.

population. Finally, TLAs not hosting HEIs have a larger (smaller) population share under (over) the age of 15 (64), are more agricultural in terms of employment, are less densely populated, have a lower house price to income ratio, and have lower shares in secondary (compared with areas only hosting polytechnics) and tertiary employment.

The similar shares of vocationally qualified working age population across groups suggests that those trained at these levels (mostly at polytechnics) do not necessarily remain in areas hosting polytechnics. This contrasts with working age population holding a bachelor degree qualification (or above), which tend to locate in TLAs that host universities. This difference suggests that gains in human capital from attending polytechnics tend to spread nationally, reducing localised benefits for TLAs hosting polytechnics.

Table 1: Summary statistics by HEI grouping

| | Hosting Universities (1) | | Hosting Polytechnic only (2) | | Not Hosting (3) | | T-test (p-value) for difference in means between groups: | | |
|---|---|---|---|---|---|---|---|---|---|
| *Dependent variables* | Mean | SD | Mean | SD | Mean | SD | 1 & 2 | 1 & 3 | 2 & 3 |
| Average annual population growth rate | 0.96 | 0.82 | 0.28 | 0.96 | 0.18 | 1.43 | 0.00 | 0.00 | 0.56 |
| Average annual employment growth rate | 1.18 | 1.75 | 0.88 | 1.72 | 0.34 | 2.44 | 0.39 | 0.06 | 0.07 |
| *Shares:* | | | | | | | | | |
| University EFTS | 11.53 | 10.26 | 0.01 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Polytechnics EFTS | 3.63 | 2.54 | 4.54 | 6.40 | 0.04 | 0.12 | 0.42 | 0.00 | 0.00 |
| WAP with a Bachelor degree or above | 10.75 | 4.24 | 5.24 | 1.92 | 4.08 | 2.14 | 0.00 | 0.00 | 0.00 |
| WAP with a 'Vocational' qualification | 22.07 | 4.46 | 21.16 | 4.55 | 21.44 | 4.35 | 0.32 | 0.45 | 0.65 |
| Under 15 years old population | 21.56 | 1.92 | 23.50 | 2.47 | 25.30 | 3.23 | 0.00 | 0.00 | 0.00 |
| 65 and over population | 11.67 | 2.00 | 13.80 | 2.38 | 11.59 | 3.14 | 0.00 | 0.89 | 0.00 |
| Māori ethnic group | 11.77 | 6.45 | 18.04 | 13.2 | 18.15 | 13.62 | 0.01 | 0.01 | 0.95 |
| Share of foreign born population | 17.22 | 5.88 | 9.41 | 2.74 | 8.60 | 2.91 | 0.00 | 0.00 | 0.03 |
| Primary industries | 4.53 | 4.49 | 17.71 | 8.92 | 28.11 | 11.01 | 0.00 | 0.00 | 0.00 |
| Secondary industries | 22.96 | 4.79 | 24.68 | 5.10 | 22.41 | 8.31 | 0.09 | 0.71 | 0.02 |
| Various tertiary industries | 19.68 | 1.79 | 18.20 | 2.93 | 16.40 | 5.06 | 0.01 | 0.00 | 0.00 |
| Finance and Insurance | 3.93 | 1.62 | 2.07 | 0.79 | 1.65 | 0.57 | 0.00 | 0.00 | 0.00 |
| Unemployment rate | 7.81 | 1.95 | 7.39 | 3.42 | 7.31 | 3.35 | 0.50 | 0.40 | 0.86 |
| Five year population projection | 0.80 | 0.56 | 0.36 | 0.76 | 0.48 | 0.85 | 0.00 | 0.03 | 0.26 |
| Ten year population projection | 0.72 | 0.53 | 0.23 | 0.66 | 0.36 | 0.74 | 0.00 | 0.01 | 0.17 |
| Twenty year population projection | 0.61 | 0.52 | 0.06 | 0.63 | 0.19 | 0.70 | 0.00 | 0.00 | 0.13 |
| *Ratios/indices* | | | | | | | | | |
| House price to income | 9.78 | 3.24 | 8.48 | 3.50 | 6.79 | 2.85 | 0.06 | 0.00 | 0.00 |
| Population ('000) per $Km^2$ | 0.15 | 0.16 | 0.04 | 0.10 | 0.02 | 0.05 | 0.00 | 0.00 | 0.04 |
| Patent application per 10,000 inhabitants | 0.79 | 0.57 | 0.60 | 0.56 | 0.47 | 0.51 | 0.11 | 0.00 | 0.08 |
| Localised Commodity Price Index | 0.98 | 0.02 | 0.96 | 0.03 | 0.97 | 0.03 | 0.00 | 0.03 | 0.13 |
| Observations | 34 | | 85 | | 166 | | - | | |

**Notes**: In all the T-tests performed, the equality of variance assumption was determined by an Equality of Variance Test performed beforehand. WAP – working age population (population at the age of 15 and above). Industries are abbreviation for full time employment in relevant industry, presented as a share of total full time employment. TLAs hosting an institution are defined by whether they host a main campus within its boundaries, whether their EFTS population is equal or greater than 1% of the national EFTS population (for the relevant type of institution), or at least 2% of their local 15-30 years old population.

# 5 Results

## 5.1 Homogeneous impact

Results for estimating the relationship between the EFTS shares and TLA population and employment growth rates are summarised in table 2. Full regression results for all of the estimates discussed in this section are presented in tables A2-A6 within appendix 3. Estimates for population growth are presented in the first three columns. The first column shows the estimates from a two-way fixed effect unweighted OLS regression, including the full suite of controls except for lagged growth. For universities, the estimates suggest a significant, positive, and concave association between the EFTS share and population growth. By contrast, the magnitude of the polytechnic EFTS coefficients are much smaller, and statistically insignificant.

For universities, the relationship continues to hold when we weight our sample by the 1986 population (second column), and also when we include the lagged dependent variable under the difference GMM specification (third column). For polytechnics, the coefficients are only significant in the GMM specification (at the 10% level), showing a positive concave association with population growth. Based on each variable's means, increasing the university and polytechnic EFTS shares by one percentage point is associated with an increase in the annual average population growth rate of 0.19% and 0.06%,[24] respectively.

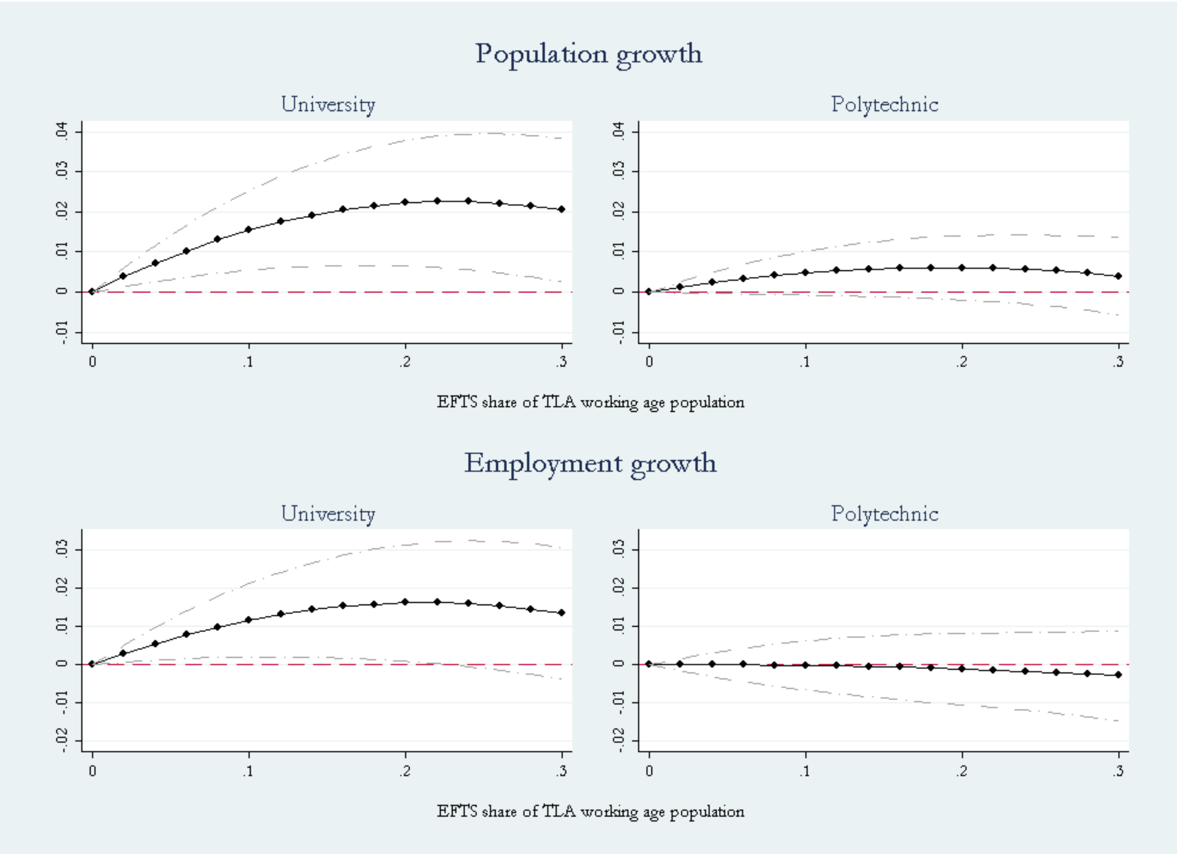
For employment growth (fourth to sixth columns), results with unweighted and (1986 employment) weighted least square specifications show a statistically insignificant relationship between employment growth and both university and polytechnic EFTS shares (fourth and fifth columns). However, after controlling for past employment growth (sixth column) and estimating using difference GMM, the university coefficients become significant, indicating a positive concave association. At the means, a one percentage point increase in the university EFTS share is associated with an increase of 0.14% in the average annual rate of employment growth. No significant relationship is found between employment growth and the polytechnic EFTS share.

As discussed previously, one possible explanation for the smaller and less significant polytechnic EFTS association is that vocationally trained graduates (mostly at polytechnics) are less likely to remain in the polytechnic hosting area after graduation. Therefore, any productivity gains through the human capital accumulation channel do not remain in the hosting area. Other possible explanations include measurement errors due to a large number of small institutions (biasing the coefficients towards zero), or if growth occurs only for some sub-sample of polytechnics which is at too fine a level to be captured by our variables.

24 Estimate for polytechnic is significant at the 10% level.

Using the estimates from the GMM specifications from table 2, figure 7 plots the predicted population and employment growth rates associated with different university and polytechnic EFTS shares. The rates of population and employment growth associated with various university EFTS shares peak at about 20% of the TLA working age population. Above this share, growth starts to decline (and become insignificant for employment). For polytechnics, most predicted growth rates are not statistically different than zero.

Figure 7: Predicted growth for varying levels of EFTS shares




**Notes**: Point estimates are in dark circles. 95% confidence intervals for estimates are in light grey dashed line.

Overall, these outcomes could suggest upper limits to the return to HEI investment during this period. On the other hand, these could also reflect the small number of observations with a very large EFTS share. For example, only Palmerston North and Dunedin Cities have university shares greater than 20%.

The difference between outcomes in the polytechnic and university coefficients may reflect difference in return by institution. In addition, it may also reflect differences in the accuracy of measuring the data, if polytechnics are measured with more noise (since they tend to be smaller). Finally, differences in returns may be caused by unobserved variables that are more prevalent in large urban areas. We examine the last explanation in more detail next.

Table 2: Population and employment growth estimates, OLS and GMM specifications

| | Population growth | | | Employment growth | | |
|---|---|---|---|---|---|---|
| | OLS | WLS | GMM | OLS | WLS | GMM |
| University EFTS as a % of working age population | 0.200*** | 0.177*** | 0.197*** | 0.077 | 0.046 | 0.153*** |
| | (0.057) | (0.061) | (0.062) | (0.060) | (0.049) | (0.059) |
| Square of University EFTS as a % of working age population | -0.436*** | -0.421*** | -0.429*** | -0.209* | -0.105 | -0.360*** |
| | (0.115) | (0.115) | (0.123) | (0.117) | (0.095) | (0.105) |
| Polytechnic EFTS as a % of working age population | 0.013 | 0.040 | 0.064* | -0.021 | 0.016 | 0.003 |
| | (0.046) | (0.042) | (0.037) | (0.048) | (0.037) | (0.044) |
| Square of Polytechnic EFTS as a % of working age population | -0.046 | -0.107 | -0.169 | 0.035 | -0.052 | -0.040 |
| | (0.098) | (0.105) | (0.103) | (0.104) | (0.094) | (0.131) |
| Observations | 285 | 285 | 228 | 285 | 285 | 171 |
| Number of TLAs | 57 | 57 | 57 | 57 | 57 | 57 |
| $R^2$ | 0.424 | 0.519 | 0.335 | 0.856 | 0.930 | 0.838 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Year and TLA Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Marginal effect of university EFTS as a % of WAP (at means) | 0.188*** | 0.165*** | 0.185*** | 0.071 | 0.044 | 0.143*** |
| Marginal effect of polytechnic EFTS as a % of WAP (at means) | 0.011 | 0.036 | 0.058* | -0.02 | 0.014 | 0.001 |
| Weights | No | Yes | No | No | Yes | No |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | - | - | 0.001 | - | - | 0.000 |
| Cragg-Donal Wald F Statistic for Weak Instrument test | - | - | 52.920 | - | - | 124.800 |
| Hansen J statistic (over-identification test) | - | - | 0.000 | - | - | 0.000 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effects are included implicitly.

## 5.2 Alternative EFTS share and sample definitions

Most of the TLAs that host a university main campus are large metropolitan centres. Two exceptions for this are Palmerston North and Dunedin Cities, which are effectively "university towns". For example, the EFTS population in these TLAs account for about a fifth of the working age population, more than twice the share recorded in the other TLAs with a large university presence. These large shares may correspond to the fall in the magnitude of association between university EFTS and growth shown in figure 7. We re-estimate the difference GMM specification in table 3, using only the linear EFTS share variables, with and without these TLAs in the sample.

The first two columns of the table present the results for population growth, while the second two present results for employment growth. The first column suggests a small and insignificant linear association between both HEI variables when using the full sample. Once Dunedin and Palmerston North Cities are removed from the sample (second column), the university EFTS term increases in magnitude and is significant. A one percentage point increase in the university EFTS share is associated with a 0.13 percentage point increase in the average annual rate of population growth. For employment, the university EFTS coefficient is again only significant once the two TLAs are removed, suggesting almost a 0.09 percentage point increase in the employment growth rate for every percentage point increase in university EFTS share. The linear results excluding the two smaller 'university TLAs' are similar to the non-linear results when including all TLAs, indicating that our results in table 2 are not being driven by the two 'university TLAs' in the sample.

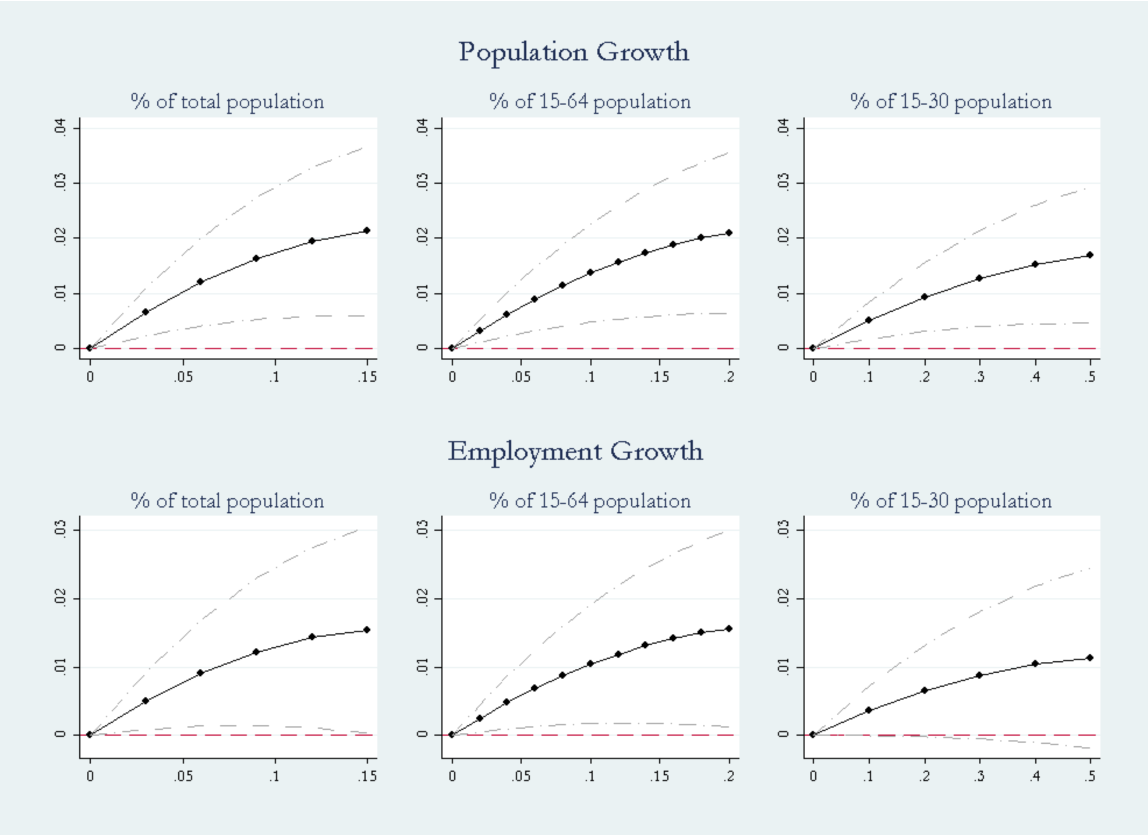
Next, we re-estimate the difference GMM regression using alternative specifications. We replace our EFTS denominator (working age population), estimating the relationship using EFTS as a share of the local total population, population between the ages of 15 and 64, and population between the ages of 15 and 30. We find that the patterns of relationship between university EFTS share and growth continue to hold. For polytechnics, there is some evidence for a positive relationship when using the entire and 15-64 population as a denominator. However, these results tend to be weaker (first and second columns in table A3 in the appendix). Figures 8 and 9 show the predicted population and employment growth under the various definitions. For universities, the concave pattern holds, showing strong resemblance to the results found previously. As before, polytechnic estimates are imprecisely estimated and predicted growth rates are very close to zero for employment.

Table 3: Population and employment growth GMM estimates, using linear EFTS shares, including and excluding Palmerston North and Dunedin Cities

| | Population growth | | Employment growth | |
|---|---|---|---|---|
| | Including | Excluding | Including | Excluding |
| University EFTS as a % of working age population | 0.003 | 0.128*** | -0.019 | 0.085** |
| | (0.028) | (0.050) | (0.021) | (0.041) |
| Polytechnic EFTS as a % of working age population | -0.005 | -0.001 | -0.010 | -0.015 |
| | (0.019) | (0.019) | (0.02) | (0.023) |
| Observations | 228 | 220 | 171 | 165 |
| Number of TLAs | 57 | 55 | 57 | 55 |
| $R^2$ | 0.50 | 0.50 | 0.84 | 0.84 |
| Controls | Yes | Yes | Yes | Yes |
| Year and TLA Fixed Effects | Yes | Yes | Yes | Yes |
| Weights | No | No | No | No |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | 0.00 | 0.00 | 0.00 | 0.00 |
| Weak identification test (Cragg-Donal Wald F Statistic) | 78.41 | 80.52 | 141.60 | 125.40 |
| Hansen J Statistic (Over-identification test) | 0.00 | 0.00 | 0.00 | 0.00 |

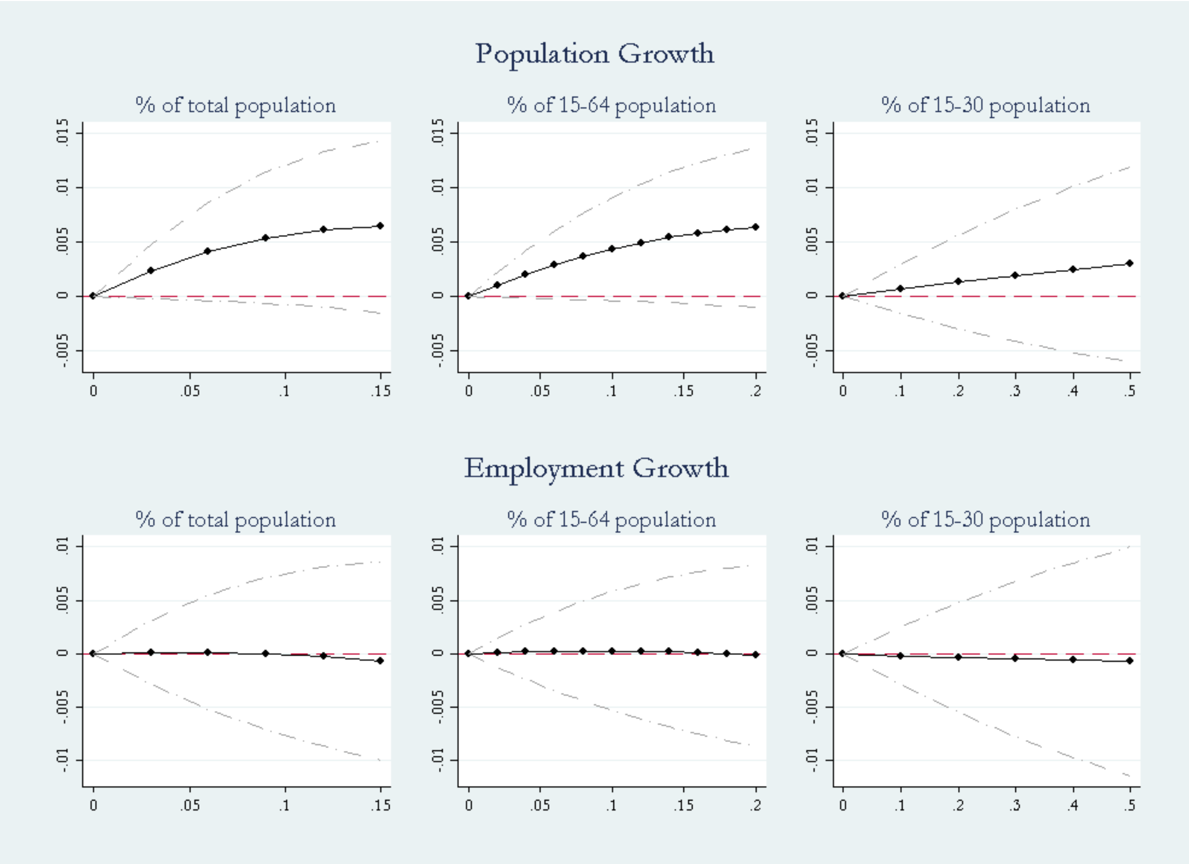
**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effects are included implicitly.

Figure 8: Predicted growth rates for various university EFTS shares




Notes: Point estimates are in dark circles. 95% confidence intervals for estimates are in light grey dashed line.

Figure 9: Predicted growth rates for various polytechnic EFTS shares




**Notes**: Point estimates are in dark circles. 95% confidence intervals for estimates are in light grey dashed line.

## 5.3 Heterogeneity in impact

Focusing on the difference in impact across types of areas we now examine whether the underlying characteristics of the hosting TLA affect the strength of relationships. For this, we interact the HEI variables with each of population (in '000) per $Km^2$, employment shares in the Finance and Insurance industry, patent applications per 10,000 inhabitants, and share of working age population with a bachelor degree or above as highest qualification.

Each interaction is estimated in a separate regression (with the relevant interaction variable shown in the column heading), and the results are presented in table A5 in appendix 3. The table shows no (significant) evidence of heterogeneity in impact across any of the characteristics.

Finally, we examine whether HEI activity is associated with changes in employment shares in the following period. We examine this hypothesis using the difference GMM specification for the primary, secondary, other tertiary services, and Finance and Insurance services industries (table A6 in appendix 3). Under all specifications, we failed to find any significant relationships.

# 6 Conclusions

We have examined the relationship between the presence of Higher Education Institutions (HEIs) and local growth within New Zealand. Using a sample of 57 Territorial Local Authorities (TLAs) between 1986 and 2013, we find that holding all else equal, TLAs with a greater share of Equivalent Full Time Students (EFTS) (relative to their local working-age population) grow faster both in terms of population and employment. This is particularly the case for university EFTS.

We consider an HEI as a form of infrastructure which has the potential of improving both the local level of productivity and the local stock of amenities, leading to an inflow of people and jobs. We test for this relationship while controlling for local time-invariant factors, national time-variant factors and local observable and unobservable time-variant factors. The latter include the official five, ten and twenty year (medium) population projections that were publicly available in each period. We include these projections to control for variation in HEI activity driven by the perceived future potential of the area, since official projections often play a role in shaping strategies and actions taken by policy makers. We control for the possibility of reverse causality by including the lagged growth rate, and we estimate our relationships using difference GMM. Robustness testing includes use of alternative samples, alternative HEI variable definitions and two different estimation techniques.

Overall, we consistently find a positive relationship between the relative size of the university EFTS population and local growth. At the means, a one percentage point increase in the university EFTS share is associated with a 0.19 (0.14) percentage point increase in the annual average population (employment) growth rate. We find some similarities for increases in polytechnic EFTS shares, but their association with growth is weaker and is estimated far less precisely.

We investigate whether the magnitude of the relationships vary across levels of 'urbanisation' and 'innovative activity'. We do so by estimating a number of specifications that include interactions between HEI activities and proxies for urbanisation and innovative activity. However, we find no evidence of complementarities between these activities and the presence of an HEI. Similarly, we find no evidence that the presence of HEI altered the industrial structure of local areas.

It is always possible that omission of some factors that affect both EFTS shares and population or employment growth could account for the positive relationships that we estimate. However we have attempted to minimise this possibility by: (i) including a large set of control variables in all our regressions, (ii) including lagged growth to control for reverse causality, and especially by: (iii) including projected population growth to account for unobservable time-variant factors that may have impacted on both EFTS shares and population and employment growth. Inclusion of these projections is a novel element of our approach designed to capture the influence of time-variant factors that are otherwise unobservable to the econometrician. This approach could be of use in other regional studies.

A natural extension to our work would be to analyse whether differing courses of study within universities and polytechnics have differing effects on local population and/or employment growth. Investigation into the complementarities between these differing courses of study and local characteristics (such as urbanisation or innovative activity) should be of strong interest (data limitations unfortunately preclude analysis along these lines using our sample.) Even without this extension, based on our results, local policy-makers who wish to support local employment and population growth – and especially policy-makers within university cities – may wish to facilitate the expansion of their higher education institutions.

# References


Anderson, Theodore Wilbur, and Cheng Hsiao. 1981. “Estimation of Dynamic Models with Error Components.” *Journal of the American Statistical Association* 76 (375): 598–606.

———. 1982. “Formulation and Estimation of Dynamic Models Using Panel Data.” *Journal of Econometrics* 18 (1): 47–82.

Arellano, Manuel. 1989. “A Note on the Anderson-Hsiao Estimator for Panel Data.” *Economics Letters* 31 (4): 337–41.

Ascani, Andrea, Riccardo Crescenzi, and Simona Iammarino. 2012. “Regional Economic Development.”

Asheim, Bjorn T, and Meric S Gertler. 2006. “The Geography of Innovation: Regional Innovation Systems.” In *The Oxford Handbook of Innovation*, edited by Jan Fagerberg, David C Mowery, and Richard R Nelson. Oxford: Oxford University Press.

Barro, Robert J. 2001. “Human Capital and Growth.” *American Economic Review* 91 (2): 12–17.

Benhabib, Jess, and Mark M. Spiegel. 1994. “The Role of Human Capital in Economic Development Evidence from Aggregate Cross-Country Data.” *Journal of Monetary Economics* 34 (2): 143–73.

Crescenzi, Riccardo. 2005. “Innovation and Regional Growth in the Enlarged Europe: The Role of Local Innovative Capabilities, Peripherality, and Education.” *Growth and Change* 36 (4): 471–507.

Deltas, George, and Sotiris Karkalakos. 2013. “Similarity of R&D Activities, Physical Proximity, and R&D Spillovers.” *Regional Science and Urban Economics* 43 (1): 124–31.

Department of Education. 1988. “Education Statistics of New Zealand 1987.” Wellington, New Zealand: Research and Statistics Division, Department of Education.

———. 1992. *New Zealand Education Statistics 1991*. Wellington: Ministry of Education.

Doppelhofer, Gernot, Ronald I. Miller, and Xavier Sala-i-Martin. 2000. “Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach.” NBER Working Paper No. 7750. National Bureau of Economic Research.

Duch-Brown, Néstor, Javier García-Estévez, and Martí Parellada-Sabata. 2011. “Universities and Regional Economic Growth in Spanish Regions.” Working Papers 2011/6. Barcelona, Spain: Institut d’Economia de Barcelona (IEB).

Fagerberg, Jan. 1987. “A Technology Gap Approach to Why Growth Rates Differ.” *Research Policy* 16 (2): 87–99.

Fagerberg, Jan, Bart Verspagen, and Marjolein Caniels. 1997. “Technology, Growth and Unemployment across European Regions.” *Regional Studies* 31 (5): 457–66.

Glaeser, Edward L. 1999. “Learning in Cities.” *Journal of Urban Economics* 46 (2): 254–77.

Glaeser, Edward Lawler, Hedi D. Kallal, Jose A. Scheinkman, and Andrei Shleifer. 1992. “Growth in Cities.” *Journal of Political Economy* 100 (6): 1126–52.

Glaeser, Edward L., José A. Scheinkman, and Andrei Shleifer. 1995. “Economic Growth in a Cross-Section of Cities.” *Journal of Monetary Economics* 36 (1): 117–43.

Gregorio, Jose De, and Jong-Wha Lee. 2002. “Education and Income Inequality: New Evidence from Cross-Country Data.” *Review of Income and Wealth* 48 (3): 395–416.

Grimes, Arthur. 2014. “Infrastructure and Regional Economic Growth.” In *Handbook of Regional Science*, 331–52. Springer.

Grimes, Arthur, and Sean Hyland. 2013. “Passing the Buck: Impacts of Commodity Price Shocks on Local Outcomes.” Motu Working Paper 13-10. Wellington: Motu Economic and Public Policy Research.

Hughes, Jonathan. 2012. “The Role of Universities in New Zealand’s Research System.” presented at the Te Pokai Tara - Universities New Zealand, Wellington, New Zealand.

Jacobs, Jane. 1969. *The Economy of Cities*. New York: Vintage Books.

Jaffe, Adam B. 1989. “Real Effects of Academic Research.” *American Economic Review* 79 (5): 957–70.

Jaffe, Adam B, M Trajtenberg, and R Henderson. 1993. "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations." *Quarterly Journal of Economics* 108: 577–98.

Jovanovic, Boyan, and Rafael Rob. 1989. "The Growth and Diffusion of Knowledge." *The Review of Economic Studies* 56 (4): 569–82.

Karlsson, Charlie, and Martin Andersson. 2007. "Knowledge in Regional Economic Growth: The Role of Knowledge Accessibility." *Industry and Innovation, Taylor & Francis Journals* 14 (2): 129–49.

Krugman, Paul. 1991. "Increasing Returns and Economic Geography." *Journal of Political Economy* 99 (3): 483–99.

Lucas, Robert. 1988. "On the Mechanics of Economic Development." *Journal of Monetary Economics* 22 (July): 3–42.

Mankiw, N Gregory, David Romer, and David N Weil. 1992. "A Contribution to the Empirics of Economic Growth." *Quarterly Journal of Economics* 107 (2): 407–37.

Ministry of Education. 1997. "Education Statistics of New Zealand for 1996." Wellington, New Zealand: Data Management and Analysis Division, Ministry of Education.

———. 2002. "Education Statistics of New Zealand for 2001." Wellington, New Zealand: Education Information and Analysis, Ministry of Education.

———. 2006. "OECD Thematic Review of Tertiary Education: New Zealand Country Background Report."

———. 2013. "Tertiary Education Statistics - Customised Data Request."

Ministry of Education - Education Counts. 2015. "Participation Statistics." https://www.educationcounts.govt.nz/statistics/tertiary_education/participation.

Nelson, Richard R., and Edmund S. Phelps. 1966. "Investment in Humans, Technological Diffusion, and Economic Growth." *The American Economic Review*, 69–75.

New Zealand Parliament. 1989. "Education Act." 80. Wellignton, New Zealand: New Zealand Parliament.

Nickell, Stephen. 1981. "Biases in Dynamic Models with Fixed Effects." *Econometrica: Journal of the Econometric Society*, 1417–26.

NZQA. 2016. "About Education Organisations." *New Zealand Qualifications Authority (NZQA): About Education Organisations*. http://www.nzqa.govt.nz/providers-partners/about-education-organisations/.

Overman, Henry G, Patricia Rice, and Anthony J. Venables. 2010. "Economic Linkages across Space." *Regional Studies* 44 (1): 17–33.

Rebelo, Sergio. 1998. "The Role of Knowledge and Capital in Economic Growth." *Northwestern University, Mimeo*. http://www.worldbank.org/research/growth/notes.htm.

Rebelo, Sergio T. 1991. "Long Run Policy Analysis and Long Run Growth." *Journal of Political Economy* 99 (3): 500–521.

Roback, Jennifer. 1982. "Wages, Rents, and the Quality of Life." *Journal of Political Economy* 90 (6): 1257–78.

Rodríguez-Pose, Andrěs. 1999. "Innovation Prone and Innovation Averse Societies: Economic Performance in Europe." *Growth and Change* 30 (1): 75–105.

Rodríguez-Pose, Andrés, and Riccardo Crescenzi. 2008. "Research and Development, Spillovers, Innovation Systems, and the Genesis of Regional Growth in Europe." *Regional Studies* 42 (1): 51–67.

Romer, Paul M. 1986. "Increasing Returns and Long-Run Growth." *Journal of Political Economy* 94 (1002-1037).

Rosen, H. 1979. "Housing Decisions and the U.S. Income Tax: An Econometric Analysis." *Journal of Public Economics* 11 (1): 1–23.

Statistics New Zealand. Various years. "Demographic Trends - Sub National Projections." Wellington, New Zealand: Statistics New Zealand.

———. Various. "International Travel and Migration." Wellington, New Zealand: Statistics New Zealand.

———. 2015. "Geographic Definitions." http://www.stats.govt.nz/Census/2013-census/info-about-2013-census-data/2013-census-definitions-forms/definitions/geographic.aspx.

———. 2016. "Historical Population Estimates Tables." http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/historical-population-tables.aspx.

Sterlacchini, Alessandro. 2008. "R&D, Higher Education and Regional Growth: Uneven Linkages among European Regions." *Research Policy* 37 (6): 1096–1107.

Taonga, New Zealand Ministry for Culture and Heritage Te Manatu. 2015. "Tertiary Education." *Te Ara - The Encyclopaedia of New Zealand*. New Zealand Ministry for Culture and Heritage. http://www.teara.govt.nz/en/tertiary-education.

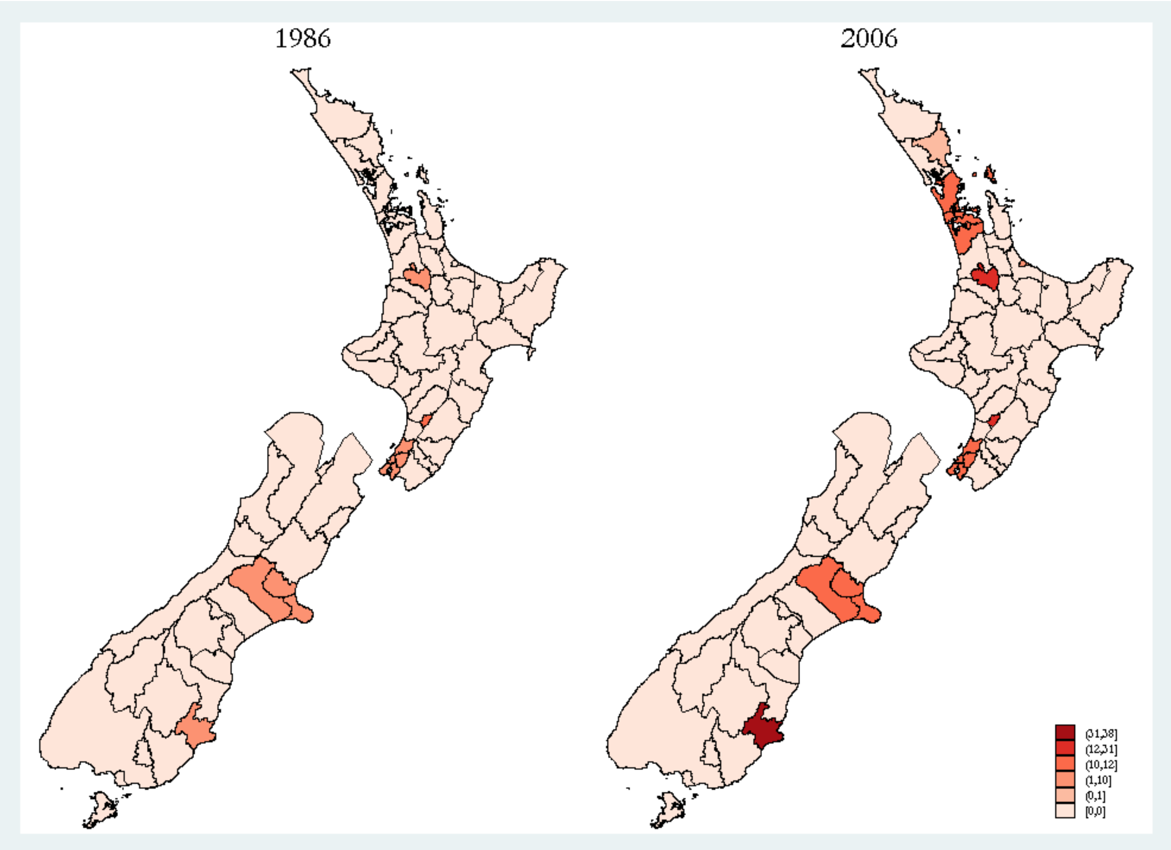
Trendle, Bernard, and Warren Pears. 2004. "The Role of Education in Regional Income Determination-A Cross Sectional Study of Small Areas in Queensland." *Australasian Journal of Regional Studies* 10 (3): 383.

Wang, Hui-Chen. 2010. "Institutions of Higher Education and the Regional Economy: A Long-Term Spatial Analysis." Economic Research International Article ID 376148. Volume 2010. Mississippi, U.S.A: Department of Economics, University of Mississippi.

# Appendix

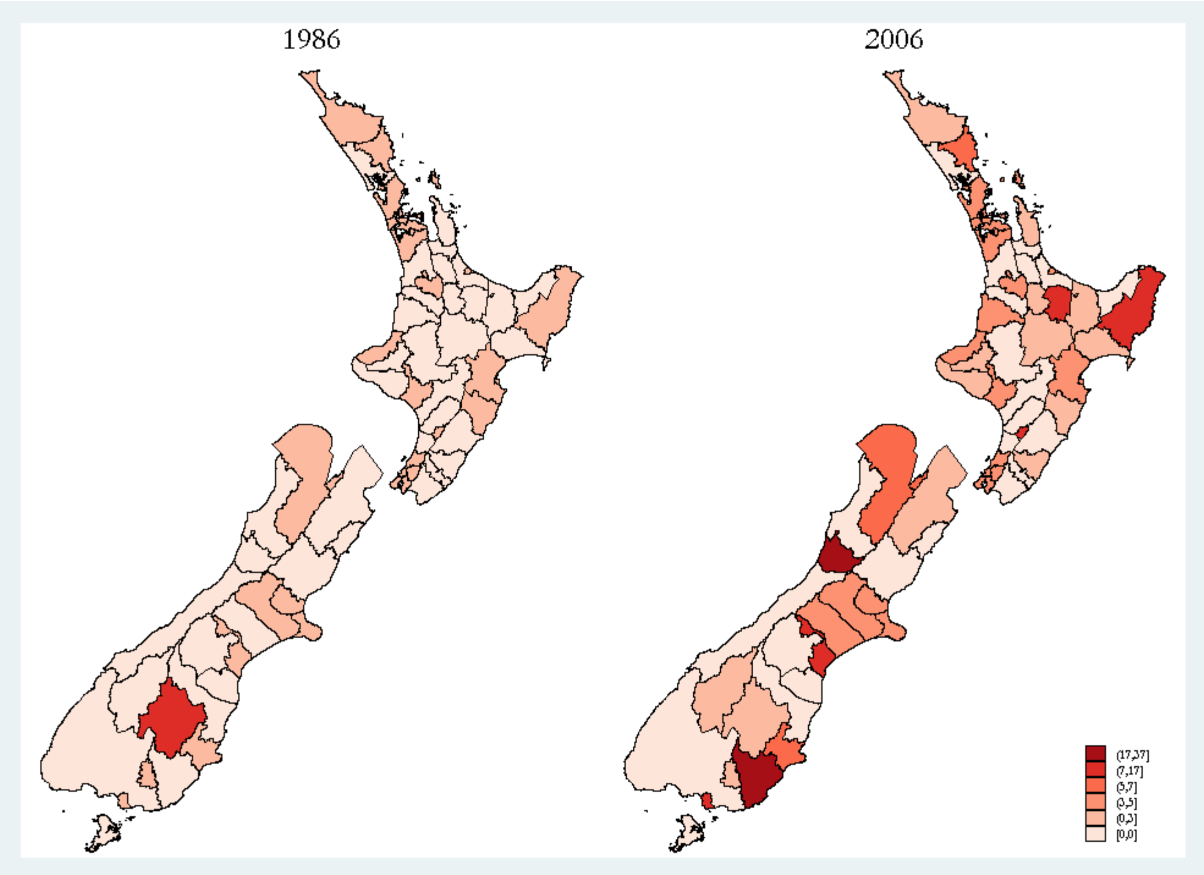
## Appendix 1: Distribution of Higher Education Institutions (HEIs)

Figure A1: University EFTS shares by TLA




**Notes**: University TLA EFTS population as a percentage of TLA working age population.

Figure A2: Polytechnic EFTS shares by TLA




Notes: Polytechnic TLA EFTS population as a percentage of TLA working age population.

## Appendix 2: Description of variables

Table A1: Description of variables

| Variable | Source | Notes |
|---|---|---|
| Annual average population growth rate | Statistics New Zealand (2015) | Census usually resident population |
| Annual average employment growth rate | | Census usually resident employed population |
| University Equivalent Full Time Student (EFTS) | Statistics New Zealand (2015); Ministry of Education (2015); various university and polytechnic annual reports | As a % of census usually resident working age population |
| Polytechnic Equivalent Full Time Student (EFTS) | | As a % of census usually resident working age population |
| Population under the age of 15 | Statistics New Zealand (2015) | As a % of census usually resident population |
| Population over the age of 64 | | As a % of census usually resident population |
| Māori population | | As a % of census usually resident population |
| Foreign born population | | As a % of census usually resident population |
| National migration flow | Statistics New Zealand (various) | Total annual (March year) long term and permanent population inflow |
| Population with a vocational qualification | | As a % of census usually resident working age population. Highest qualification at the above secondary and below bachelor degree |
| Population with a bachelor degree or above | Statistics New Zealand (2015) | As a % of working age population. Highest qualification at the bachelor degree or above |
| Full time employment in agriculture, manufacturing, and finance and insurance industries | | As a % of total full time employment in all industries. Industry codes: 1986 (NZSIC1986), 1991 & 1996 (NZSIC1987), 2001 (ANZSIC96), 2006 (ANZSIC2006) |
| Unemployment rate | | Defined as $\frac{unemployed}{employed+unemployed}$ |
| Median house price to median household income ratio | Quotable Value Ltd (2015); Statistics New Zealand (2015) | Unweighted four quarterly average of quarterly median house price to median annual income. Income and house price data for the amalgamated TLAs are averaged across areas, weighted by the relative population size of each TLA. |
| Population ('000) per Km$^2$ | Department of Internal Affairs (2015); Statistics New Zealand (2015) | Land is measured by Km$^2$ for the 2014 boundaries, and excludes inland waters or oceanic areas. |
| Annual average projected population growth rate | Statistics New Zealand (1986, 1991, 1995, 2001, 2006) | Projections are the five, ten, and twenty year medium projections. 1991 based projections use the 1991 estimated population. 1986 values are aggregated to TLA from the Local Authority (e.g. Borough, District, etc.) level. |
| Patent applications per 10,000 inhabitants | OECD Patent database (2015) | Total applications to the PCT and EPO. Variable aggregated at the regional council level. |
| Localised commodity price index | Quotable Value Ltd (2015); Statistics New Zealand (2015); Australia-New Zealand Bank (2015) | Aggregated at the regional council level. Prices for region *i* in period *t* are: $PCom_{i,t} = \sum_{j \in ANZ} \left( \frac{LV_{i,j,t}}{LV_{i,t}} * \frac{ANZ^{w}_{j,t}}{CPI_t} \right) + (1 - \sum_{j \in ANZ} \frac{LV_{i,j,t}}{LV_{i,t}}) * (\frac{CPI_t}{CPI_t})$. $ANZ^{w}_{j,t}$ is the ANZ's commodity price index for the j$^{th}$ commodity, in world dominated prices. $LV_{i,j,t}$ is the total sale value (including land) in region *i* of all properties with main activity *j*. |

**Notes**: Blank column indicates the same source for variable as above

## Appendix 3: Additional regression tables

Table A2: Population and employment growth estimates, OLS and GMM specifications

| | Population growth | | | Employment growth | | |
|---|---|---|---|---|---|---|
| | OLS | WLS | GMM | OLS | WLS | GMM |
| University EFTS as a % of working age population | 0.200*** | 0.177*** | 0.197*** | 0.077 | 0.046 | 0.153*** |
| | (0.057) | (0.061) | (0.062) | (0.060) | (0.049) | (0.059) |
| Square of University EFTS as a % of working age population | -0.436*** | -0.421*** | -0.429*** | -0.209* | -0.105 | -0.360*** |
| | (0.115) | (0.115) | (0.123) | (0.117) | (0.095) | (0.105) |
| Polytechnic EFTS as a % of working age population | 0.013 | 0.040 | 0.064* | -0.021 | 0.016 | 0.003 |
| | (0.046) | (0.042) | (0.037) | (0.048) | (0.037) | (0.044) |
| Square of Polytechnic EFTS as a % of working age population | -0.046 | -0.107 | -0.169 | 0.035 | -0.052 | -0.040 |
| | (0.098) | (0.105) | (0.103) | (0.104) | (0.094) | (0.131) |
| Share of working age population with a bachelor degree or above | 0.161 | 0.066 | 0.196 | 0.213 | 0.113 | -0.207 |
| | (0.117) | (0.103) | (0.166) | (0.159) | (0.112) | (0.160) |
| Share of working age population with a vocational qualification | 0.056 | 0.023 | 0.122** | -0.135* | -0.184** | -0.059 |
| | (0.046) | (0.060) | (0.055) | (0.074) | (0.071) | (0.078) |
| Under 15 population as a % of total population | -0.021 | -0.251** | 0.052 | 0.250* | 0.243* | 0.277* |
| | (0.109) | (0.109) | (0.115) | (0.146) | (0.122) | (0.156) |
| 65 or over population as a % of total population | 0.345*** | 0.095 | 0.663*** | 0.285 | 0.277* | 0.411** |
| | (0.113) | (0.127) | (0.179) | (0.184) | (0.142) | (0.203) |
| Maori as a % of population | 0.025 | 0.086 | 0.163 | -0.211** | -0.235** | -0.276*** |
| | (0.073) | (0.097) | (0.123) | (0.092) | (0.089) | (0.072) |
| Foreign born as a % of population | 0.219 | 0.029 | 0.042 | 0.229 | 0.159 | -0.171 |
| | (0.142) | (0.125) | (0.234) | (0.146) | (0.111) | (0.212) |

| | | | | | | |
|---|---|---|---|---|---|---|
| National migration inflow * Foreign born as a % of population | -0.000 | -0.000 | -0.000 | -0.000*** | - 0.000*** | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Share of (full time) employment in primary industries | 0.047* | 0.034 | 0.081* | 0.095*** | 0.083** | 0.135*** |
| | (0.026) | (0.028) | (0.044) | (0.034) | (0.035) | (0.039) |
| Share of (full time) employment in secondary industries | 0.029 | 0.001 | 0.066* | 0.027 | 0.021 | 0.096** |
| | (0.033) | (0.038) | (0.038) | (0.038) | (0.035) | (0.046) |
| Share of (full time) employment in various tertiary industries | 0.094** | 0.109 | 0.164** | 0.168*** | 0.172** | 0.197*** |
| | (0.046) | (0.076) | (0.076) | (0.051) | (0.077) | (0.073) |
| Share of (full time) employment in finance and insurance | 0.033 | 0.067 | 0.103 | 0.282 | 0.272 | 0.211 |
| | (0.219) | (0.144) | (0.216) | (0.248) | (0.177) | (0.281) |
| Unemployment rate | 0.006 | 0.021 | -0.031 | 0.356*** | 0.424*** | 0.278*** |
| | (0.059) | (0.072) | (0.067) | (0.078) | (0.067) | (0.093) |
| Population ('000) per km$^2$ | 0.013 | 0.008 | 0.012 | 0.006 | 0.005 | -0.006 |
| | (0.013) | (0.016) | (0.052) | (0.021) | (0.015) | (0.055) |
| House price to income ratio | -0.002*** | -0.001* | -0.001* | -0.000 | -0.000 | -0.002*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Patents applied to EPO and PCT per 10,000 inhabitants | -0.002 | -0.000 | 0.003 | -0.001 | 0.000 | 0.000 |
| | (0.002) | (0.002) | (0.002) | (0.003) | (0.002) | (0.003) |
| No applications for patents | -0.003* | -0.001 | -0.002 | -0.003 | -0.002 | -0.002 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| RC specific com price index | 0.011 | -0.001 | -0.015 | 0.107*** | 0.010 | 0.079* |
| | (0.032) | (0.024) | (0.033) | (0.038) | (0.035) | (0.044) |
| Five year medium population projection | 0.410 | 0.483** | 0.805** | 0.248 | 0.060 | 1.191*** |
| | (0.346) | (0.228) | (0.327) | (0.499) | (0.253) | (0.401) |
| Ten year medium population projection | -0.372 | -0.976* | -0.931 | 0.640 | 0.341 | -1.430* |
| | (0.603) | (0.543) | (0.596) | (1.001) | (0.791) | (0.730) |
| Twenty year medium population projection | -0.018 | 0.490 | 0.211 | -0.803 | -0.613 | 0.039 |
| | (0.356) | (0.408) | (0.293) | (0.576) | (0.630) | (0.382) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Lagged dependent variable | | | 0.073 | | | -0.188 |
| | | | (0.161) | | | (0.117) |
| Constant | -0.102** | 0.014 | -0.011 | -0.257*** | -0.130** | 0.014* |
| | (0.046) | (0.050) | (0.008) | (0.074) | (0.059) | (0.007) |
| Observations | 285 | 285 | 228 | 285 | 285 | 171 |
| Number of TLAs | 57 | 57 | 57 | 57 | 57 | 57 |
| Adjusted R-squared | 0.412 | 0.519 | 0.513 | 0.860 | 0.934 | 0.845 |
| Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Year and TLA fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Weights | No | Yes | No | No | Yes | No |
| Marginal effect of University EFTS as a % of working age population (At means) | 0.188*** | 0.165*** | 0.185*** | 0.071 | 0.044 | 0.143*** |
| Marginal effect of Polytechnic EFTS as a % of working age population (At means) | 0.011 | 0.036 | 0.058* | -0.02 | 0.014 | 0.001 |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | - | - | 0.00 | - | - | 0.00 |
| Weak identification test (Cragg-Donal Wald F Statistic) | - | - | 80.39 | - | - | 151.10 |
| Hansen J statistic (over-identification test) | - | - | 0.00 | - | - | 0.00 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (Differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effects are included implicitly.

Table A3: Population and employment growth GMM estimates, using linear EFTS shares, including and excluding Palmerston North and Dunedin Cities

| | Population growth | | Employment growth | |
|---|---|---|---|---|
| | Including | Excluding | Including | Excluding |
| University EFTS as a % of working age population | -0.003 | 0.128** | -0.019 | 0.085** |
| | (0.028) | (0.050) | (0.021) | (0.041) |
| Polytechnic EFTS as a % of working age population | 0.005 | 0.001 | -0.010 | -0.015 |
| | (0.019) | (0.019) | (0.023) | (0.023) |
| Share of working age population with a bachelor degree or above | 0.232 | 0.186 | -0.183 | -0.222 |
| | (0.166) | (0.165) | (0.165) | (0.162) |
| Share of working age population with a vocational qualification | 0.114** | 0.120** | -0.065 | -0.065 |
| | (0.056) | (0.055) | (0.080) | (0.080) |
| Under 15 population as a % of total population | 0.059 | 0.071 | 0.277* | 0.282* |
| | (0.116) | (0.117) | (0.158) | (0.159) |
| 65 or over population as a % of total population | 0.612*** | 0.631*** | 0.398** | 0.412** |
| | (0.172) | (0.172) | (0.196) | (0.197) |
| Maori as a % of population | 0.157 | 0.155 | -0.278*** | -0.275*** |
| | (0.130) | (0.126) | (0.074) | (0.071) |
| Foreign born as a % of population | -0.029 | 0.034 | -0.249 | -0.168 |
| | (0.241) | (0.235) | (0.218) | (0.210) |
| National migration inflow * Foreign born as a % of population | -0.000 | -0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Share of (full time) employment in primary industries | 0.090** | 0.085* | 0.141*** | 0.136*** |
| | (0.044) | (0.044) | (0.039) | (0.039) |
| Share of (full time) employment in secondary industries | 0.063 | 0.065* | 0.098** | 0.098** |
| | (0.038) | (0.039) | (0.046) | (0.047) |
| Share of (full time) employment in various tertiary industries | 0.160** | 0.161** | 0.199*** | 0.199*** |
| | (0.076) | (0.076) | (0.075) | (0.074) |
| Share of (full time) employment in finance and insurance | 0.079 | 0.129 | 0.197 | 0.189 |
| | (0.219) | (0.223) | (0.285) | (0.287) |
| Unemployment rate | -0.031 | -0.030 | 0.290*** | 0.276*** |
| | (0.069) | (0.069) | (0.093) | (0.094) |
| Population ('000) per km$^2$ | 0.006 | 0.013 | -0.009 | 0.001 |
| | (0.051) | (0.055) | (0.054) | (0.057) |
| House price to income ratio | -0.001 | -0.001* | -0.002*** | -0.002*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Patents applied to EPO and PCT per 10,000 inhabitants | 0.005** | 0.004 | 0.001 | -0.000 |
| | (0.002) | (0.002) | (0.003) | (0.003) |

| | | | | |
|---|---|---|---|---|
| No applications for patents | -0.002 | -0.002 | -0.002 | -0.003 |
| | (0.002) | (0.002) | (0.002) | (0.002) |
| RC specific com price index | -0.007 | -0.007 | 0.080* | 0.082* |
| | (0.032) | (0.032) | (0.043) | (0.044) |
| Five year medium population projection | 0.790** | 0.848** | 1.162*** | 1.211*** |
| | (0.320) | (0.330) | (0.383) | (0.401) |
| Ten year medium population projection | -0.882 | -0.927 | -1.358* | -1.454* |
| | (0.603) | (0.619) | (0.729) | (0.748) |
| Twenty year medium population projection | 0.221 | 0.180 | 0.047 | 0.035 |
| | (0.299) | (0.301) | (0.382) | (0.383) |
| Lagged dependent variable | 0.093 | 0.070 | -0.180 | -0.188 |
| | (0.156) | (0.159) | (0.118) | (0.118) |
| Constant | -0.012 | -0.009 | 0.013* | 0.015** |
| | (0.008) | (0.007) | (0.007) | (0.007) |
| Observations | 228 | 220 | 171 | 165 |
| Number of TLA | 57 | 55 | 57 | 55 |
| $R^2$ | 0.50 | 0.50 | 0.84 | 0.84 |
| Year and TLA fixed effects | Yes | Yes | Yes | Yes |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | 0.00 | 0.00 | 0.00 | 0.00 |
| Weak identification test (Cragg-Donal Wald F Statistic) | 78.41 | 80.52 | 141.60 | 152.40 |
| Hansen J statistic (over-identification test) | 0.00 | 0.00 | 0.00 | 0.00 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (Differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effects are included implicitly.

Table A4: Population and employment growth estimates using various specifications (GMM)

| | Population growth | | | Employment growth | | |
|---|---|---|---|---|---|---|
| | EFTS share of total population | EFTS share of 15-64 year old population | EFTS share of 15-30 year old population | EFTS share of total population | EFTS share of 15-64 year old population | EFTS share of 15-30 year old population |
| University EFTS share | 0.241*** | 0.168*** | 0.055*** | 0.185** | 0.131** | 0.039** |
| | (0.079) | (0.054) | (0.018) | (0.076) | (0.052) | (0.020) |
| Square of University EFTS share | -0.661*** | -0.317*** | -0.042*** | -0.551*** | -0.267*** | -0.033** |
| | (0.195) | (0.092) | (0.013) | (0.171) | (0.082) | (0.013) |
| Polytechnic EFTS share | 0.086* | 0.055* | 0.007 | 0.007 | 0.006 | -0.002 |
| | (0.047) | (0.030) | (0.012) | (0.057) | (0.036) | (0.015) |
| Square of Polytechnic EFTS share | -0.287* | -0.118* | -0.003 | -0.076 | -0.034 | 0.001 |
| | (0.170) | (0.070) | (0.006) | (0.215) | (0.089) | (0.007) |
| Share of working age population with a bachelor degree or above | 0.196 | 0.197 | 0.186 | -0.204 | -0.205 | -0.213 |
| | (0.167) | (0.166) | (0.163) | (0.161) | (0.161) | (0.162) |
| Share of working age population with a vocational qualification | 0.122** | 0.122** | 0.123** | -0.059 | -0.058 | -0.059 |
| | (0.055) | (0.055) | (0.055) | (0.078) | (0.078) | (0.078) |
| Under 15 population as a % of total population | 0.052 | 0.052 | 0.044 | 0.276* | 0.276* | 0.265* |
| | (0.115) | (0.115) | (0.117) | (0.156) | (0.155) | (0.156) |
| 65 or over population as a % of total population | 0.664*** | 0.664*** | 0.626*** | 0.412** | 0.414** | 0.395** |
| | (0.179) | (0.179) | (0.172) | (0.204) | (0.203) | (0.196) |
| Maori as a % of population | 0.163 | 0.163 | 0.158 | -0.276*** | -0.276*** | -0.278*** |
| | (0.123) | (0.123) | (0.125) | (0.072) | (0.072) | (0.072) |
| Foreign born as a % of population | 0.039 | 0.040 | 0.018 | -0.175 | -0.173 | -0.195 |
| | (0.235) | (0.234) | (0.234) | (0.212) | (0.212) | (0.213) |
| National migration inflow * Foreign born as a % of population | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Share of (full time) employment in primary industries | 0.081* | 0.081* | 0.081* | 0.135*** | 0.134*** | 0.133*** |
| | (0.044) | (0.044) | (0.044) | (0.039) | (0.039) | (0.039) |
| Share of (full time) employment in secondary industries | 0.066* | 0.066* | 0.065* | 0.096** | 0.096** | 0.094** |
| | (0.038) | (0.038) | (0.038) | (0.046) | (0.046) | (0.046) |
| Share of (full time) employment in various tertiary industries | 0.164** | 0.164** | 0.158** | 0.198*** | 0.197*** | 0.192*** |
| | (0.076) | (0.076) | (0.075) | (0.073) | (0.073) | (0.073) |
| Share of (full time) employment in finance and insurance | 0.102 | 0.101 | 0.086 | 0.210 | 0.207 | 0.186 |
| | (0.217) | (0.217) | (0.218) | (0.281) | (0.281) | (0.286) |
| Unemployment rate | -0.031 | -0.031 | -0.029 | 0.278*** | 0.278*** | 0.280*** |
| | (0.067) | (0.067) | (0.067) | (0.093) | (0.093) | (0.093) |
| Population ('000) per km$^2$ | 0.011 | 0.011 | 0.008 | -0.007 | -0.007 | -0.008 |
| | (0.052) | (0.052) | (0.052) | (0.055) | (0.054) | (0.055) |
| House price to income ratio | -0.001* | -0.001* | -0.001* | -0.002*** | -0.002*** | -0.002*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Patents applied to EPO and PCT per 10,000 inhabitants | 0.003 | 0.003 | 0.004* | 0.000 | 0.000 | 0.001 |
| | (0.002) | (0.002) | (0.002) | (0.003) | (0.003) | (0.003) |
| No applications for patents | -0.002 | -0.002 | -0.002 | -0.002 | -0.002 | -0.003 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| RC specific com price index | -0.015 | -0.014 | -0.012 | 0.079* | 0.079* | 0.078* |
| | (0.033) | (0.033) | (0.034) | (0.044) | (0.044) | (0.045) |
| Five year medium population projection | 0.801** | 0.803** | 0.811** | 1.184*** | 1.185*** | 1.209*** |
| | (0.327) | (0.326) | (0.322) | (0.402) | (0.402) | (0.391) |
| Ten year medium population projection | -0.926 | -0.930 | -0.887 | -1.422* | -1.429* | -1.422* |
| | (0.597) | (0.596) | (0.597) | (0.731) | (0.730) | (0.739) |
| Twenty year medium population projection | 0.211 | 0.213 | 0.165 | 0.043 | 0.046 | 0.020 |
| | (0.293) | (0.293) | (0.296) | (0.381) | (0.380) | (0.387) |
| Lagged dependent variable | 0.074 | 0.073 | 0.075 | -0.188 | -0.189 | -0.184 |
| | (0.161) | (0.161) | (0.159) | (0.118) | (0.118) | (0.116) |
| Constant | -0.011 | -0.011 | -0.011 | 0.014* | 0.014* | 0.014* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.008) | (0.008) | (0.008) | (0.007) | (0.007) | (0.007) |
| Observations | 228 | 228 | 228 | 171 | 171 | 171 |
| Number of TLA | 57 | 57 | 57 | 57 | 57 | 57 |
| $R^2$ | 0.51 | 0.51 | 0.51 | 0.84 | 0.84 | 0.84 |
| Year and TLA fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Weak identification test (Cragg-Donal Wald F Statistic) | 80.40 | 80.14 | 79.50 | 151.00 | 150.70 | 153.90 |
| Hansen J statistic (over-identification test) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (Differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effecssts are included implicitly.

Table A5: Population and employment growth GMM estimates with interactions

| | Population growth | | | | Employment growth | | | |
|---|---|---|---|---|---|---|---|---|
| | Population ('000) per Km2 | Employment share in Finance and Insurance industries | Patents applied to EPO and PCT per 10,000 inhabitants | Share of working age population with a bachelor degree or above | Population ('000) per Km2 | Employment share in Finance and Insurance industries | Patents applied to EPO and PCT per 10,000 inhabitants | Share of working age population with a bachelor degree or above |
| University EFTS as a % of working age population | 0.126 | 0.125 | 0.199*** | 0.263** | 0.125 | 0.083 | 0.178** | 0.252** |
| | (0.102) | (0.095) | (0.069) | (0.105) | (0.120) | (0.093) | (0.071) | (0.120) |
| Square of University EFTS as a % of working age population | 0.063 | -0.021 | 0.127** | 0.100 | -0.035 | 0.041 | 0.009 | -0.016 |
| | (0.043) | (0.095) | (0.063) | (0.077) | (0.049) | (0.110) | (0.090) | (0.103) |
| Polytechnic EFTS as a % of working age population | -0.235 | -0.109 | -0.452*** | -0.759*** | -0.282 | 0.369 | -0.480*** | -0.783** |
| | (0.226) | (0.425) | (0.167) | (0.277) | (0.270) | (0.468) | (0.155) | (0.321) |
| Square of Polytechnic EFTS as a % of working age population | -0.159 | 0.327 | -0.310** | -0.558 | 0.029 | 0.005 | -0.056 | -0.371 |
| | (0.113) | (0.370) | (0.154) | (0.351) | (0.135) | (0.486) | (0.218) | (0.476) |
| Population ('000) per km$^2$ | -0.008 | 0.010 | 0.015 | 0.015 | -0.026 | -0.003 | -0.002 | -0.004 |
| | (0.060) | (0.052) | (0.051) | (0.053) | (0.051) | (0.057) | (0.054) | (0.057) |
| Share of (full time) employment in finance and insurance | 0.122 | 0.057 | 0.076 | 0.103 | 0.115 | 0.305 | 0.217 | 0.179 |
| | (0.228) | (0.259) | (0.222) | (0.222) | (0.296) | (0.341) | (0.282) | (0.294) |
| Patents applied to EPO and PCT per 10,000 inhabitants | 0.003 | 0.003 | 0.004 | 0.003 | 0.001 | -0.000 | -0.000 | -0.000 |
| | (0.002) | (0.002) | (0.003) | (0.002) | (0.003) | (0.003) | (0.004) | (0.003) |
| Share of working age population with a bachelor degree or above | 0.200 | 0.190 | 0.195 | 0.200 | -0.245 | -0.191 | -0.217 | -0.231 |
| | (0.168) | (0.169) | (0.169) | (0.177) | (0.162) | (0.160) | (0.160) | (0.174) |
| Interactions with EFTS variables: | | | | | | | | |
| University EFTS as a % of working age population | 0.547 | 2.375 | 0.000 | -0.466 | -0.191 | 4.569 | -0.008 | -0.834 |
| | (0.918) | (3.446) | (0.049) | (0.983) | (0.952) | (4.041) | (0.054) | (0.987) |
| Square of University EFTS as a % of working age population | 0.368 | 3.095 | -0.072 | -0.820 | -0.147 | -2.883 | -0.022 | -0.067 |
| | (0.784) | (3.601) | (0.063) | (0.996) | (0.820) | (4.895) | (0.091) | (1.512) |
| Polytechnic EFTS as a % of working age population | -1.418 | -10.522 | 0.022 | 2.719 | 0.246 | -28.861 | 0.130 | 3.702 |
| | (1.975) | (16.280) | (0.149) | (2.547) | (2.007) | (18.748) | (0.161) | (2.673) |
| Square of Polytechnic EFTS as a % of working age population | -4.082 | -23.911 | 0.142 | 7.391 | 9.531 | -1.054 | 0.034 | 6.737 |
| | (8.155) | (17.824) | (0.220) | (5.359) | (8.271) | (25.479) | (0.299) | (7.458) |
| Other controls | | | | | | | | |
| Share of working age population with a vocational qualification | 0.126** | 0.121** | 0.122** | 0.120** | -0.051 | -0.078 | -0.065 | -0.059 |
| | (0.054) | (0.058) | (0.055) | (0.055) | (0.078) | (0.085) | (0.079) | (0.080) |
| Under 15 population as a % of total population | 0.054 | 0.063 | 0.051 | 0.062 | 0.285* | 0.252 | 0.286* | 0.283* |
| | (0.116) | (0.123) | (0.115) | (0.115) | (0.156) | (0.163) | (0.158) | (0.157) |
| 65 or over population as a % of total population | 0.664*** | 0.668*** | 0.659*** | 0.668*** | 0.393* | 0.403* | 0.423** | 0.412** |
| | (0.181) | (0.180) | (0.181) | (0.177) | (0.203) | (0.207) | (0.210) | (0.203) |
| Maori as a % of population | 0.160 | 0.169 | 0.164 | 0.163 | -0.277*** | -0.278*** | -0.277*** | -0.280*** |
| | (0.122) | (0.123) | (0.122) | (0.124) | (0.072) | (0.073) | (0.071) | (0.071) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Foreign born as a % of population | 0.065 | 0.052 | 0.046 | 0.021 | -0.167 | -0.163 | -0.149 | -0.200 |
| | (0.240) | (0.246) | (0.233) | (0.241) | (0.228) | (0.225) | (0.209) | (0.214) |
| National migration inflow * Foreign born as a % of population | -0.000 | -0.000 | -0.000 | -0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Share of (full time) employment in primary industries | 0.081* | 0.083* | 0.083* | 0.081* | 0.134*** | 0.142*** | 0.138*** | 0.136*** |
| | (0.044) | (0.044) | (0.043) | (0.043) | (0.039) | (0.040) | (0.040) | (0.039) |
| Share of (full time) employment in secondary industries | 0.066* | 0.068* | 0.064* | 0.067* | 0.094** | 0.102** | 0.101** | 0.098** |
| | (0.037) | (0.038) | (0.038) | (0.038) | (0.046) | (0.048) | (0.047) | (0.047) |
| Share of (full time) employment in various tertiary industries | 0.161** | 0.166** | 0.162** | 0.163** | 0.197*** | 0.204*** | 0.204*** | 0.201*** |
| | (0.076) | (0.076) | (0.076) | (0.076) | (0.074) | (0.074) | (0.073) | (0.073) |
| Unemployment rate | -0.028 | -0.033 | -0.028 | -0.030 | 0.260*** | 0.280*** | 0.284*** | 0.277*** |
| | (0.066) | (0.067) | (0.068) | (0.067) | (0.096) | (0.094) | (0.096) | (0.097) |
| House price to income ratio | -0.001* | -0.001* | -0.001* | -0.001* | -0.002*** | -0.002*** | -0.002*** | -0.002*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| No applications for patents | -0.002 | -0.002 | -0.002 | -0.002 | -0.002 | -0.003 | -0.003 | -0.003 |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| RC specific com price index | -0.016 | -0.012 | -0.015 | -0.009 | 0.086* | 0.085* | 0.085* | 0.089** |
| | (0.033) | (0.033) | (0.033) | (0.033) | (0.044) | (0.045) | (0.045) | (0.044) |
| Five year medium population projection | 0.782** | 0.778** | 0.821** | 0.818** | 1.189*** | 1.189*** | 1.147*** | 1.194*** |
| | (0.339) | (0.333) | (0.332) | (0.330) | (0.407) | (0.423) | (0.424) | (0.417) |
| Ten year medium population projection | -0.898 | -0.866 | -1.023* | -0.975 | -1.477** | -1.375* | -1.368* | -1.445* |
| | (0.608) | (0.610) | (0.611) | (0.604) | (0.741) | (0.762) | (0.779) | (0.768) |
| Twenty year medium population projection | 0.205 | 0.173 | 0.298 | 0.239 | 0.038 | -0.011 | 0.030 | 0.028 |
| | (0.293) | (0.299) | (0.296) | (0.299) | (0.388) | (0.382) | (0.396) | (0.393) |
| Lagged dependent variable | 0.066 | 0.068 | 0.070 | 0.072 | -0.191* | -0.191 | -0.195* | -0.190* |
| | (0.159) | (0.161) | (0.158) | (0.157) | (0.111) | (0.121) | (0.117) | (0.113) |
| Constant | -0.011 | -0.011 | -0.011 | -0.011 | 0.014* | 0.015** | 0.016** | 0.015** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.007) | (0.008) | (0.007) | (0.007) |
| Observations | 228 | 228 | 228 | 228 | 171 | 171 | 171 | 171 |
| Number of TLA | 57 | 57 | 57 | 57 | 57 | 57 | 57 | 57 |
| $R^2$ | 0.575 | 0.577 | 0.576 | 0.577 | 0.872 | 0.871 | 0.871 | 0.872 |
| Year and TLA Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Weak identification test (Cragg-Donal Wald F Statistic) | 93.01 | 79.72 | 77.98 | 89.21 | 153.90 | 145.10 | 145.30 | 159.00 |
| Hansen J statistic (over-identification test) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (Differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA fixed effects are included implicitly.

Table A6: Change in various industry (full time) employment shares

| | Full time employment share in following period by industry | | | |
|---|---|---|---|---|
| | Primary | Secondary | Various tertiary services | Finance and Insurance |
| University EFTS as a % of working age population | 0.131 | 0.368 | -0.071 | 0.002 |
| | (0.297) | (0.365) | (0.257) | (0.061) |
| Square of University EFTS as a % of working age population | -0.431 | -0.967 | -0.213 | 0.020 |
| | (0.536) | (0.709) | (0.574) | (0.105) |
| Polytechnic EFTS as a % of working age population | -0.168 | -0.105 | 0.083 | 0.004 |
| | (0.200) | (0.172) | (0.129) | (0.021) |
| Square of Polytechnic EFTS as a % of working age population | 0.218 | 0.166 | -0.205 | -0.040 |
| | (0.487) | (0.435) | (0.312) | (0.054) |
| Share of working age population with a bachelor degree or above | 0.174 | -0.043 | 0.603 | -0.004 |
| | (0.866) | (0.647) | (0.663) | (0.077) |
| Share of working age population with a vocational qualification | 0.343 | -0.145 | 0.098 | -0.104** |
| | (0.339) | (0.315) | (0.255) | (0.045) |
| Under 15 population as a % of total population | -0.159 | 0.243 | -0.352 | 0.008 |
| | (0.578) | (0.560) | (0.330) | (0.057) |
| 65 or over population as a % of total population | -0.240 | 1.057 | 0.271 | 0.014 |
| | (0.907) | (0.870) | (0.611) | (0.085) |
| Maori as a % of population | 0.190 | 0.210 | 0.286 | 0.013 |
| | (0.309) | (0.345) | (0.306) | (0.037) |
| Foreign born as a % of population | -1.191 | -1.175 | -1.135 | 0.017 |
| | (1.042) | (1.263) | (1.211) | (0.127) |
| National migration inflow * Foreign born as a % of population | 0.000 | 0.000 | 0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Share of (full time) employment in primary industries | 2.288*** | 1.316*** | 0.600 | 0.057 |
| | (0.763) | (0.507) | (0.541) | (0.040) |
| Share of (full time) employment in secondary industries | 1.289*** | 2.086** | 0.752 | 0.065* |
| | (0.475) | (0.869) | (0.647) | (0.038) |
| Share of (full time) employment in various tertiary industries | 1.771** | 1.925** | 2.389 | 0.068 |
| | (0.753) | (0.838) | (1.997) | (0.042) |
| Share of (full time) employment in finance and insurance | 4.919** | 4.310** | 1.267 | 1.182* |
| | (2.297) | (1.888) | (1.328) | (0.632) |
| Unemployment rate | 0.590* | 0.604* | -0.032 | -0.073** |
| | (0.335) | (0.345) | (0.231) | (0.037) |
| Population ('000) per km$^2$ | -0.184 | -0.015 | 0.016 | -0.003 |
| | (0.186) | (0.182) | (0.203) | (0.015) |
| House price to income ratio | 0.008* | -0.001 | -0.001 | 0.000 |
| | (0.004) | (0.003) | (0.003) | (0.000) |

| | | | | |
|---|---|---|---|---|
| Patents applied to EPO and PCT per 10,000 inhabitants | 0.005 | 0.006 | -0.003 | -0.001 |
| | (0.011) | (0.012) | (0.011) | (0.001) |
| No applications for patents | -0.001 | -0.002 | -0.004 | 0.000 |
| | (0.008) | (0.009) | (0.006) | (0.001) |
| RC specific com price index | -0.029 | 0.218 | -0.078 | -0.025 |
| | (0.168) | (0.171) | (0.117) | (0.020) |
| Five year medium population projection | -2.717 | -2.415 | 1.002 | 0.228 |
| | (1.883) | (1.976) | (1.052) | (0.162) |
| Ten year medium population projection | 0.391 | 3.247 | -2.138 | -0.285 |
| | (3.748) | (3.523) | (2.741) | (0.337) |
| Twenty year medium population projection | 3.823 | 0.224 | 1.164 | 0.038 |
| | (2.393) | (1.564) | (1.951) | (0.195) |
| Constant | 0.026 | 0.051 | 0.015 | 0.003 |
| | (0.035) | (0.033) | (0.031) | (0.003) |
| Observations | 228 | 228 | 228 | 228 |
| Number of TLA | 57 | 57 | 57 | 57 |
| $R^2$ | - | - | - | - |
| Year and TLA fixed effects | Yes | Yes | Yes | Yes |
| P-value for Kleibergen-Paap rk LM statistic (under-identification test) | 0.00 | 0.00 | 0.18 | 0.01 |
| Weak identification test (Cragg-Donal Wald F Statistic) | 11.29 | 9.59 | 1.86 | 4.83 |
| Hansen J statistic (over-identification test) | 0.00 | 0.00 | 0.00 | 0.00 |

**Notes**: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. (Differenced) Lagged dependent is instrumented by the twice lagged dependent variable. The null hypothesis of the under identification test is that the equation is under-identified. The null hypothesis of the weak instrument test is that the instruments are weak (endogenous). The joint null hypothesis of the over-identification test is that the excluded instruments are valid. Under all specifications, the instruments were found not to be weak, and the equation is exactly identified. In the difference GMM, TLA mixed effects are included implicitly.

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