Universities as Instruments of Regional Development in Canada's Provinces

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February 26, 2018

Summary:

Do research and teaching activities in a province's universities result in stronger economic performance for the regional economy? Universities are perceived to be sources of knowledge spillovers which are positive externalities in terms of encouraging industrial agglomeration and higher incomes in the local economy. Despite the high commitment of public expenditures to universities for teaching and research, there is surprisingly little empirical evidence to demonstrate that universities do, in fact, have positive impacts on the regional economy. This study investigates whether measures of university student enrolments, research funding and overall university budgets are correlated with provincial GDP growth, labour productivity growth, employment growth, investment and Total Factor Productivity growth. Using data from Statistics Canada's CANSIM database and CAUBO's FIUC database, we measure the regional economic impacts of universities in the 10 Canadian provinces between 2000 and 2014. Our results show that, on the margin, research funding and expenditures on universities have no effect on the growth of the regional economy. For the large population provinces, we find that overall university enrolment, research funding and size of university budgets have no significant economic impacts. For the 6 smaller population provinces, we find that increases in undergraduate engineering enrolment are positively associated with GDP growth, productivity growth and total factor productivity (innovation), suggesting that faculties or schools of engineering are a source of knowledge spillovers that compensate for the lack of scale economies from agglomeration in the region. The results of this study suggest that universities could boost provincial economic growth by increasing engineering enrolment, as well as by exploring opportunities for greater alignment of the missions of other faculties with regional labour market and knowledge infrastructure needs.

[1] The author thanks Derek Mikola, Joseph MacCallum and Jingyu Cui for their research assistance and Bethany Daigle for her editorial work. The author acknowledges support for research assistance from an anonymous donor to UNB under a gift agreement. The funder had no contact with the author and had no role in the conduct of the analyses, drafting of the report and the formation of conclusions and recommendations. Department of Economics, University of New Brunswick, Fredericton NB, E3B 5A3. hemery@unb.ca

"The word useful should be banished from the university vocabulary."

Basil Gildersleeve, Professor of Classics, Johns Hopkins University, 1877

Do research and teaching activities in a province's universities result in stronger economic performance for the regional economy? Despite the sizeable provincial and federal government expenditures on universities and university research, there is surprisingly little empirical evidence to demonstrate that universities do, in fact, drive growth of the regional economy (Goldstein and Drucker 2006, Drucker and Goldstein 2007, Kantor and Whalley 2014). Universities in Canada are recognized as important developers of human capital for the national economy as degree programs have produced graduates to be mobile across jobs, employers, industries, regions and nations.[2] Universities in Canada have also increased the research intensity of their missions over time, attracting internationally recognized researchers and producing commercializable discoveries. While research funding largely comes from federal government granting agencies, university operations in Canada are funded provincially. Canada's six smaller population provinces have less fiscal capacity to fund universities to the same levels as the large population provinces, and federal research funding is concentrated in the large population provinces. With perennial fiscal challenges in many provinces, sustaining the current scale of university operations and research as the number of provincial residents of university age declines, can appear to be a luxury rather than a necessity as provincial taxpayers have less appetite for subsidizing exports of the young population to other regions of the country.

In this study, we investigate whether provinces experience higher GDP growth, labour productivity and innovative activity by investing in their own universities over a strategy of importing/attracting human capital and relying on innovations produced outside the province. Goldstein and Drucker (2006) summarize some of the various ways that universities could spur regional economic growth including attracting and retaining technology-intensive industries and innovative firms; supplying the labor force with needed skills, and enhancing regional abilities to adjust to changing economic circumstances. "As public producers of knowledge," they write, "universities can strengthen technology transfer programs, encourage university-industry partnerships, and tailor educational curricula to match the skill demands of knowledge-based industries."[3] Kantor and Whalley (2014) discuss how knowledge spillovers from research universities may be a positive externality that clusters labour and capital in the regional economy which in turn results in industrial development and regional growth.

Goldstein and Drucker (2006) and Drucker and Goldstein (2007) find that research universities may aid small population regions in overcoming industrial disadvantages arising from a lack of

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[2]Emery and Norrie (2017). Simona Chiose, "Canadian university degrees still highly valued by employers worldwide: survey" The Globe and Mail, November 15, 2017 https://www.theglobeandmail.com/news/national/canadian-university-degrees-still-highly-valued-by-employers-worldwide-survey/article36997630/

[3] Goldstein, Maier, and Luger (1995) identify eight different functions or outputs of modern research universities that lead to economic development impacts: (a) creation of knowledge, (b) human capital creation, (c) transfer of existing know-how, (d) technological innovation, (e) capital investment, (f) regional leadership, (g) influence on regional milieu and (h) knowledge infrastructure production.

the scale advantages from agglomeration economies also described by Kantor and Whalley. Drucker and Goldstein (2007, 40) summarize that

> Although there is considerable variety in the magnitude and confidence of the results obtained, and often, nonuniversity regional factors are more influential than university factors, the majority of empirical analyses do demonstrate that the impacts of university activities on regional economic development are considerable. This serves, to some extent, to validate state and local policies that are designed to boost the new university economic development functions as well as those that support the more traditional research and human-capital creation activities of regional universities.

But even if local universities do have positive effects on regional development, then it is still not the case that investment in local universities is necessary for strong innovation performance and growth in the regional economy. As Uyarra (2010, 1238) observes, regions with strong performance regarding innovation and growth attract high-quality graduates, thereby reducing the return to investment in producing them. For teaching and research activities at local universities to have an impact on regional economic outcomes, they would need to produce skills, ideas and innovations otherwise not readily available (or affordable) from national and international markets. Feldman and Desrochers (2003, 14) find that, compared to other academic disciplines, the applied orientations of traditional engineering schools are more amenable to commercial activity and local economic development. Kantor and Whalley (2014) discuss several studies that show that knowledge spillovers from research universities are localized likely due network effects of university faculty, research staff and students. Universities may be a hub that connects knowledge creators with users of frontier ideas that spur economic development. This can occur directly from the university's research but also from the connection of university researchers to a broad network of researchers external to the region. In other words, research universities are the regional economy's "point of entry" for knowledge and ideas.

The extent to which universities have an impact on the regional economy is an empirical question. If migration of skilled labour to the province is a suitable substitute for graduates produced in provincial universities, then provincial incomes, investment and employment are independent of provincial expenditures on universities and the size of enrolments. If ideas and innovations produced elsewhere are available to the regional economy, then there may be little return in investing in research and development locally. We investigate whether the financial indicators of research activity, university operations or student enrolment in a province are associated with provincial economic outcomes. To accomplish this, we use data from Statistics Canada's CANSIM database and Canadian Association of University Business Officers (CAUBO) Financial Information of Universities and Colleges (FIUC) database to measure the regional economic impacts of universities in the 10 Canadian provinces between the fiscal years 2000 and 2014. We investigate if measures of university student enrolments, research funding and overall university budgets are correlated with provincial GDP growth, labour productivity growth, employment growth, investment and total factor productivity growth.

Our results show that for the study sample of all 10 provinces, on the margin, research funding and expenditures on universities have no effect on the growth of the regional economy. For the large population provinces (Ontario, Quebec, British Columbia and Alberta), we find that overall university enrolment, research funding and size of university budgets have no significant economic impacts—a finding which is similar to the results of Goldstein and Drucker's (2006) and Drucker's (2016) studies of the regional economic impacts of universities in the United States. For the 6 smaller population provinces, which have populations of around one million or less, we find that increases in undergraduate engineering enrolment are positively associated with GDP growth, productivity growth and total factor productivity (innovation), whereas non-engineering enrolment is associated with slower rates of increase in those outcomes. The results of this study suggest that universities could boost provincial economic growth by increasing engineering enrolment, as well as by exploring opportunities for greater alignment of the missions of other faculties with regional labour market and knowledge infrastructure needs.

UNIVERSITIES AS INSTRUMENTS FOR REGIONAL DEVELOPMENT

For universities to have an impact on the growth of the regional economy, the skills, knowledge and ideas produced by universities in the region must not have close substitutes that can be imported from universities outside the region. A province can invest in its own universities' capacities for education, training and innovation, or it can "free ride" on the outcomes of investments made in universities elsewhere. Universities have local and global impacts: they produce human capital and ideas for which there are both local and global demands. Graduates of local universities have employment prospects in labour markets beyond the regional economy,[4] and innovation emerging from university research may be exported and commercialized outside of the region. The returns to a province's investment in university teaching and research is monetized through the incomes of the graduates, royalties on patents, startup firms, industry research contracts, etc., which may not remain in the province.

Given the wide availability of skills and ideas on the global market, it is possible that local research performed at universities is not necessary for regional economic performance. If local university graduates can be readily substituted for graduates from other provinces or countries, then investment in local degree programs is unlikely to produce an incremental economic impact for the region (Uyarra 2010). If one can import and costlessly apply research, ideas and technology produced by other institutions, investment in local research capacity is unlikely to provide a return to investment in university research in the region. However, when graduates are able to address a local need that cannot be met by imports of people or ideas, or by direct applications of innovation produced elsewhere, we are likely to see a return to local investment in university programs and research. If research universities have spillover benefits for the regional economy, then the positive externalities of the local production of knowledge and human capital cannot be realized with human capital and knowledge imports (Kantor and Whalley 2014). Similarly, if knowledge spillovers are localized and hence ideas are costly to import and apply in the region, or if the university provides the necessary capacity to translate and apply imported knowledge to the regional economy, then local university activities would result in economic growth in the region. Drucker and Goldstein (2007, 39-40) propose that if economic benefits of universities are not localized, then "the positive influences of universities

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[4] Simona Chiose, "Canadian university degrees still highly valued by employers worldwide: survey" The Globe and Mail, November 15, 2017 https://www.theglobeandmail.com/news/national/canadian-university-degrees-still-highly-valued-by-employers-worldwide-survey/article36997630/

extend to larger distances…" which would reduce the "need for smaller branch campuses and would instead support policies to concentrate resources (and take advantage of economies of scale) in the large flagship institutions."

Second, to produce a measurable impact on the regional economy, universities must be a large, or at least influential, contributor to the region's overall knowledge infrastructure. Goldstein and Drucker (2006) note that a regional knowledge infrastructure includes public and private institutions of knowledge production; the capacities of firms, workers and institutions for innovation and learning; and the network of connections among them. However, it is not clear how the components of knowledge infrastructure within a region interact, nor do we know if universities rely on or can be substituted for other forms of knowledge infrastructure. This makes it somewhat difficult to identify the extent to which universities impact on provincial economies. A university is, after all, only one element of a regional knowledge infrastructure—it is only one of many factors influencing the regional economy. In larger provinces, the economic influence of universities may be small in comparison to other drivers of growth.

> The empirical results demonstrate that university research, teaching, and technology development do help to raise regional average earnings, with spillovers of knowledge and other benefits across regional boundaries influential as well. The effects of universities within the region are found to be particularly important in relatively small MSAs, those containing fewer than 200,000 nonfarm jobs, suggesting that universities may serve as a substitute for sheer size in regional development. In fact, universities may be less crucial as an ingredient for regional economic advancement in larger MSAs since there they constitute a much smaller proportion of total innovative activity. (Drucker and Goldstein 2007, 38)

Third, for universities to have an impact on the regional economy it may be necessary for the university to operate with an intention of addressing needs of the regional labour market and economy. Although faculties, departments and individual faculty members within any university may have activities aligned with regional interests, their impacts on regional growth could be due to serendipity rather than design. Impacts on the regional economy may not be sustained beyond the exit or retirement of key faculty members, nor replicable with new hires. Further, orientation of research activity and offered courses to the regional economy may be a legacy of historical hiring of faculty with roots in the region.[5] As many university faculty are recruited from outside of the region, they may have no ties to, or personal interest in, the region and their scholarship is oriented toward international, disciplinary peer reviewed journal publication (Simpson and Emery 2012; Emery, Simpson and Tapp 2013).

The missions of universities are likely important determinants of whether universities are a driver of growth in the regional economy. Uyarra (2010, 1231) describes contending models of the regional roles of modern universities. The relatively detached and conventional "knowledge

[5] For example, Wright (2013) review of autobiographies of historians Michael Bliss and E.R. Forbes highlights the "home bias" of careers of historians of an earlier generation.

factory" model, in which university research is expected to passively translate into innovation outputs, is based on the assumption that basic research (or at least the research that academics unilaterally choose to pursue) will ultimately yield discoveries of "eventual value" to industry, the economy and the public. Within the knowledge factory model, the presence of research-intensive universities is expected to passively, but positively, influence the innovation activity of nearby firms and the location of knowledge-intensive activities, such as hi-tech startups.

Public sources of research funding encourage universities to pursue the knowledge factory mission. Feldman and Desrochers (2003, 13-14) argue that the prestige of and autonomy within academic professions increased with the rise of government support for universities and research after World War II in the U.S. Academic research institutions evolved to be less focused on the practical and applied research and development needs of private industry, as academic research was more oriented toward the basic and long-term applied science agendas of federal funding agencies, as well as helping academics build their academic reputations. The technology transfer from academic research institutions to industry was an ancillary activity of universities that made it their mission to produce "well trained graduates, published research results and faculty consultants." More recently, Canada's Advisory Panel on Federal Support for Fundamental Science recommended "that the federal government should rapidly increase its investment in independent investigator-led research to redress the imbalance caused by differential investments favouring priority-driven targeted research over the past decade. The recommended investment is $485 million, phased in over four years, directed to funding investigator-led research." (page xviii)

Drucker and Goldstein (2007) and Uyarra (2010) describe the association of economic and fiscal conditions and flagging public support for academic research resulting in universities seeking to contribute to regional economic competitiveness through greater collaboration with industry. Drucker and Goldstein (2007, 21) observe that "Encouraged thus at the federal, state, and local levels, United States universities have generally embraced the goal of economic development as a complement to their traditional missions of education, research, and public service. The prospect of supplementary earnings from patents, licensing, and industrial collaborations has acted as an additional lure in a period of tight public education budgets." Uyarra (2010, 1232) observes that industry collaboration with universities is expected to produce innovation through channels such as "an increased stock of useful knowledge, the training of skilled graduates, new scientific instrumentation and methodologies, networks of social interaction, scientific and technological problem-solving, and firm creation". Advances in university contributions to regional development can occur through university entrepreneurship—a strategy in which administrative offices, technology transfer offices and business incubators actively and strategically push university research into industrial application and/or commercialization. Uyarra describes an even more ambitious role in which the "engaged university" moves beyond a knowledge transfer of existing university research for regional growth to a shift in its mission, aligning its functions with regional development needs (page 1238).

It is important to recognize that universities contribute to the regional economy in ways other than economic growth. Canada's Advisory Panel on Federal Support for Fundamental Science (2017, 17) concluded that "for Canada, … , research is ultimately about harnessing the power of human ingenuity and creativity to advance objectives cherished by our citizenry. A vibrant research ecosystem is essential to a wide range of objectives."[6] Universities in Canada have been important instruments of economic adjustment, as various degree programs have been oriented toward producing exportable human capital, providing education and skills training that enables graduates to be mobile across jobs, employers, industries, regions and nations (Emery and Norrie 2017).[7]

More recently, demographic trends have seen a decline in the number or provincial residents of university attending ages. In response to the decline in enrolment of domestic students, universities have increased recruitment and enrolment of international students who are not expected to remain in the regional economy. Universities as an export industry for human capital are different from exporters of other goods and services with respect to regional economic impacts. Beyond tuition and other mandatory fees, universities have no claims on the returns to the human capital and ideas they produce; the graduates themselves capture the returns to the investment through their income after graduation. Consequently, university exports of the human capital, knowledge produced impact only the economies in which they are "purchased"—that is, employed or commercialized.[8] University degrees are often jointly financed by the student receiving the human capital and by provincial taxpayers. This means that students may not pay for the full cost of their degrees, nor will emigrating graduates pay taxes in the province of their alma mater after graduation, making university human capital exports a subsidized industry.

Finally, the expectation that universities will increase GDP through their activities and annual expenditures arises from traditional multiplier analyses. However, these calculations overlook the fact that—unless it can be shown that the university activities and outputs have no available substitutes in the regional economy or through imports of human capital—the same economic impact could be achieved from spending the same amount of money on any other activity in the region. Wilson and Raymond (1973) demonstrated that local multiplier effects of university related expenditures are smaller than for other spending because of the higher propensity for university related expenditures (the school proper, faculty, staff, and students) to leak out of the local economy, and to the high proportion of local expenditures on items with low local value added. Out of province students may not remain in the province for the four months that are not part of the regular fall and winter terms. Faculty on leave, conducting field research, travelling for conferences or commuting to work from other provinces are other sources of expenditure leakage from the local economy. On the other hand, Kantor and Whalley (2014) find that research universities have modest, but persistent, productivity spillovers to local industries expenditures on universities meaning that they may have greater economic impact than is captured by a simple fiscal multiplier. But, if increased expenditure on research universities does

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[6] According to the Panel, these include: living longer and healthier lives in a cleaner and safer environment; protecting and enriching Canada's diverse cultures and heritage; developing innovative technologies, goods, and services that contribute to our economic prosperity and create fulfilling jobs; sustaining our economic sovereignty, standard of living, and valued social programs; fostering a creative, vibrant, and inclusive society; stimulating informed public debate; and supporting evidence-based policy-making in a period of accelerating change and complex domestic and global challenges.

[7] In comparison to other institutions of higher education, such as (vocational) colleges, Drucker (2016, 1187) notes that research universities are less likely to design programmes that cater to specific regional needs.

[8] One could argue, of course, that exports still impact the local economy through alumni donations; however, because these are voluntary remittances, they are not considered economic return

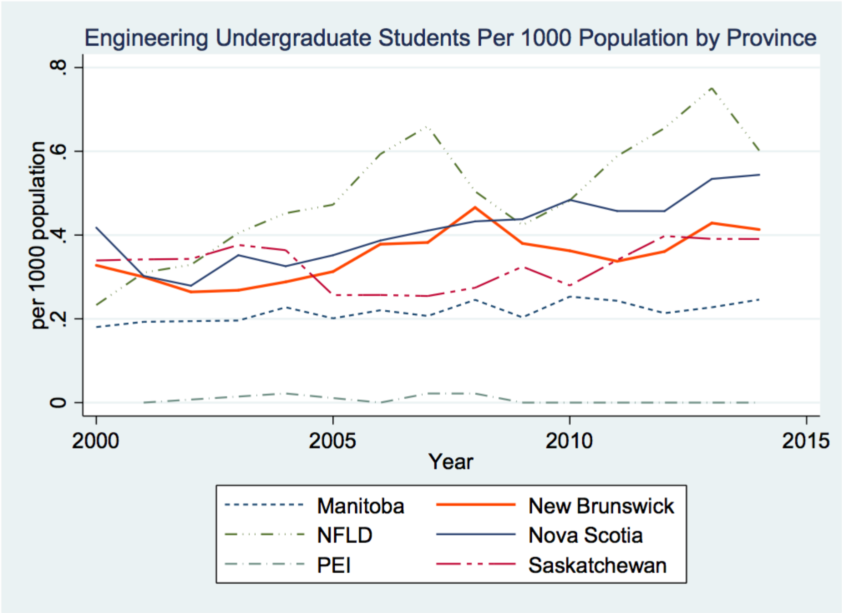
not increase the volume of knowledge spilling over, then there may be little multiplier effect on the regional economy. University output may not vary despite the monies spent on it as university inputs remain relatively fixed, resulting in increases in the prices of the inputs themselves (i.e., wages and salaries) making universities outputs more expensive. The student to faculty ratio is no longer rising in many provinces, but spending per student continues to rise because of increasing salary costs. Hicks and Whalley (2014) find that increased research spending at U.S. universities increases the number of papers produced but not necessarily the impact of knowledge produced.

DATA

For this study, we combine data from two sources. First, our measures of regional economic outcomes, GDP, labour force, employment and investment are from Statistics Canada's CANSIM database. University enrolment by province is also from CANSIM. Second, provincial funding for university research and total size of university budgets by province is from CAUBO's FIUC database. Details on data, sources and summary statistics are available in Appendix Table 1. We are restricted to the years 2000 to 2014 by CANSIM's data availability for university enrolments. Following Goldstein and Drucker (2006) who found that university activity was only correlated with regional outcomes in Metropolitan Statistical Areas (MSAs) in the United States with less than 200,000 non-farm employees, we focus on the 6 provinces with around 1 million population or less which would have universities located small to medium sized Canadian Census Metropolitan Areas (CMAs).

Following Feldman and Desrochers (2003) observation, we consider engineering school enrolment and research activities in the provinces to assess if the applied orientation of these programs is more apparent in regional economic outcomes. By referring to CANSIM's "Architecture, engineering and related technologies" category, we distinguish between enrolment in engineering programs and enrolment in all other programs not included in that category. Figure 1 shows engineering undergraduate students per 1000 population in the 6 smallest provinces with populations of around 1 million or less between 2000 and 2014. Since 2008, New Brunswick has had a drop in engineering undergraduate enrolment and lack of growth in enrolment since that time. In contrast, Nova Scotia's engineering enrolment increased over the same period. Newfoundland (NFLD) shows a much higher level of engineering enrolment per population, but it is highly variable, likely because of the effects of oil prices on the demand for engineers in the energy sector. Saskatchewan, Manitoba and PEI have shown little trend increase in engineering undergraduate enrolment over the study period.

FIGURE 1:



Non-engineering undergraduate enrolments account for the majority of university enrolment, as is apparent from the scale in Figure 2 when compared to that of Figure 1. In the context of a decline in university age populations in the smaller provinces (other than perhaps Saskatchewan, where a booming resource economy after 2005 resulted in population growth), universities have sought to maintain enrolment levels, as is suggested by a more gradual rate of change over time. The 2008 financial crisis does not appear to have affected undergraduate enrolments.

Figure 3 shows total university revenues per capita for the six smaller population provinces. University budgets increased in all provinces until 2008, and they continued to increase thereafter in Saskatchewan and NFLD, where energy sector activity led to flush provincial government budgets. While both Nova Scotia and New Brunswick show stagnant constant dollar university budgets, Nova Scotia has a much higher university revenue per capita. Of the 6 provinces in the dataset, New Brunswick universities in aggregate have the lowest total revenues per capita.

FIGURE 2:

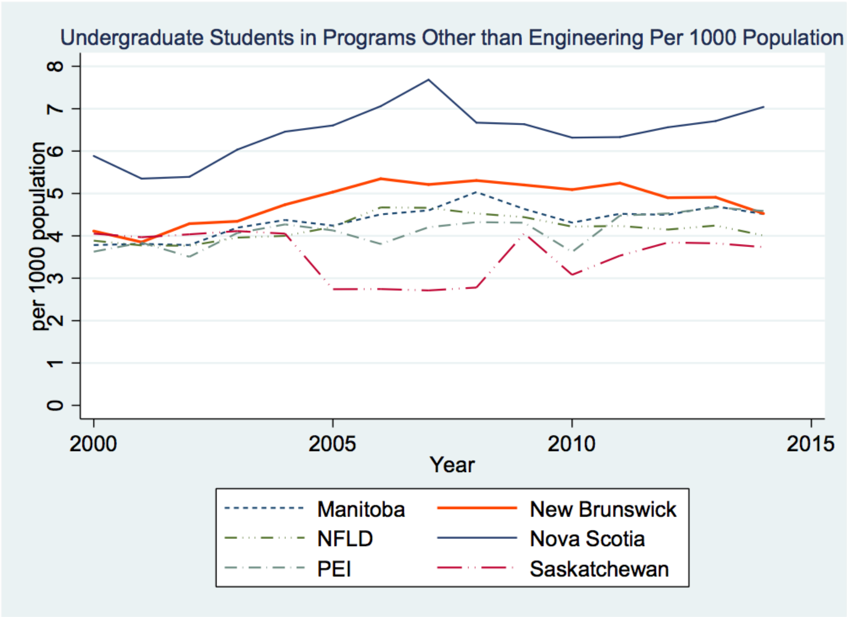


FIGURE 3:

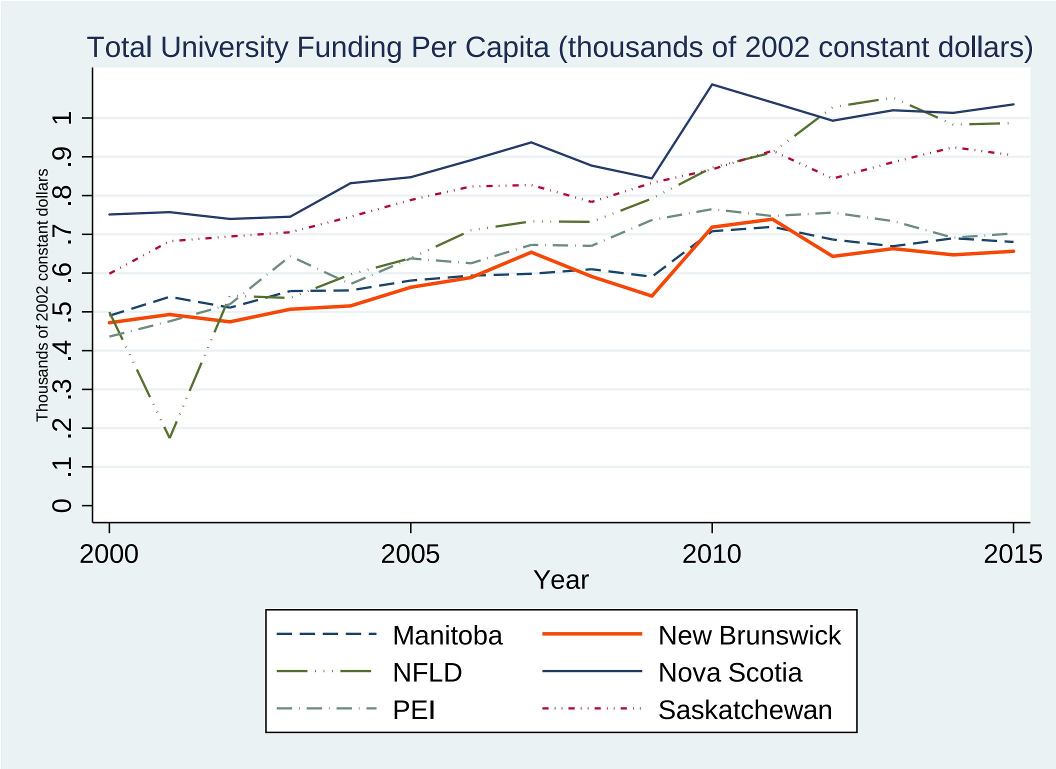
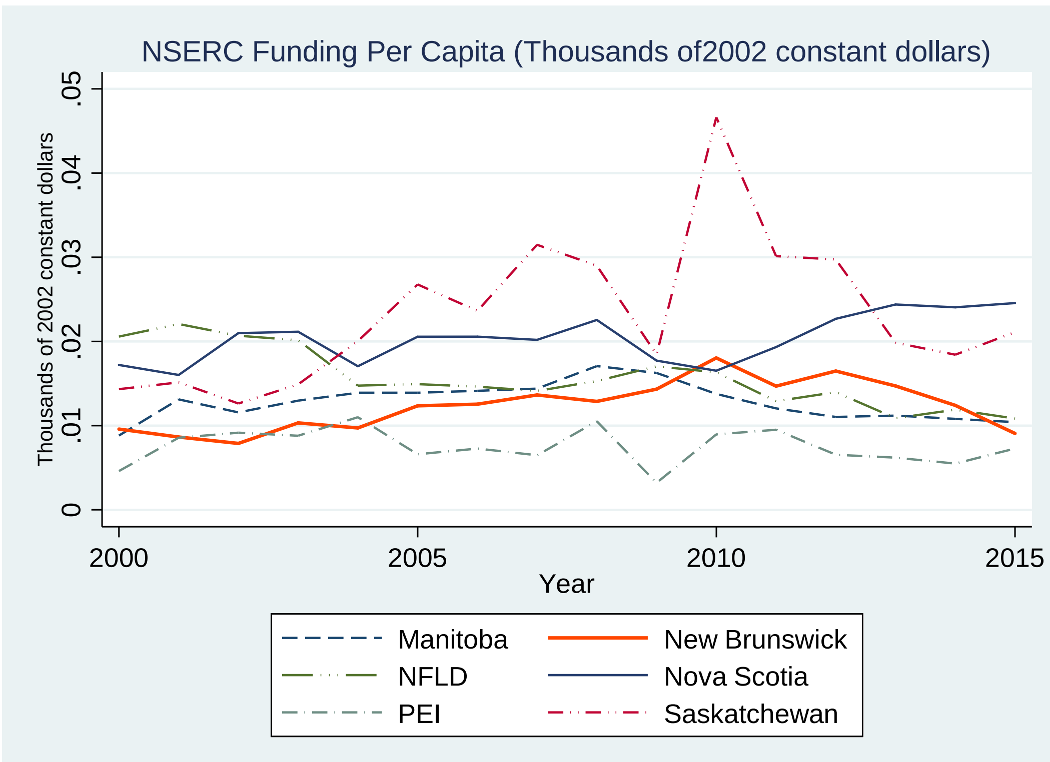


Figure 4 presents NSERC funding per capita in 2002 constant dollars for the 6 provinces between 2000 and 2014. Since 2008, only Nova Scotia has seen an increase in NSERC funding.

New Brunswick and the other provinces have shown sizeable drops in NSERC funding for research.

Across the 4 figures, Nova Scotia stands out for its high level of university funding, sustained growth in engineering enrolment and NSERC research funds. In contrast, New Brunswick has seen at best a maintenance of engineering enrolment, low levels of university funding and a steady decline in NSERC research funding since 2008. New Brunswick may have been using its scarce university revenues to maintain access to university education through prioritization of non-engineering undergraduate teaching missions over engineering programs and STEM research. (Note: New Brunswick also receives low levels of research funding from SSHRC and CIHR, the latter of which is explained by the lack of a medical school.)

FIGURE 4:



METHODS:

To investigate the impact of university teaching and research on provincial growth and other economic outcomes, we apply Ordinary Least Squares estimation methods to investigate the associations of growth rates of outcome variables using university funding and enrolment measures as explanatory variables. First differences of logarithms of outcome measures represent the annual growth rates of the dependent variable y_{it} in province *i* in year *t*. First differencing the dependent variable allows us to account for provincial fixed effects: unobserved systematic characteristics of the provinces which are not changing over the sample period.

There are several outcomes of interest for y_{it}, including GDP (in constant 2007 dollars), labour productivity (GDP in constant 2007 dollars divided by the size of the labour force), labour force size, employment, investment and total factor productivity (TFP). TFP is a calculated measure: it is the share of GDP growth not accounted for by growth in the labour force or the capital stock. TFP is a measure of residual growth, but it is often interpreted as a measure of innovation or technical progress, as it can also be interpreted as additional output for given quantities of capital and labour.

For independent variables, we use enrolment per thousand population in engineering undergraduate and graduate programs, total enrolment in university programs other than in engineering; per capita NSERC and CIHR research funds, research funding from donations, government contracts, private sector contracts, and per capita total revenues of universities in the province. All funding variables are in constant 2002 dollars in per capita terms. To allow for lagged effects of research funding, we estimate models which include the three year total research funding by category or the three year moving average of research funding by category. All right-hand-side variables are first differences—i.e. year to year changes. The coefficient estimates tell us the change in the growth of the dependent variable due to a one-unit change in the explanatory variable.

RESULTS:

Coefficient estimates, p-values and t-ratios for the 6 economic outcomes for the full sample, small province sample and big province sample are in Appendix Tables 2 to 7. Table 1 summarizes the findings across the Tables for the sample of 6 small population provinces, presenting the direction of effect on the outcome of interest. Statistically significant effects are in **bold**.

Undergraduate engineering enrolments are positively associated with all outcomes for the small population provinces except for labour force growth and investment growth. Increasing engineering enrolment in a province is associated with higher GDP growth, higher labour productivity growth, higher employment growth and higher total factor productivity. Increasing graduate enrolment in engineering is also positively associated with provincial growth outcomes, but none of the coefficient estimates differ significantly from zero. Note, the engineering enrolment effect could be a proxy measure for overall activity in an engineering faculty. Growing undergraduate enrolment may be associated with increases of full time faculty and an invigoration of teaching and research in the Faculty of Engineering. It may be that of all the measures included in the model to account for university teaching and research activity, changes in undergraduate engineering enrolment is the most sensitive to outcomes of interest.

TABLE 1: Sign and significance of association between university activity and growth outcomes, small province sample

	GDP	Labour Productivity	Total Factor Productivity	Labour Force	Investment	Employment
Research Activity						
NSERC	-	-	-	+	**+**	+
CIHR	-	-	+	-	**-**	-
Donations	+	+	+	+	+	+
Government Grant Contract	+	+	+	**-**	-	**-**
Private Grant Contract	+	+	+	+	+	+
Total University Funds	-	-	**-**	-	+	-
Teaching programs						
Engineering Undergraduate	**+**	**+**	**+**	+	+	**+**
Engineering Graduate	+	+	+	+	+	-
Undergraduate, not engineering	-	**-**	-	+	-	+
Graduate, not engineering	**-**	**-**	**-**	+	**-**	+

NOTE: + indicates positive association with outcome. – indicates negative association. **Bold** indicates statistically significant association at size 10%. Grey indicates no statistically significant association.

For non-engineering teaching programs, the association of increases in undergraduate enrolment with provincial economic outcomes is not statistically significant, but the coefficient estimates suggest that the direction of association is nonetheless negative. Graduate enrolments outside of engineering are significantly associated with slower growth in GDP, labour productivity, total factor productivity and investment.

For the research funding variables, there are few statistically significant coefficient estimates. In terms of direction, NSERC and CIHR funding is negatively associated with provincial growth, whereas donations and contract research are positively associated with economic outcomes in the province.

Increasing engineering undergraduate enrolment could have a substantial impact on provincial economic outcomes. For example, if New Brunswick enrolled 45 more engineering undergraduates per year to bring its engineering enrolment per 1000 population to match the level of enrolment in Nova Scotia, then based on the estimated effect sizes in Tables 2 through 7, that sustained increase in engineering enrolment would result in $370 million more GDP, $865 higher GDP per worker and 1400 more jobs in the province per year. If this increase were to occur in one year, then the GDP growth rate for the year of increase would be 1.3% higher due to this change. If the enrolment level was sustained after that year, there would be no further growth in GDP, but the level of GDP in the province would remain permanently higher.

To assess the robustness of the results presented here, we estimated a number of model specifications. For example, for the research funding variables we also used a three-year moving average of funding amounts, as well as current funding amounts. To assess whether the effects of enrolments were possibly endogenous to, rather than causing, growth outcomes, we included lags of the engineering enrolment variables and lags of the growth outcome. These models suggest that the effects of engineering enrolment changes persist for two years, but the lag of GDP growth does not explain engineering enrolment change. This suggests that increased engineering enrolment causes GDP growth, whereas GDP growth does not cause an increase in engineering enrolment.

The engineering enrolment variable was expanded to include mathematics and other STEM fields. This broader measure of STEM enrolment showed a weaker effect on economic outcomes than the narrower engineering enrolment variable.

We also used a second data set in which a city/location was the unit of observation. This data set provides an opportunity to corroborate results at the level of province, but the impacts of universities are also identified at a local level. The majority of observations are from the Census Metropolitan Areas (CMAs) and Census Agglomerations (CAs) in Canada. For each CMA, CA or other location, we counted the number of universities in the medical-doctoral, comprehensive and primarily undergraduate categories. We included a dummy variable equal to 1 if the CMA, CA or other location had an engineering faculty or school in one of the universities at that locale. It is important to note that all medical-doctoral and comprehensive universities have engineering programs; therefore, the engineering indicator variable will capture effects common to the two categories of universities. Because enrolment data is only available at the level of province, we have not included enrolment measures. From the CAUBO/FIUC data by university, we have created total dollar amounts reported by all institutions in a given CMA/CA/other location. The categories of funding variables are the same as in the previous analysis. We have more limited measures of economic outcomes for the level of the CMA/CA/other location. We used the total number of taxfilers per year, the total income of taxfilers and median income of taxfilers as outcome measures. These measures will be correlated with employment and GDP.

All models have the first differences of logarithms of the outcome variable regressed on annual changes in financial variables, counts of universities by category and an indicator variable for the presence of an engineering faculty or school in the locale. The sample is unbalanced in terms of years of observation. For CMAs, we have data for the years 2001 to 2014. For CAs and non-CMA/CA aggregate locations, we have data for the years 2008 to 2014. We also include locations with no universities.

We find no statistically significant effects of research funding or university expenditures on the numbers of taxfilers, total taxfiler income or median incomes in Canadian cities. We find that universities with primarily undergraduate programmes have no impact on these economic outcomes. We also reach the same result when the regression models only include the financial variables but not the controls for types of universities. Medical-doctoral universities are associated with significantly faster growth in the numbers of taxfilers, taxfiler incomes and median incomes. However, these institutions are in the larger CMAs, which are known to have faster growing populations and economies. Removing Toronto, Montreal and Vancouver from the sample does not change the findings. These results are also replicated when using only locations in the Atlantic provinces. We find no significant associations between the presence of comprehensive universities in a city and the rate of growth in the number of taxfilers or incomes in the same city.

When we include an indicator variable for the presence of an engineering school or faculty in a city, we find that the presence of either is significantly associated with growth in the number of taxfilers, total taxfiler incomes and median incomes in that city. The largest effect is on total taxfiler income, which on average grows 1% faster than in cities that do not have an engineering school or program. Growth rates in the number of tax filers and median incomes of taxfilers are both 0.5% higher than in cities without an engineering school or program.

LIMITATIONS:

We are unable to assess if there are causal interpretations of the reported associations. Small sample sizes have low statistical power for identifying effects of interest with respect to university activities and provincial economic outcomes. The lack of a near term correlation of universities and local economic outcomes should not come as a surprise if the knowledge and discoveries coming from universities have long gestation periods in terms of generating downstream economic impacts. This perspective would hold that the economic benefits we seek to measure will be present but on a time scale of decades rather than years. If this is the case then caution should be exercised in shifting university resources toward activities with nearer term expected economic benefits (e.g from basic research to commercializable applied research). Doing so could undermine the longer term benefits associated with the current allocation of university resources.

DISCUSSION:

In smaller provinces, universities present a potential policy lever for stimulating the provincial economy. Our results show that increases in engineering enrolment at the undergraduate level are associated with improvements in regional economic outcomes. A supporting analysis of economic outcomes at the level of cities shows that the presence of an engineering school or faculty within a city is associated with the faster economic growth of the city. Overall university budgets, research funding and the bulk of degree programs have no significant direct impact on the regional economy. Apart from faculties of engineering, universities in the Canadian provinces appear to be functioning as what Uyarra (2010) describes as "cathedrals in the desert," having little direct relevance to the human capital needs and innovation ecosystem of the regional economy.[9]

Is the lack of correlation of university research and teaching activities and regional economic performance a problem? Some would argue, as we note in the limitations, that university outputs have long gestation periods before they have economic and social impacts so our short term measures would not capture those benefits. Or, it may be that there are important social beenfits that our economic outcomes do not capture. Some would go further and argue that the lack of correlation of university activities and economic outcomes shows that universities are doing what they are supposed to do by aiming to advance knowledge rather than addressing societal needs and issues of the day. Canada's Advisory Panel on Federal Support for Fundamental Science (2017, 17) concluded that "for Canada, … , research is ultimately about harnessing the power of human ingenuity and creativity to advance objectives cherished by our citizenry. A vibrant research ecosystem is essential to a wide range of objectives."[10] Stanley Fish (2008, 55-57) would take issue with our study and its goal of demonstrating if there is a benefit to the economy, let alone the local economy. Fish sees the "inutility" of academic work for economic and societal outcomes as "a fact about it, and a defining, not a limiting, fact". Fish goes further arguing that "universities argue from weakness when they say … 'see, what we do does fact contribute to the state's prosperity, or to the community's cultural life, or to the production of a skilled workforce" (page 104). Fish contends that it is not the job of liberal arts education to bring about particular effects in the world and the value of that education should not be defined by extra-curricular payoffs. If Fish is correct, then Moggridge's (2008, 314- 315) observation identifies the funding implication for universities: "Clearly if the public decided "scientific culture" was desirable, it should be supported, but it was a form of consumption expenditure in competition with other uses of funds such as the relief of poverty, aid to less-developed

[9] Drucker (2016, 1187) notes that research universities are less likely to design programmes that cater to specific regional needs when compared to other institutions of higher education, such as (vocational) colleges.

[10] According to the Panel, these include: living longer and healthier lives in a cleaner and safer environment; protecting and enriching Canada's diverse cultures and heritage; developing innovative technologies, goods, and services that contribute to our economic prosperity and create fulfilling jobs; sustaining our economic sovereignty, standard of living, and valued social programs; fostering a creative, vibrant, and inclusive society; stimulating informed public debate; and supporting evidence-based policy-making in a period of accelerating change and complex domestic and global challenges.

countries, or increased consumption by taxpayers." Moggridge quotes economist Harry Johnson who in 1964 observed that

> Most of the contemporary "scientific culture" argument for government support of basic science research is to put it … in the class of economically functionless activity. The argument that individuals with a talent for such research should be supported by society… differs little from arguments formerly advanced in support of the rights of owners of landed property to a leisured existence, and is accompanied by a similar assumption of superior social worth of the privileged individuals over common men. Again, insistence on the obligation of society to support the pursuit of scientific knowledge for its own sake differs little from the historically earlier insistence on the obligation of society to support pursuit of religious truth, an obligation accompanied by a similarly unspecific and problematical payoff in the distant future.

While the overall value of university research and teaching within a province is not determined solely by its impact on the province's economic outcomes, local economic impacts are of interest to provincial funders of universities. In short, provincial governments and taxpayers may recognize the value of university education and research but they have a choice to free ride on the investments in universities elsewhere. If university impacts are observed locally—whether provinces experience a return on GDP growth, labour productivity and innovative activity, then that would signal a return to provincial residents from investing in their own universities over a strategy of importing/attracting human capital and relying on innovations produced outside the province. The existence of an association between a university program and regional economic outcomes shows that imports of human capital and innovations from outside the province are not perfect substitutes for the outputs of that program.

The importance of engineering programs for regional development informs us about the process by which universities can influence the regional economies. Although faculties, departments and individual faculty members within any university may have activities aligned with regional interests, their impacts on regional growth are due to serendipity rather than design. Kantor and Whalley (2014) find that research university activity generates modest productivity spillovers to other local industries with the size of the spillover effect increasing with the research intensity of the university and when university activities are technologically aligned with local firms. Feldman and Desrochers (2003, 14) note that "among academic disciplines, engineering is the most practically oriented and typically has extensive interaction with industry… traditionally engineering schools had a more applied orientation that was amenable to commercial activity and perhaps more relevant to local development." Engineering programs are perceived to be more aligned with the knowledge infrastructure required for growth and innovative activity in the regional economy. The lack of impact that graduate student enrolments, non-engineering enrolment, overall university budgets and research funding have on economic outcomes in the provinces could suggest that the bulk of university's agendas are not oriented to address regional economic development.

Could universities do more to address provincial economic growth? This question should be of interest, as the majority of university funds comes from provincial taxpayers and students—stakeholders who often do not have an active role in defining university missions. Drucker (2016) notes that scholars have urged research universities to purposefully consider the ways in which their activities impact regional innovation, entrepreneurship and economic performance. Furthermore, he notes, an accurate assessment of the impact of universities on regional economic growth demands better and more detailed empirical information and understanding.

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APPENDIX TABLES:

TABLE 1: Data Sources, Variables, Means and Standard Deviations

Dependent Variables	Data Sources		Obs.	Mean	St.Dev.
GDP ‘000s Constant 2007 dollars	CANSIM, 384-0038	2000 - 2015	160	154048.5	179162.6
GDP_PerEmployment ‘000s Constant 2007 dollars	*derived*	2000 - 2015	160	92.26015	19.20663
GDP_PerLabour ‘000s Constant 2007 dollars	*derived*	2000 - 2015	160	84.9	18.24742
Investment_TotalNonRes ‘000s Constant 2007 dollars	CANSIM, 031-0007	2000 - 2015	160	23810.14	26257.84
Employment_Over15	CANSIM, 282-0002	2000 - 2015	160	1654.063	1964.887
LabourForce_Over15	CANSIM, 282-0002	2000 - 2015	160	1780.761	2118.644
Provincial_Pop	CANSIM, 051-0001	2000 - 2015	160	3307092	3905528
Funding Thousands of constant 2007 dollars					
CIHR	FIUC	2000 - 2015	160	65571.49	93028.22
Donations	FIUC	2000 - 2015	160	19928.43	29744.17
GovGrantContract	FIUC	2000 - 2015	160	258377.8	334574.9
NSERC	FIUC	2000 - 2015	160	66203.34	80535.08
PrivGrantContract	FIUC	2000 - 2015	160	134244.3	202619.5
UnivTotFund	FIUC	2000 - 2015	160	2570840	3208390
Students					
ENG_Under	CANSIM, 477-0030	2000 - 2014	146	1273.664	1724.858
ENG_Grad2	CANSIM, 477-0030	2000 - 2014	135	500.9111	668.5418
ENG_Grad3	CANSIM, 477-0030	2000 - 2014	150	88.22	128.7355
NOTENG_Under	CANSIM, 477-0030	2000 - 2014	150	14533.44	19302.42
NOTENG_Grad2	CANSIM, 477-0030	2000 - 2014	150	3116.2	4125.12
NOTENG_Grad3	CANSIM, 477-0030	2000 - 2014	150	424.7	585.4545

TABLE 2: Ordinary Least Squares Coefficient Estimates: Real GDP Growth

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	-0.875	-0.246	-3.862*
	(-1.40)	(-0.34)	(-1.81)
ΔCIHR_CUM_PC	0.939	-0.622	1.170
	(0.80)	(-0.36)	(0.48)
ΔDonations_CUM_PC	0.0344	0.511	-1.972*
	(0.08)	(0.99)	(-1.79)
ΔGovGrantContract_CUM_PC	0.286	0.239	0.759
	(1.08)	(0.75)	(1.12)
ΔPrivGrantContract_CUM_PC	0.181	0.276	-0.413
	(0.52)	(0.66)	(-0.49)
ΔUnivTotFund_CUM_PC	-0.104***	-0.0714	-0.148**
	(-2.78)	(-1.40)	(-2.26)
ΔENG_Under_PT	0.214***	0.222***	0.164
	(3.29)	(2.96)	(0.82)
ΔNOTENG_Under_PT	-0.0114	-0.0167	-0.00442
	(-1.31)	(-1.52)	(-0.27)
ΔENG_Grad_PT	-0.0126	0.0572	-0.225

	(-0.09)	(0.32)	(-1.00)
ΔNOTENG_Grad_PT	-0.0511	-0.0860**	0.0312
	(-1.59)	(-2.03)	(0.59)
Constant	0.0217***	0.0179***	0.0252***
	(5.57)	(3.08)	(4.87)
R^2	0.178	0.251	0.310
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 3: Ordinary Least Squares Coefficient Estimates: Labour Productivity Growth

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	-1.210*	-0.687	-3.962*
	(-1.95)	(-0.93)	(-1.94)
ΔCIHR_CUM_PC	1.415	-0.0231	4.364*
	(1.21)	(-0.01)	(1.87)
ΔDonations_CUM_PC	0.00234	0.355	-1.742
	(0.01)	(0.67)	(-1.65)
ΔGovGrantContract_CUM_PC	0.399	0.459	0.0950
	(1.51)	(1.41)	(0.15)
ΔPrivGrantContract_CUM_PC	0.206	0.227	-0.141
	(0.60)	(0.53)	(-0.17)
ΔUnivTotFund_CUM_PC	-0.0977**	-0.0658	-0.169**
	(-2.62)	(-1.26)	(-2.68)
ΔENG_Under_PT	0.200***	0.201**	0.154
	(3.10)	(2.61)	(0.81)
ΔNOTENG_Under_PT	-0.0136	-0.0200*	0.00119
	(-1.56)	(-1.77)	(0.08)
ΔENG_Grad_PT	0.0139	0.0997	-0.223
	(0.10)	(0.54)	(-1.03)

ΔNOTENG_Grad_PT	-0.0578*	-0.0936**	0.0138
	(-1.81)	(-2.16)	(0.27)
Constant	0.0102***	0.00893	0.0109**
	(2.65)	(1.50)	(2.20)
R^2	0.200	0.252	0.366
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 4: Ordinary Least Squares Coefficient Estimates: Total Factor Productivity

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	-1.219**	-0.937	-3.523*
	(-2.06)	(-1.29)	(-1.88)
ΔCIHR_CUM_PC	2.623**	2.306	4.957**
	(2.36)	(1.31)	(2.32)
ΔDonations_CUM_PC	-0.146	0.00925	-1.415
	(-0.36)	(0.02)	(-1.46)
ΔGovGrantContract_CUM_PC	0.348	0.487	-0.188
	(1.39)	(1.52)	(-0.32)
ΔPrivGrantContract_CUM_PC	0.108	0.0129	-0.165
	(0.33)	(0.03)	(-0.22)
ΔUnivTotFund_CUM_PC	-0.121***	-0.111**	-0.144**
	(-3.41)	(-2.14)	(-2.50)
ΔENG_Under_PT	0.204***	0.211***	0.203
	(3.32)	(2.77)	(1.16)
ΔNOTENG_Under_PT	-0.0118	-0.0174	-0.000283
	(-1.43)	(-1.56)	(-0.02)
ΔENG_Grad_PT	-0.0235	0.0214	-0.118
	(-0.18)	(0.12)	(-0.60)

ΔNOTENG_Grad_PT	-0.0538*	-0.0910**	0.0181
	(-1.77)	(-2.12)	(0.39)
Constant	0.00435	0.00409	0.00393
	(1.18)	(0.69)	(0.87)
R^2	0.249	0.288	0.371
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 5: Ordinary Least Squares Coefficient Estimates: Labour Force Growth

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	0.335	0.440	0.0992
	(1.21)	(1.50)	(0.10)
ΔCIHR_CUM_PC	-0.476	-0.599	-3.194***
	(-0.92)	(-0.85)	(-2.93)
ΔDonations_CUM_PC	0.0320	0.156	-0.231
	(0.17)	(0.74)	(-0.47)
ΔGovGrantContract_CUM_PC	-0.112	-0.220*	0.664**
	(-0.96)	(-1.70)	(2.19)
ΔPrivGrantContract_CUM_PC	-0.0247	0.0483	-0.271
	(-0.16)	(0.28)	(-0.72)
ΔUnivTotFund_CUM_PC	-0.00672	-0.00560	0.0204
	(-0.40)	(-0.27)	(0.69)
ΔENG_Under_PT	0.0146	0.0205	0.00998
	(0.51)	(0.67)	(0.11)
ΔNOTENG_Under_PT	0.00213	0.00327	-0.00561
	(0.55)	(0.73)	(-0.76)
ΔENG_Grad_PT	-0.0265	-0.0424	-0.00185
	(-0.43)	(-0.57)	(-0.02)

ΔNOTENG_Grad_PT	0.00666	0.00764	0.0173
	(0.47)	(0.44)	(0.73)
Constant	0.0115***	0.00897***	0.0143***
	(6.67)	(3.77)	(6.18)
R^2	0.078	0.175	0.272
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 6: Ordinary Least Squares Coefficient Estimates: Investment Growth

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	2.838	5.504*	-2.508
	(1.12)	(1.98)	(-0.31)
ΔCIHR_CUM_PC	-3.787	-15.29**	0.330
	(-0.79)	(-2.28)	(0.04)
ΔDonations_CUM_PC	0.460	3.325	-9.057**
	(0.26)	(1.67)	(-2.17)
ΔGovGrantContract_CUM_PC	0.743	-0.451	4.735*
	(0.69)	(-0.37)	(1.84)
ΔPrivGrantContract_CUM_PC	-0.242	0.890	-1.081
	(-0.17)	(0.55)	(-0.34)
ΔUnivTotFund_CUM_PC	-0.0740	0.0811	-0.608**
	(-0.49)	(0.41)	(-2.44)
ΔENG_Under_PT	0.360	0.288	0.143
	(1.37)	(0.99)	(0.19)
ΔNOTENG_Under_PT	-0.0453	-0.0360	-0.0575
	(-1.28)	(-0.84)	(-0.92)
ΔENG_Grad_PT	0.247	0.533	-1.261
	(0.44)	(0.76)	(-1.48)

ΔNOTENG_Grad_PT	-0.224*	-0.345**	0.0485
	(-1.73)	(-2.10)	(0.24)
Constant	0.0528***	0.0609***	0.0431**
	(3.34)	(2.70)	(2.20)
R^2	0.083	0.243	0.346
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

TABLE 7: Ordinary Least Squares Coefficient Estimates: Employment Growth

	All Provinces	Small Provinces	Big Provinces
ΔNSERC_CUM_PC	0.0177	0.345	-1.753
	(0.05)	(0.98)	(-1.24)
ΔCIHR_CUM_PC	0.335	-0.118	-2.122
	(0.49)	(-0.14)	(-1.31)
ΔDonations_CUM_PC	-0.112	0.221	-1.134
	(-0.45)	(0.88)	(-1.55)
ΔGovGrantContract_CUM_PC	-0.104	-0.300*	0.971**
	(-0.68)	(-1.94)	(2.16)
ΔPrivGrantContract_CUM_PC	-0.136	0.0378	-0.605
	(-0.68)	(0.19)	(-1.08)
ΔUnivTotFund_CUM_PC	-0.0200	-0.00208	-0.0269
	(-0.92)	(-0.08)	(-0.62)
ΔENG_Under_PT	0.0835**	0.0662*	0.161
	(2.23)	(1.80)	(1.21)
ΔNOTENG_Under_PT	-0.000770	0.00213	-0.0120
	(-0.15)	(0.39)	(-1.09)
ΔENG_Grad_PT	-0.0162	-0.0364	-0.0454
	(-0.20)	(-0.41)	(-0.30)

ΔNOTENG_Grad_PT	0.000970	0.00494	0.0190
	(0.05)	(0.24)	(0.54)
Constant	0.0125***	0.00969***	0.0153***
	(5.56)	(3.40)	(4.44)
R^2	0.084	0.216	0.264
N	99	55	44

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

	Number of Taxfilers			Total Income of Taxfilers			Median Income		
	All locations	excluding TOR, MTL and VAN	Maritime Provinces	All locations	excluding TOR, MTL and VAN	Maritime Provinces	All locations	excluding TOR, MTL and VAN	Maritime Provinces
Model 1									
(Intercept)	**0.00605 (4.91e-14)**	**0.00607 (1.02e-13)**	**0.00405 (0.00454)**	**0.0304 (6.36e-133)**	**0.0304 (3.78e-129)**	**0.033 (8.19e-39)**	**0.025 (2.36e-257)**	**0.0249 (5.78e-254)**	**0.0307 (1.36e-77)**
numMD	0.00326 (0.18)	0.00426 (0.154)	0.00138 (0.827)	0.00763 (0.0241)	0.00771 (0.0633)	0.0158 (0.0748)	0.0037 (0.0372)	0.00256 (0.234)	0.0132 (0.00209)
numCS	-0.000697 (0.57)	0.000669 (0.782)	-0.00032 (0.969)	-0.00337 (0.0483)	-0.00308 (0.358)	-0.00572 (0.614)	-0.00272 (0.00249)	-0.00396 (0.0228)	-0.00633 (0.246)
numUG	-6.54e-05 (0.934)	-0.000435 (0.615)	-0.000727 (0.48)	-3.04e-05 (0.978)	2.98e-05 (0.98)	-0.00367 (0.0116)	-2.9e-05 (0.96)	0.000604 (0.331)	-0.00277 (8.92e-05)
Engineering	0.00623 (0.0104)	0.00571 (0.0394)	0.0098 (0.0797)	0.00961 (0.00458)	0.00941 (0.0145)	0.00967 (0.215)	0.0041 (0.0212)	0.00439 (0.0278)	5.52e-05 (0.988)
SampleSize	1389	1344	187	1389	1344	187	1389	1344	187

Model 2									
(Intercept)	0.00603 (2.3e-14)	0.00601 (6.65e-14)	0.00377 (0.00569)	0.0303 (6.6e-136)	0.0303 (1.17e-132)	0.0317 (3.57e-38)	0.025 (1.41e-261)	0.025 (3.51e-260)	0.0296 (1.2e-75)
numMD	0.0028 (0.221)	0.00379 (0.173)	0.000455 (0.927)	0.00545 (0.0874)	0.00895 (0.0206)	0.0129 (0.069)	0.00195 (0.246)	0.00443 (0.0273)	0.0119 (0.000768)
Engineering	0.00598 (0.00413)	0.0055 (0.0119)	0.00921 (0.0305)	0.00882 (0.00243)	0.00772 (0.011)	0.00488 (0.417)	0.00346 (0.0238)	0.00297 (0.0596)	-0.00444 (0.136)
SampleSize	1389	1344	187	1389	1344	187	1389	1344	187
Model 3									
(Intercept)	0.00603 (2.2e-14)	0.00601 (6.54e-14)	0.00377 (0.00556)	0.0303 (7.43e-136)	0.0303 (2.14e-132)	0.0317 (6.12e-38)	0.025 (1.18e-261)	0.025 (8.18e-260)	0.0296 (5.69e-74)
Engineering	0.00773 (3.44e-07)	0.00752 (3.09e-06)	0.00951 (0.000569)	0.0122 (7.82e-09)	0.0125 (2.71e-08)	0.0133 (0.000779)	0.00468 (2.58e-05)	0.00532 (4.71e-06)	0.00332 (0.0922)
SampleSize	1389	1344	187	1389	1344	187	1389	1344	187

Input	Number of Taxfilers		Total income of taxfilers		Median Income	
(Intercept)	0.00606 (1.32e-13)	0.00637 (2.57e-15)	0.0303 (2.11e-128)	0.0308 (2.52e-135)	0.0249 (1.61e-252)	0.0252 (1.83e-261)
numMD	0.00459 (0.132)	0.00824 (0.000944)	0.00803 (0.0579)	0.0139 (5.72e-05)	0.00279 (0.204)	0.00553 (0.00201)
numCS	0.000811 (0.739)	0.00307 (0.158)	-0.00262 (0.437)	0.00104 (0.73)	-0.00378 (0.0308)	-0.00208 (0.184)
numUG	-0.000419 (0.629)	0.000244 (0.762)	2.64e-05 (0.983)	0.0011 (0.326)	0.000637 (0.308)	0.00114 (0.0506)
Engineering	0.00573 (0.0395)		0.00928 (0.0163)		0.00431 (0.0312)	
NSERC_Diff	7.72e-08 (0.854)	7.48e-08 (0.858)	3.94e-07 (0.498)	3.9e-07 (0.503)	1.85e-08 (0.951)	1.67e-08 (0.956)
CIHR_Diff	-1.08e-07 (0.802)	-1.24e-07 (0.775)	-3.6e-07 (0.548)	-3.85e-07 (0.522)	-3.33e-07 (0.284)	-3.44e-07 (0.269)

CFI_Diff	1.58e-07 (0.546)	1.56e-07 (0.551)	2.49e-07 (0.493)	2.46e-07 (0.498)	3.31e-08 (0.86)	3.18e-08 (0.866)
CRC_Diff	-5.18e-08 (0.83)	-5.34e-08 (0.825)	9.2e-08 (0.783)	8.95e-08 (0.789)	9.79e-08 (0.572)	9.67e-08 (0.577)
TotalFederalGrants_Diff	-1.52e-07 (0.406)	-1.44e-07 (0.432)	-3.32e-07 (0.19)	-3.19e-07 (0.209)	-3.65e-08 (0.781)	-3.05e-08 (0.817)
Donations_Diff	9.08e-08 (0.636)	1.02e-07 (0.595)	3.79e-07 (0.155)	3.97e-07 (0.137)	9.42e-08 (0.495)	1.03e-07 (0.457)
NonGovernmentGrants_Diff	1.66e-08 (0.879)	2.16e-08 (0.843)	1.1e-07 (0.465)	1.18e-07 (0.433)	4.81e-08 (0.538)	5.19e-08 (0.507)
RemainingFunds_Diff	3.14e-09 (0.807)	3.27e-09 (0.8)	1.64e-08 (0.359)	1.66e-08 (0.354)	4.42e-10 (0.962)	5.38e-10 (0.954)
SampleSize	1344	1344	1344	1344	1344	1344