

REGIONAL INNOVATION AND DEVELOPMENT: A LATENT GROWTH MODEL OF REGIONAL INNOVATION DETERMINANTS

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We propose arguments supporting regional innovation to be dependent upon the simultaneous influence of movement of citizens and the industry structure within the region. Our hypotheses state that regions with a high industry concentration gain relatively more from individuals moving in respectively out from the region compared to regions with a low industry concentration. We tested our model and hypotheses on a four year longitudinal data from official registers on the complete population of 290 Swedish municipalities. Results support that regions with a high industry concentration gain innovation activity from increases in both in- and outflows of citizens from the region. Results on regions with a low industry concentration are inconclusive but indicate, in support of our arguments, that such regions gain relatively more from stability (i.e., low movement) in the region.

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Introduction

The heterogeneous regional distribution of innovation activity and outcomes has been of academic and policy interest for some time (Cooke, 1992). In the present study we examine how flows of individuals into and out from regions influence the level and growth of regional innovation. We expect that the independent variables can predict not only the level of regional innovation but also the change that occurs in regional innovation over time (i.e., regional development). We believe that the examination of inter-regional differences in level of innovation together with modeling the trajectory of change across regions measurement points with latent growth curves can contribute to more fine-grained explanations for how regional innovation occurs and for how entrepreneurial ecosystems function.

Previous studies witness that innovation output is geographically heterogeneously distributed (Cooke, Uranga, & Etxebarria, 1997; Doloreux & Parto, 2005). Some regions report high innovation output while others report no to very low innovation activities (Acs, Anselin, & Varga, 2002). To date, many studies have tried to provide a set of regional differences that can explain why some regions seemingly are better equipped to foster and support innovation (Cooke, 2002). In general, our review of the literature reveal that regional innovation have been suggested to be embedded in and dependent of specific social, economic, political and cultural contexts (Doloreux & Parto, 2005). We especially focus on the movement of individuals between (both in and out of) regions and take into consideration the regional industrial structure to understand their influence on

regional innovation. We develop our arguments for the main hypotheses based on literature on human and relational capital (Edvinsson & Malone, 1997). Following these literatures we argue that regions can gain from inflow of citizens as this contribute to the human capital in the region which subsequently is important for regional innovation. Also, we argue that regions can benefit regional innovation from outflows of citizens as such can contribute to relational capital where citizens moving out act as brokers between their old and their new regions. Further, we also argue that regions with an industry structure dominated of a few large companies have better abilities to make use of the additional human and relational capital gained by the inflow and outflow of citizens.

Hypotheses

We model regional innovation with latent growth modeling techniques (Chan, 2002) to acknowledge that the independent variables can predict not only the initial level of regional innovation but also the growth or decline that occurs in regional innovation over time. We use a four year time period in the dependent variable (years 2006-2010) and assume that the independent variables (as captured in 2006) are influential over this period of time. The hypothesized model is depicted in Figure 1. We assume regional innovation to be positively influenced by regional inflow and outflow of citizens, and that this effect is attenuated in regions which have an industry concentration dominated by a fewer larger companies. We develop the mechanisms for these relationships in the following sub-sections.

INSERT FIGURE 1 ABOUT HERE

Citizen mobility and regional innovation

Knowledge flows has been regarded as one of the principal sources of technological development and innovation (Asheim & Coenen, 2005). From a regional perspective, knowledge flows can complement the local developments and add new perspectives valuable for developing new products, services and processes.

Basically, innovation as an activity has become increasingly interactive and socially organized. This perspective is much supported by literature streams such as the ones on open innovation (Chesbrough, 2003), on external networks in innovation activities (Freel, 2000) and also in general literature on R&D and innovation. These literature streams suggest a high specialization in most innovation projects requiring a group of individuals with complementary skills. As such, the geographical concentration of relevant actors with diverse knowledge and competencies seem to be important to increase a regions innovation capacity (Nelson, 1993). Therefore, we believe that the flow of actors into a region will increase the diversity in knowledge and competences required for regional innovation, and thereby also increase the regions innovation capacity and subsequently regional innovation (Edquist, 1997).

Following the work of Bathelt, Malmberg, and Maskell (2004) we believe that the inflow of individuals to a region can add complementary knowledge and competencies to the local supply and thereby foster innovation. Some individuals are employed and thereby flow into a region to match ongoing innovation projects whereby it is likely that the inflow of individuals into a region can increase the level (i.e., intercept) of regional innovation. Also, it is likely that individuals flowing into regions with time can find social structures in which they can contribute to innovation whereby we believe that the inflow of individuals into a region also can contribute to the growth (i.e., slope) of regional innovation over time. Thereby, we propose the following hypotheses:

Hypothesis 1a. Inflow of citizens into a region is positively related to the initial level (i.e., intercept) of regional innovation.

Hypothesis 1b. Inflow of citizens into a region is positively related to the growth (i.e., slope) of regional innovation over time.

While the inflow of citizens has been argued to add knowledge to a region we also believe that the outflow of citizens can contribute to regional innovation. The argument for inflow of citizens rests on the addition of human capital while the suggested mechanism for outflow of citizens rests on the addition of relational capital to the region. Especially, we believe that individuals moving out from regions, in most cases, will keep some relation to the region that they are moving from. In some cases through friends and relatives and in other cases even with work related contacts. In doing so individuals moving out from a region can act as brokers to facilitate market relationships and cooperation with firms, institutions and individuals from their original region (Hanna & Walsh, 2002). As such, we believe that the outflow of individuals also can influence regional innovation.

Hypothesis 2a. Outflow of citizens into a region is positively related to the initial level (i.e., intercept) of regional innovation.

Hypothesis 2b. Outflow of citizens into a region is positively related to the growth (i.e., slope) of regional innovation over time.

Industry structure and regional innovation

A regions potential to make use of increases in human and structural capital depends likely on the nature of their industrial structure. Following the work by Schumpeter (1942), Cohen and Levin (1989), and Pisano (1991) we argue that regions which are dominated by a few large companies have better abilities to make use of increased human (i.e., inflow of citizens) and relational (i.e., outflow of citizens) capital. Regions with an industry structure dominated by a few large companies

have the potential advantage of integrating human and relational capital into established formal R&D programs. As such, we assume that a regions industry structure moderates the relation from inflow and outflow of citizens on both the initial level (i.e., intercept) and the growth (i.e., slope) of regional innovation. Therefore, we propose the following hypotheses:

Hypothesis 3a. The regional industry structure moderates the influence of inflow of citizens into a region on the initial level (i.e., intercept) of regional innovation: When the regional industry is dominated by a few large actors, increases in inflow of citizens will be positively related to the initial level of regional innovation.

Hypothesis 3b. The regional industry structure moderates the influence of inflow of citizens into a region on the growth (i.e., slope) of regional innovation over time: When the regional industry is dominated by a few large actors, increases in inflow of citizens will be positively related to the growth in regional innovation over time.

Hypothesis 4a. The regional industry structure moderates the influence of outflow of citizens from a region on the initial level (i.e., intercept) of regional innovation: When the regional industry is dominated by a few large actors, increases in outflow of citizens will be positively related to the initial level of regional innovation.

Hypothesis 4b. The regional industry structure moderates the influence of outflow of citizens from a region on the growth (i.e., slope) of regional innovation over time: When the regional industry is dominated by a few large actors, increases in outflow of citizens will be positively related to the growth in regional innovation over time.

Research Methods

Data

We tested our model and hypotheses on a four year longitudinal data on the complete population of 290 Swedish municipalities. Sampling municipalities is close to the original meaning of region. Rooted in the Latin word regio (from regere), region means “to govern”. As such we operationalize regions using administrative boundaries rather than cultural boundaries (Cooke, Uranga, & Etxebarria, 1997). In the Swedish economy the municipality is since 1971 the administrative division for local governance. As such, municipality is the administrative division of a country which has relevance for policy-making interventions, which often is the core essence in definitions of regions (Kaufmann & Tödting, 2002). We gather all data from public registers such as Statistics Sweden and the Swedish Patent and Registration Office. The dependent variable is captured for the years 2006-2010 while the independent variables and the control variables are gathered for 2006.

Measures

We measure our dependent variable – *regional innovation* – with the number of patent applications that are filed from a region each year. The measure has been adopted from the Swedish Patent and Registration Office. Adopting patent applications as a proxy for innovation has been widely used and its validity as a measure for regional innovation has been examined and supported (Acs, Anselin, & Varga, 2002).

The measures of – *inflow and outflow of citizens* – are gathered from Statistics Sweden and are counts of the number of citizens moving into respectively out from each municipality during the year 2006. We operationalize - *industry structure* – as the share of employees employed by the 15 largest firms in each region. The variable was extracted from Statistics Sweden and was measured for the year 2006. Concentration ratios have been commonly adopted to operationalize industry structure (Chuang & Lin, 1999; Dean & Meyer, 1996). The industry structure can vary between a low of close to 0 percent to a high of 100 percent. 0 percent demarcates that the 15 largest

companies employ a very low share (i.e., no individuals) of the regions citizens. 100 percent implies that all regional citizens are employed by the largest 15 companies.

We included in our analysis a number of control variables to account for possible alternative explanations and confounding processes. At first, we control for the size of the regional population by including the number of citizens in a municipality in year 2006. We do also control for regional business activities by including the number of new ventures established in each region in year 2006. Finally we also control for the rate of unemployment in the regions as an indicator of regional business conditions.

Results

Table 1 presents descriptive statistics for all variables used in the analyses in the form of average values and standard deviations at each measurement occasion. We measured patent applications from each region at time 1, 2, 3, and 4. An inspection of the averages and standard deviations presented reveal that the number of patent applications filed actually decrease over time, even if this is a marginal decrease. The descriptives also reveal that the average region has about 24 thousand citizens and a yearly inflow and outflow of approximately a thousand citizens. In each region about 49 new ventures are founded each year, and 73% of the employees work for the 15 largest companies in the region. The average unemployment rate is about 7 percent. However, common for all these figures is that the variation is quite substantial, implying that the regions are quite different comparing these variables.

INSERT TABLE 1 ABOUT HERE

Before estimating the full model, we examined the univariate curve analysis of regional innovation (see Table 2). Model fit indicators and model results suggest that the proposed model represent the empirical data well and that it is possible to use the data to represent both the intercept and slope of regional innovation. Although the chi-square statistics (as presented in Table 2) is significant we find the goodness-of-fit values in form of the CFI to be well within recommended levels (i.e., >.90). Table 2 also reports on the average and variance of initial levels and rates of change in regional innovation. All values are significant, which illustrates that we can estimate both the initial levels and the rate of change of regional innovation. Specifically, the initial value of regional innovation in terms of patent applications was 4.89 (mean initial level) and the average rate of change was -0.54 (mean rate of change). This implies a significant developmental decrease in regional innovation (number of patent applications filed in an averaged region = $4.89 - 0.54t$, at $t = 2006, 2007, 2008,$ and 2009).

INSERT TABLE 2 ABOUT HERE

Table 3 reports the results for the structural equation estimation of the hypothesized model (as specified in Figure 1). We found both the model of inflow and outflow of citizens to provide acceptable goodness of fit values (i.e., NFI=.99; CFI=.99; RMSEA=.00). The model on inflow reports a $\chi^2(21)=17.93$ which is non-significant ($p=.65$). The model on outflow reports a $\chi^2(21)=17.63$ which is non-significant ($p=.67$). Out of the control variables we find the number of new ventures in the regions to be positively and significantly related to the intercept of regional innovation in both the inflow and the outflow models. In support of Hypotheses 1a and 2a we found that the inflow and outflow of citizens to be positively and significantly related to regional innovation. However, not supporting Hypotheses 1b and 2b, we found neither inflow nor outflow of

citizens to significantly influence regional innovation. Yet, we found that when controlling for the moderation of regional industry structure we also found (at least one of the) interaction effects to significantly influence the growth (i.e., slope) of regional innovation over time. As such, we found support for Hypotheses 3a, 3b and 4a. To further examine the interaction effects we plot the significant interactions in Figures 3a, 3b, and 4a. The plots clearly demonstrates support for the hypotheses and show that regions with a industry structure dominated by a few large companies are better able to make use of the inflow (human capital) and outflow (relational capital) of citizens.

INSERT TABLE 3 ABOUT HERE

INSERT FIGURE 3a,b ABOUT HERE

INSERT FIGURE 4a ABOUT HERE

Discussion

We expand prior work on entrepreneurial ecosystems and regional innovation by theorizing and empirically jointly testing a set of determinants of regional innovation, and by including a longitudinal aspect where we test how innovation determinants influence both the level and the development of innovation in regions. In specific, the present study adds to the contemporary knowledge about regional innovation and development by developing arguments and empirically

testing hypotheses related to the role of human and relational capital gained from regional inflows and outflow of citizens for the initial levels of and growth in regional innovation over time. Also we contribute by adding arguments for the importance of the regional industrial structure.

While this study sheds light on the dynamics of regional innovation and use longitudinal testing to assert causality and the potential lag in effects from the independent variables, it has some limitations that must be taken into consideration. Still, we report our empirical findings for regions in a specific country (Sweden) at a specific time, and related to administrative regions (i.e., municipalities) rather than cultural regions. Other settings might offer different results than those we report herein. We therefore challenge future studies to replicate this study in other regions and with other time frames.

The aim of this study was to open up for more fine grained examinations on the flows of citizens into and out from regions. We hope that this effort encourages future research to continue this examination with inclusion of other potential important variables which could influence the relationships studied here.

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Figure 2
Predicted and Observed Averages of Regional Innovation

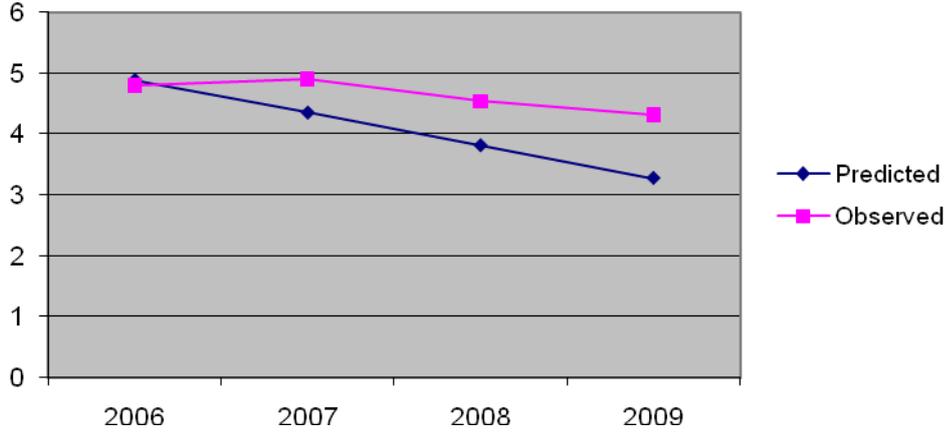
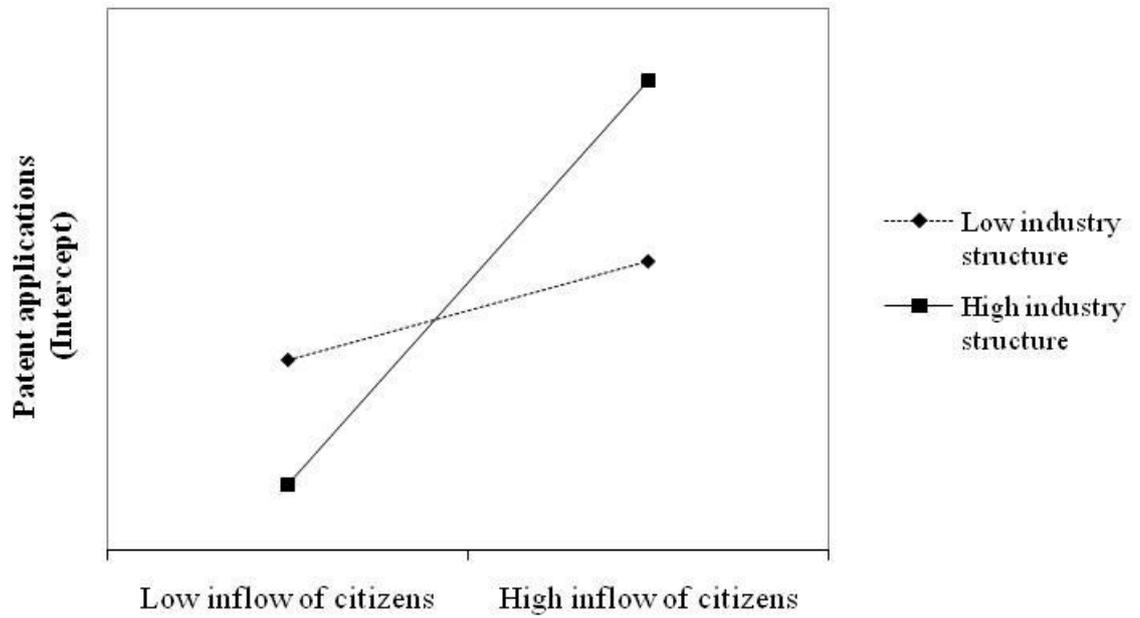


Figure 3
Inflow of Citizens and Industry Structure Interaction

a) Intercept of Patent Applications



b) Slope of Patent Applications

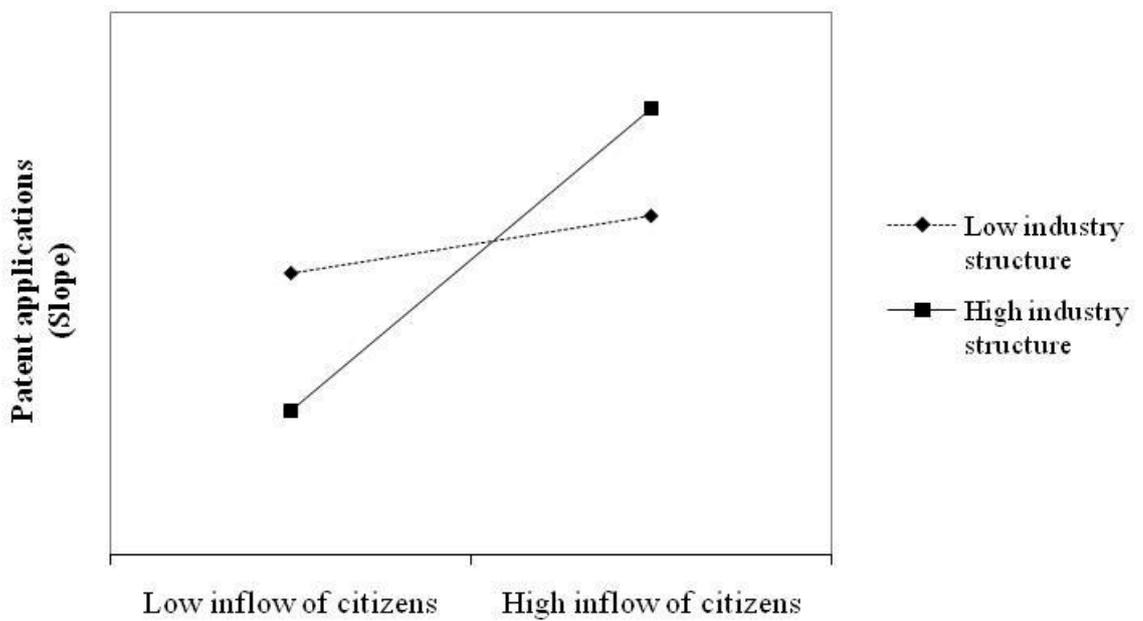


Figure 4
Outflow of Citizens and Industry Structure Interaction

a) Intercept of Patent Applications

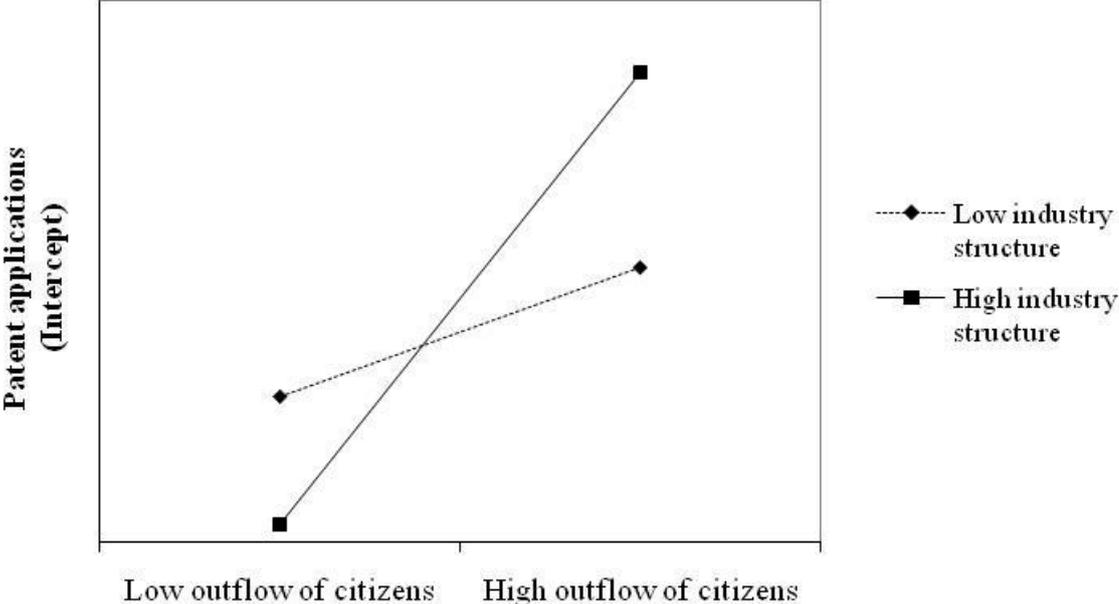


Table 2
Estimates for univariate growth curve

Variable	Loadings				Initial level		Rate of change		χ^2	CFI
	λ_{12}	λ_{22}	λ_{32}	λ_{42}	M	Variance	M	Variance		
1. Regional innovation	0.00	0.33	0.67	1.00	4.89***	52.71***	-0.54*	7.66***	86.12(8) (p=.01)	.93

* p<.05, ** p<.01, *** p<.001

Table 3
Estimated Coefficients^a

Variables	Inflow of Citizens				Outflow of Citizens			
	Intercept		Slope		Intercept		Slope	
Regional population	.10	(.12)	.02	(.12)	.06	(.12)	.01	(.12)
New ventures	.24***	(.04)	-.04	(.04)	.23***	(.04)	-.02	(.04)
Unemployed	.01	(.02)	.03	(.02)	.01	(.02)	.03	(.02)
Industry structure	-.02	(.03)	.04	(.03)	.05	(.03)	-.03	(.03)
Inflow of Citizens	.32**	(.12)	.20	(.11)				
Outflow of Citizens					.43***	(.12)	.14	(.12)
Inflow of Citizens x Industry structure	.20**	(.08)	.14*	(.07)				
Outflow of Citizens x Industry structure					.24***	(.08)	.09	(.07)

^a Unstandardized path-coefficients, standard error within parentheses.

* p<.05, ** p<.01, *** p<.001