Regional determinants of technology entrepreneurship

Jianhong Xue*

College of Economics and Management,
Northwest A&F University,
3 Taicheng Road,
Yangling, Shaanxi, 712100, China
E-mail: xuej@nwsuaf.edu.cn
*Corresponding author

Peter G. Klein

Division of Applied Social Sciences,
University of Missouri,
135D Mumford Hall,
Columbia, MO 65211, USA
E-mail: pklein@missouri.edu

Abstract: We explore the regional determinants of entrepreneurial activity with latent variables framework in which entrepreneurship is not observed directly, but manifested in activities such as producing patentable innovations, receiving venture funding and establishing new enterprises. We find that R&D expenditures, the presence of anchor firms, good (small) government and the availability of intellectual-property lawyers are positively associated with entrepreneurial activity, while the numbers of scientists, the presence of anchor universities and other measures of the political environment do not have statistically significant effects. We argue more generally for the benefits of treating entrepreneurship as a latent construct.

Keywords: entrepreneurship; economic growth; technology; latent variables models.

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Biographical notes: Jianhong Xue is a Professor at Northwest A&F University and a Research Associate of the McQuinn Center for Entrepreneurial Leadership. He was previously an Instructor at Carleton University, Canada.

Peter G. Klein is an Associate Professor in the Division of Applied Social Sciences at the University of Missouri, Research Associate of the McQuinn Center for Entrepreneurial Leadership and an Adjunct Professor at the Norwegian School of Economics and Business Administration. He also serves as Associate Director of the Contracting and Organizations Research Institute (CORI).

1 Introduction

The measurement and definition of entrepreneurship continues to be a major challenge for empirical research in entrepreneurship and innovation. Most of the literature treats entrepreneurship in an *occupational* or *structural* sense. Occupational theories of entrepreneurship define entrepreneurship as self-employment and treat the individual as the unit of analysis. This literature seeks to describe the characteristics of individuals who start their own businesses and to explain the choice between employment and self-employment. Structural concepts take the firm or industry as the unit of analysis, using the term 'entrepreneurial' to denote new firms, small firms or rapidly growing sectors. By contrast, the classic contributions to the economic theory of entrepreneurship model entrepreneurship as a function, activity or process, not an employment category or a firm or market structure. Entrepreneurship, whether conceived as innovation (Schumpeter, 1911), uncertainty bearing (Knight, 1921), alertness (Kirzner, 1973) or adaptation (Schultz, 1975), is exercised by people in many job categories and in many types of firms.

If entrepreneurship is modelled as a function, how is this function to be parameterised? Entrepreneurs create and discover opportunities, but opportunities themselves are not observed. We observe the fruits of entrepreneurship – the introduction of new goods and services, expenditures on R&D, the establishment of new firms and so on – but we do not observe entrepreneurship itself. Moreover, opportunities can be conceived, but not carried out; opportunity creation and discovery, in other words, do not lead necessarily to opportunity exploitation. In light of these considerations we focus on *entrepreneurial activity*, i.e., opportunities that are pursued. This form of entrepreneurship is manifested in a variety of ways such as producing patentable innovations, receiving venture funding and establishing new enterprises. Rather than analyse these separately, we model entrepreneurial activity as a latent variable in a structural-equations framework. Focusing on the information and communication technology (ICT) and biotech sectors, where innovation and entrepreneurship are particularly important, we use patents, small business innovation rewards, venture funding and the number of new technology establishments as indicators for entrepreneurial action and construct an entrepreneurial activity index for US states. Use of such a composite measure allows us to sidestep the thorny questions about the measurement and definition of entrepreneurship that plague the empirical literature.

We next use this index to examine the effects of local and regional characteristics on entrepreneurial activity. The entrepreneurship literature often treats the entrepreneur's vision as a unique, individual phenomenon (Hagen, 1962; McClelland, 1961, 1987; Kihlstrom and Laffont, 1979; Kirzner, 1979, 1997; Casson, 1982). However, recent literature in economic geography (e.g., Porter, 1990, 1998; Feldman and Francis, 2004) indicates that entrepreneurial and industrial activities tend to cluster geographically, suggesting that the ability to convert entrepreneurial ideas into entrepreneurial action varies systematically across regions. After all, entrepreneurs choose a 'region' to start their businesses. This is especially true for entrepreneurial activity in innovative or technological production (Feldman, 1994; Audretsch and Feldman, 1996). More generally, entrepreneurship appears to have significant regional and temporal dimensions. For instance, Western Europe and the USA have persistently led the world in entrepreneurial innovation for centuries; and in the USA, entrepreneurial activity has mainly clustered in its coastal areas such as Silicon Valley and Route 128. In Japan, the rising of entrepreneurship and modern enterprises occurred only after the Meiji Restoration. Today, the massive emergence of entrepreneurial activity in China and India has followed decades of institutional reform and remains concentrated in a handful of regions.

To explore the regional determinants of entrepreneurial activity, we model entrepreneurial activity as a function of the availability of strategic resources, the ease with which resources can be combined, the ease with which firms can be founded and the security of doing business. We collect indicators for each of these four factors, using US state-level data and treat them as explanatory variables in a model that regress our entrepreneurial activity index on environmental characteristics. We find that R&D expenditures, the presence of anchor firms, good (small) government and the availability of intellectual property lawyers are positively associated with entrepreneurial activity, while the numbers of scientists, the presence of anchor universities and other measures of the political environment do not have statistically significant effects.

Section 2 reviews prior literature and describes our conceptual framework. Section 3 explains our modelling constructs and data. Section 4 presents the results and Section 5 concludes with a brief summary and discussion.

2 Theory and conceptual framework

Much of the entrepreneurship literature in economics focuses on the individual entrepreneur and characteristics such as attitudes toward risk (Kihlstrom and Laffont, 1979) and uncertainty (Knight, 1921), human capital (Schultz, 1975; Klein and Cook, 2006), breadth of skills (Lazear, 2004), vision and creativity (McClelland, 1961, 1987; Witt, 1999) and the usual demographic indicators [Parker, (2004), Chapter 3]. A parallel literature in economic geography examines the spatial clustering of innovation (Krugman, 1991a, 1991b; Feldman, 1994; Henderson, 1994; Porter, 1990, 1998; Arthur, 1990). The basic ideas date back at least to Marshall (1890) and have gained increasing attention in academic and policy circles. This literature explains regional advantages in terms of positive spillovers from co-location or positive feedback triggered by some initial shock, possibly historical accident. Explaining the initial shock, or why one region tends to attract a cluster instead of another, has proven more difficult.

We tie these literatures together by arguing that some factors attracting entrepreneurs, and fostering entrepreneurial activity, are region-specific. While some studies have linked the concentration of entrepreneurial activities to the formation of firm and industry clusters (e.g., Feldman, 2001; Feldman and Francis, 2001), 'the region' as part of the entrepreneur's stock of resources has not been fully investigated. What regional characteristics drive the emergence of entrepreneurship?

2.1 A composite measure of entrepreneurial activity

The entrepreneurship literature measures entrepreneurial activity in many, frequently inconsistent, ways. We start by defining a composite, multidimensional measure of entrepreneurship that avoids some of the difficult issues of measurement and definition. 'Entrepreneurship' is, of course, more than simply start-ups or patents or growth rates or whatever. We cannot see it, but we see various 'footprints' that entrepreneurship leaves behind. This should not be an insurmountable obstacle; after all, behavioural and social science researchers frequently work with concepts that cannot be directly observed or measured such as intelligence, self-esteem, democracy and so on, by treating them as latent variables in a structural-equations framework. Concepts that cannot be directly observed are termed latent variables and multiple, indirect, but observable measures are used as indicators to manifest these unobservable concepts. For example, human intelligence cannot be directly observed and measured, but SAT scores and grade point averages can be used as indicators for intelligence.

We argue that entrepreneurship can usefully be treated, in similar fashion, as a latent variable. The entrepreneurial act, broadly conceived, may be unobservable, but various manifestations of entrepreneurship are easily measured. Gartner and Shane (1995) use the number of organisations per capita as an indicator of entrepreneurship. Likewise, the Kauffman Foundation's Index of Entrepreneurial Activity counts the proportion of a state's adult population not already business owners who start a new business in a given month. However, as argued by Foss and Klein (2005) and Foss et al. (2007), the entrepreneurial function does not cease with the establishment of a new venture. Rather, entrepreneurs continue to establish organisational goals, delegate rights and responsibilities, experiment with organisational design, adjust the boundaries of the organisation and so on. Schumpeter (1911) describes at least five means by which entrepreneurs carry out new combinations:

1. introducing a new good or a new quality of a good
2. introducing a new production method
3. opening a new market
4. establishing a new source of supply of raw materials or intermediate goods
5. creating a new organisational form.

This suggests that simply measuring organisational birth rates does not capture the full impact of entrepreneurship.

Our analysis distinguishes *entrepreneurial ideas* – e.g., the creation or discovery of profit opportunities (Kirzner, 1973, 1979, 1997; Alvarez and Barney, 2007) – from *entrepreneurial action* (Klein, 2008). These actions are manifest in a variety of ways, including the establishment of new enterprises, the discovery of patentable innovations and the provision of private and public financial capital to new ventures. We collect data on patents, Small Business Innovation Research (SBIR) awards, venture capital funding and establishments and use confirmatory factor analysis (CFA) to construct an entrepreneurial activity index (*EA*) with a composite score for each state. This is used as the dependent variable in the analysis that follows.

2.2 Regional determinants of entrepreneurial activity

We posit that entrepreneurial activity, measured by *EA*, is a function of the entrepreneurial opportunity set that a region presents. This opportunity set consists of four components: the availability of strategic resources (*ASR*), the ease of recombining resources (*ERR*), the ease of founding a firm (*EFF*) and the security of doing business (*SEC*). Consider each in turn:

- *The availability of strategic resources (ASR)*. According to Schumpeter (1911), entrepreneurs combine resources to make new products and services. Without key resources or inputs, entrepreneurs cannot organise profitable production. In the early age of industrialisation, natural resources, such as land, water ways and mines, were more important to economic production. However, human resources, especially intellectual capital, are key strategic assets in the age of technology. This is consistent with the resource-based theory of the firm (e.g., Wernerfelt, 1984; Barney, 1991), in which the relationship between profitability and strategic resources has been illustrated.
- *The ease of recombining resources (ERR).* Again, according to Schumpeter (1911), the function of an entrepreneur is to carry out 'new combinations of means of production'. However, how efficient an entrepreneur can perform such a function depends not only on his ability but also on the ease of the flow of economic goods. In addition, conceiving new ideas of doing business or finding of new means of production requires human interaction, particularly in the age of the knowledge-based economy. A region that facilitates the transactions of economic goods and the exchange of ideas can provide a larger and better opportunity set for entrepreneurial performance.
- *The ease of founding a firm (EFF).* Entrepreneurs need a firm to carry out their function (e.g., Witt, 1999; Foss and Klein, 2005). How easily a firm can be founded in a region is also an important factor of the entrepreneur's location decision.
- *The security of doing business (SEC).* As with any other form of commercial activity or investment, entrepreneurship thrives in a stable institutional environment. A region with high legal, political or regulatory risk is less attractive to an entrepreneur than a region with more predictable rules and with institutions that protect private property, allow free movements of capital and labour, support an unhampered price system and so on.

Based on these arguments, we posit the following conceptual model:

$$EA = f\left(ASR, ERR, EFF, SEC\right), \tag{1}$$

where *EA* represents the entrepreneurial activity in a region, $f(\bullet)$ describes the entrepreneur's opportunity set and *ASR*, *ERR*, *EFF* and *SEC* are defined as above.

We next define a set of indicator variables corresponding to *ASR*, *ERR*, *EFF* and *SEC*. The availability of strategic resources (*ASR*) is likely to be a particularly important component of the entrepreneur's opportunity set. While natural resources are important for traditional economic production, human or intellectual capital is critical to technological or innovative production. Moreover, the literature on innovation (e.g., Pakes and Griliches, 1980) has long argued for the importance of investment in research and development (R&D) as a critical input. This suggests the following hypotheses:

Hypothesis 1a A region's technology entrepreneurship activity (*EA*) is positively related to the number of scientists (*NOS*) of the region.

Hypothesis 1b A region's technology entrepreneurship activity (*EA*) is positively related to the region's R&D investment (*RND*).

For the ease of recombining resources (*ERR*), the presence of certain institutions in the region is likely to be a critical factor. While investigating the role of existing firms in the formation of biotech industry cluster, Feldman (2003) characterises anchor organisations such as universities and large established firms as role models for attracting pools of skilled labour and intermediate industries and for guiding economic production in the region to certain specialised industries. Besides attracting resources, the anchor organisation also provide a platform for the interaction of individuals and, thus, the ease of recombining resources. We term these anchor organisations 'anchor universities' (*ACU*) and 'anchor firms' (*ACF*). Hyde (2003) also argues that various institutions in Silicon Valley leading to what he terms 'a high-velocity labour market' are important for the formation of the high technology industry cluster, suggesting that the free movement of individuals eases the entrepreneur's attempt to recombine resources. While direct data on those institutions are largely unavailable, labour market freedom, as measured by freedom index Area 3 (*FI_III*), an index calculated by The Fraser Institute and the National Center for Policy Analysis (2005), can proxy for mobility. Hence:

Hypothesis 2a A region's technology entrepreneurship activity (*EA*) is positively related to the number of anchor universities (*ACU*) of the region.

Hypothesis 2b A region's technology entrepreneurship activity (*EA*) is positively related to the number of anchor firms (*ACF*) of the region.

Hypothesis 2c A region's technology entrepreneurship activity (*EA*) is positively related to the region's labour market freedom (*FI_III*).

Given the importance of new businesses to the US economy and the fragility (high failure rate) of new business ventures (Birch, 1979, 1987), business incubators can play an important role in fostering high-technology companies (Barrow, 2001). However, the evidence on the impact of business incubators is largely anecdotal. While business consulting service may have a similar role to play as business incubation, over control or restriction from the government may discourage the founding of new business in a region. Consequently, for the ease of the founding of a firm (*EFF*), we include the number of technology consulting firm establishments (*TC*), the number of business incubators (*BICB*) and the size of the government (measured by the freedom index Area 1, *FI_I*; smaller size of government represents less control and higher score on *FI_I*). This suggests the following additional hypotheses:

Hypothesis 3a A region's technology entrepreneurship activity (*EA*) is positively related to the region's number of technology consulting services (*TC*).

Hypothesis 3b A region's technology entrepreneurship activity (*EA*) is positively related to the number of business incubators (*BICB*) in the region.

Hypothesis 3c A region's technology entrepreneurship activity (*EA*) is positively related to the region's size of government (*FI_I*).

The security of doing business (*SEC*) in the region is also a concern for entrepreneurs. We use the security of doing business to measure this risk. Of course, political and social stability would be important factors defining the security of doing business. While such factors may not be relevant in the case of entrepreneurial practice at the US state-level, particularly in technology sectors, we argue that the practice of intellectual property laws could secure individuals' innovative production and settle disputes among innovators. In addition, takings and discriminatory taxations can be a concern for all type of businesses. Arguing that the former can be measured using the number of intellectual property lawyers (*IPL*) and the latter may be measured by freedom index Area 2 (*FI_II*) data, we generate the following hypotheses:

Hypothesis 4a a region's technology entrepreneurship activity (*EA*) is positively related to the number of intellectual property lawyers (*IPL*) in the region.

Hypothesis 4b a region's technology entrepreneurship activity (*EA*) is positively related to the 'takings and discriminatory taxation' (*FI_II*) by the region.

3 Methods and data

We investigate these hypotheses using state-level US data. As discussed below, data limitations prevent us from using full structural equations model in which not only entrepreneurial activity, but also *ASR*, *ERR*, *EFF* and *SEC* are treated as latent variables. Instead, we employ a hybrid approach in which *EA* is treated as a latent variable and the indicators for regional factors are used as regressors in an OLS model.

3.1 Measuring entrepreneurial activity

We restrict our investigation to the information and communications technology (ICT) and biotechnology sectors to keep the sample manageable and to focus on sectors with a high proportion of new ventures, products and business practices. We start by selecting four indicators for entrepreneurial activity (*EA*) in these sectors: the number of technology patents (*PATENT*), the number of Small Business Innovation Research awards (*SBIR*), venture capital disbursements (*VC*) and the number of technology establishments (*TE*). Ideally, we would include measures of new product and service introductions, reorganisations and other indicators, but we could not find reliable data for these. The number of technology establishments is an obvious indicator for ICT and biotechnology innovation. Patent registration, establishing intellectual property rights for innovators, frequently represents an important step toward the development of new products, services or processes. Likewise, SBIR grants indicate technologies that are sufficiently mature to be marketable, at least potentially. Venture capital investment indicates the approval of market participants and is another important indicator of entrepreneurial activity.

We collect state-level data and conduct a CFA of the proposed relationship between the four variables and the latent measure of entrepreneurial activity. Figure 1 depicts the hypothesised relationship. *EA* is the latent variable which stands for technology entrepreneurship activity; the four variables within a rectangle are indicator variables chosen to measure the latent concept, technology entrepreneurship activity. The arrows between the latent variable, *EA*, and its indicator variables signify the causal relationship, implying that the indicators reflect the presence of underlying entrepreneurial activity. The variables λ_1 to λ_4 are factor loadings or factor scores representing the strength of the relationships between each indicator and the latent variable; and δ_1 to δ_4 denote measurement errors. Such a measurement model construct can also be specified and expressed mathematically via the following set of equations:

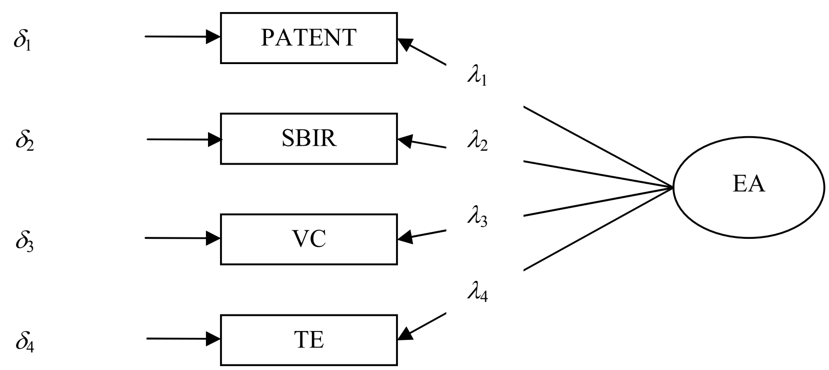
$$PATENT = \lambda_1 EA + \delta_1 \quad (2)$$

$$SBIR = \lambda_2 EA + \delta_2 \quad (3)$$

$$VC = \lambda_3 EA + \delta_3 \quad (4)$$

$$TE = \lambda_4 EA + \delta_4 \quad (5)$$

Figure 1 LISREL path diagram with output for the CFA model



Unlike traditional hypothesis testing, the purpose of empirical testing of the latent variables model is to reveal how well the hypothesised model construct fits the data. That is, the plausibility of the proposed model is to be tested based on sample data of all indicator or observable variables. Such plausibility is determined by a set of goodness-of-fit measures between the hypothesised model and the sample data. In such a procedure, a researcher imposes the structure of the proposed model on the sample data and then tests how well the observed sample data fits the restricted model structure (Byrne, 1998).

Data for the indicator variables are collected at the US state-level in the ICT and biotechnology sectors. The number of technology establishments (*TE*) is based on the North American Industry Classification System (NAICS) codes to define both the ICT industries and the Biotech industries (see Table 1). For information and telecommunication industries, the following codes are included: 334 (computer and electronic product manufacturing), 333295 (semiconductor machinery), 5112 (software publishers), 516 (internet publishing and broadcasting), 517 (telecommunications), 518 (internet service providers, web search portals and data processing services) and 5415 (computer systems design and related services). For biotechnology industry, 3254 (pharmaceutical and medicine manufacturing) and 54171 (R&D in the physical engineering and life sciences) are included. In addition, the NAICS code 541380 (testing laboratories) is also counted for both the ICT and Biotech industries. The number of establishments on these codes is collected from the American FactFinder, US Census Bureau, 2002 Census; and the data is scaled on per capita basis.

Table 1 Definition of ICT and biotech industries

NAICS	*Industry description*
ICT industry	
334	Computer and electronic product manufacturing
333295	Semiconductor machinery
5112	Software publishers
516	Internet publishing and broadcasting
517	Telecommunications
518	Internet service providers, web search portals and data processing services
5415	Computer systems design and related services
Biotech industry	
3254	Pharmaceutical and medicine manufacturing
54171	R&D in the phys. engineering and life sciences
ICT and biotech	
54138	Testing laboratories

Source: US Census (2002)

The number of technology patents (*PATENT*) is based on 32 technology patent classes which largely cover both the ICT and biotech industries. The data are provided by the US Patent and Trademark Office and the average number of patents from 2000 to 2004 on a per capita basis is used in empirical testing. Data on venture capital investment (*VC*) for both information technology and biotechnology are collected from the SDC Database, managed by Thomson Financial Inc., for the period of 2000 to 2004. The average amount of venture capital disbursement over the period is calculated in millions of dollars per capita. Data on the number of small business innovation rewards (*SBIR*) are extracted from the TECH-*NET* Database, managed by the Office of Technology, Small Business Administration (SBA) and the average number of small business innovation rewards over the period of 2000 to 2004 is also calculated on a per capita basis.

The descriptive statistics are summarised in Table 2 (these are the actual data, expressed in per capita terms, not factor scores from the CFA). We use LISREL to perform the CFA; results are shown in Table 3. The estimates for all factor loadings, λ_1 to λ_4, are positive, as expected and statistically significant and the measurement errors or error variances, δ_1 to δ_4, are relatively small. R^2 values for the measurement equations (1) to (4) are 0.24, 0.73, 0.81 and 0.60, respectively.

Table 2 Descriptive statistics for indicators of entrepreneurial activity

Variable	*N*	*Minimum*	*Maximum*	*Mean*	*Std. deviation*
Patents	50	0.02	2.21	0.31	0.38
SBIR awards	50	0.02	0.59	0.09	0.10
Venture capital	50	0.00	3.21	0.36	0.58
Technology establishments	50	0.34	1.41	0.72	0.26

Notes: Figures are expressed in per capita terms. Variables are as described in the text.

Table 3 Parameter estimates for CFA model of entrepreneurial activity

Indicator	*Standardised loading*	*Error variances*	R^2
Patents	0.18	0.11	0.24
	(0.053)	(0.023)	
SBIR awards	0.085	0.003	0.73
	(0.012)	(0.001)	
Venture capital	0.52	0.062	0.81
	(0.068)	(0.028)	
Technology establishments	0.20	0.026	0.60
	(0.032)	(0.007)	

Notes: χ^2 = 2.20; df = 2; NFI = 0.98; GFI = 0.98; CFI = 1.00; RMSEA = 0.0; RMSR = 0.003.
Construct is entrepreneurial activity (*EA*). Standardised factor loadings provided with *t* statistics from unstandardised solution in parentheses.

Table 3 also includes a series of goodness-of-fit statistics. The interpretations differ somewhat from those in regression models. The χ^2 value is small relative to the degrees of freedom but the normed fit index (NFI), comparative fit index (CFI), incremental fit index (IFI), relative fit index (RFI) and goodness-of-fit index (GFI) are all greater than 0.90, indicating good model fit (Byrne, 1998). The root mean square error of approximation (RMSEA) and root mean square residual (RMR) are well within acceptable ranges for good fit. From this we conclude that the proposed CFA is a reasonable way to capture a broad set of entrepreneurial indicators.

As we discuss below, data restrictions prevent us from running a full latent variables model that incorporates both the measurement model and the structure model, including dependent and independent variables. An alternative approach is to construct a single dependent variable based on the standardised factor loading scores obtained from a CFA patterned after the full latent variables model, then use traditional multivariate techniques to test hypotheses about the effects of explanatory variables on this dependent variable. For this purpose we calculate a (technology) entrepreneurship activity index (*EA*) based on the results obtained from the CFA model estimates as:

$$EA = sum\left[\left(data\ on\ each\ indicator\ variable / sample\ average\right) * factor\ score\right] \quad (6)$$

Table 4 shows how our *EA* compares to the entrepreneurial activity index developed by the Kauffman Foundation (Fairlie, 2006). The table shows the top and bottom five states for both our *EA* and the Kauffman index. The figures in parentheses in the first two columns represent the *EA* score as calculated according to equation (6). The figures in parentheses in the third and fourth columns represent the percentage of adult non-business owners who start a business each month, the basis of the Kauffman rankings.

Surprisingly, the two series are virtually uncorrelated (the correlation coefficient is 0.015 and is not statistically significant). As seen in the Table, none of our most entrepreneurial states appear at the top of the Kauffman ranking and vice versa (only West Virginia appears near the bottom of both lists). Clearly our index and the Kauffman index measure different phenomena. We rely on a broad set of indicators including, but not limited to, the number of establishments. Moreover, ours is a stock measure while Kauffman's is a flow (tracking the increase in establishments, or individuals creating an establishment). And we include only the ICT and biotechnology sectors, while the Kauffman index includes all sectors (restaurants, dry cleaners, professional services firms and the like, as well as technology establishments). Our results are probably more intuitive; most people think of Massachusetts and California (tops in our index) and not Vermont, Colorado, Montana, Wyoming and Idaho (tops in the Kauffman index), as centres of entrepreneurial activity.

Table 4 Comparison between (technology) entrepreneurship activity index (*EA*) and Kauffman index of entrepreneurial activity

EA		*Kauffman index*	
Top five states	*Bottom five states*	*Top five states*	*Bottom five states*
Massachusetts	Arkansas	Vermont	Delaware
(6.06)	(0.16)	(0.0055)	(0.0016)
California	Mississippi	Colorado	West Virginia
(4.14)	(0.17)	(0.0053)	(0.0017)
Colorado	West Virginia	Montana	Alabama
(2.85)	(0.18)	(0.0049)	(0.0017)
New Jersey	Louisiana	Wyoming	Kentucky
(2.21)	(0.19)	(0.0048)	(0.0018)
New Hampshire	Alaska	Idaho	Pennsylvania
(2.150)	(0.22)	(0.0047)	(0.0018)

Notes: The first two columns are based on our *EA* index calculated according to equation (6) in the text. It reflects overall technology entrepreneurial activity based on factor-loaded (weighted) average of the number of technology patents, the number of small business innovation rewards, venture capital disbursements and the number of technology establishments. See text for details. The figures in parentheses represent the index scores. The source for second two columns is Fairlie (2006). The figures in parentheses represent the percentage of adult non-business owners who start a business each month. The correlation coefficient between the two series is 0.015 (not statistically significant).

3.2 Measuring regional influences on entrepreneurship

As discussed above, we hypothesise that entrepreneurial activity is a function of the entrepreneur's regional opportunity set. This opportunity set consists of four components: the availability of strategic resources (*ASR*), the ease of founding a firm (*EFF*), the ease of recombining resources (*ERR*) and the security of doing business (*SEC*). These components are not directly observable but, as in the case of *EA* itself, they are manifested in various indicators that can be measured directly. To examine the effect the regional opportunity set on entrepreneurial activity, we choose the following indicators: lagged values of the number of scientists (*NOS*) and R&D investment (*RND*) as indicators for the availability of strategic resources (*ASR*); the number of anchor universities (*ACU*), the number of anchor firms (*ACF*) and 'labour market freedom' represented by the Fraser Institute's freedom index Area 3 (*FI_III*) (less restriction on labour market freedom leads to higher score on *FI_III*) for the ease of the recombining resources (*ERR*); the number of technology consultants (*TC*), the number of business incubators (*BICB*) and the 'size of the government' measured by freedom index Area 1 (*FI_I*) (the smaller the size of government the higher the score of *FI_I*) for the ease of founding a firm (*EFF*); and the number of intellectual property lawyers and 'takings and discriminatory taxation' measured by freedom index Area 2 (*FI_II*) (the smaller the takings and discriminatory taxation the higher of the score of *FI_II*) for the security of doing business (*SEC*).[1]

Data descriptions and sources are provided in Table 5. The number of scientists (*NOS*) is measured by the number of Doctorate holders in science and engineering in per capita basis in the year of 1997, provided by the National Science Foundation. Data on R&D investment (*RND*) are also collected from the NSF, calculated as the average amount in thousand-dollars per capita over the year of 1995 to 1999. The anchor university (*ACU*) is defined as a university that received federal R&D investment during 1995 to 1999 (according to NSF) and the number of which is scaled by population in millions. Anchor firms (*ACF*) are the firms (defined by NAICS codes, see Table 1) with more than 1,000 employees during 1995 to 1999; the number of which are also scaled by per million population, and the data were extracted from the database, Compustat, S&P. The number of business incubators (*BICB*) was collected from the National Business Incubation Association's (NBIA) website, along with a telephone interview with representatives of each incubator.[2] The number of technology consultants (*TC*) is extracted from American Fact Finder, 1997 US Census data, based on the NAICS code 5416 (management, scientific and technical consulting services); and the number of employees under which are scaled in per capita basis.

The number of intellectual property lawyers is extracted from Martindale-Hubbell Law Directory 1998 and scaled by population in millions. Data on the following three variables, *FI_I* (size of the government; the smaller the government size the higher the score on *FI_I*), *FI_II* (takings and discriminatory taxation; the lower the takings and discriminatory taxation the higher the score on *FI_II*) and *FI_III* (labour market freedom; less restriction on labour market means higher score on *FI_III*), are all provided by Fraser Institute in Canada and the National Center of Policy Analysis in the USA; all of which are the average of index scores over the year of 1995 to 1999. Table 5 also provides descriptive statistics.

Ideally, we would estimate a full model as a system of structural equations in which these indicators are determinants of the latent independent variables *ASR*, *ERR*, *EFF* and *SEC* and *EA* as described above is the latent dependent variable. This approach offers several potential advantages over conventional multivariate techniques: it takes a confirmatory, rather than an explanatory, approach; it offers explicit estimates of measurement errors; and its estimation procedure incorporates both unobservable (latent) and observable variables. However, a large sample is required to produce acceptable outcomes for such a model with many variables. We attempted to collect data on all our indicator variables for all 265 metropolitan statistical areas (MSAs) in the USA. Unfortunately, some variables are only available at the state-level (such as the Fraser Institute's economic freedom measures and the number of scientists) and a sample of 50 state-level observations is too small for the full model to converge.

Table 5 Data description and sources for regional indicators of entrepreneurial activity

Variable	*Description*	*Source*	*Mean*	*Std. dev.*	*Min.*	*Max.*
PATENT	Number of utility patents per capita, 32 classes, 2000–2004 average	US PTO	0.31	0.38	0.02	2.21
SBIR	Number of small business rewards per capita, 2000–2004 average	TECH-NET, SBA	0.09	0.10	0.02	0.59
VC	Amount of venture capital, mil./per capita, 2000–2004 average	SDC Database	0.36	0.58	0.00	3.21
TE	Number of high-tech establishments (10 NAICS) per capita, 2002	US Census	0.72	0.26	0.34	1.41
NOS	Number of S&E Doctorate holders per capita, 1997	NSF	1.87	0.82	0.84	4.69
RND	Federal R&D investment in millions per capita, 1995–1999 average	NSF	0.22	0.26	0.03	1.45
ACU	Number of universities (with federal R&D) per million population, during 1995–1999	NSF	5.16	3.19	1.90	16.97
ACF	Number of firms (> 1,000 employees) per capita (based on 10 NAICS codes), 1995–1999	COMPUSTAT, S&P	1.15	1.12	0.00	6.10
BICB	Number of business incubators per million population, before 2000	NBIA	1.47	1.54	0.00	5.63
TC	Number of technology consultants (NAICS 5416) per capita, 1997	US Census	1.45	0.84	0.40	3.77
IPL	Number of intellectual property lawyers per million population, 1998	Martindale-Hubbell	15.95	12.85	0.00	54.86
FI_I	A measure of the size of government (the smaller the size the higher the score on FI_I), 1995–1999 average	Fraser and NCPA	7.32	0.72	5.44	8.68
FI_II	Taking and discriminatory taxation (less takings and discriminatory taxation means higher the score on FI_II), 1995–1999 average	Fraser and NCPA	5.75	0.53	4.62	7.02
FI_III	Labour market freedom (less restriction on labour market indicates higher score on FI_III), 1995–1999 average	Fraser and NCPA	6.88	0.68	5.84	8.36

Note: Sample – 50 US states

As an alternative, we employ a hybrid approach in which the latent dependent variable is estimated using CFA as described in Section 3.1 and the manifest independent variables enter independently into an OLS regression. Our dependent variable is the index *EA* defined above.

Table 6 OLS estimates of regional indicators on entrepreneurial activity

Variables	*Model 1*	*Model 2*	*Model 3*
	Untransformed with all variables	*Log-transformed (ln_EA_1) with all variables*	*Log-transformed (ln_EA_1) and reduced*
Intercept	−2.254	−3.479	−4.248
	(−1.722)	(−3.350)	(−6.265)
NOS	0.110	0.121	0.104
	(0.099)	(1.119)	(1.098)
RND	0.243**	0.264**	0.274**
	(2.070)	(2.282)	(3.002)
ACU	0.002	−0.037	
	(0.024)	(–0.42)5	
ACF	0.680***	0.396***	0.419***
	(5.953)	(3.522)	(4.331)
TC	−0.111	0.051	
	(−0.877)	(0.411)	
BICB	−0.010	0.006	
	(−0.121)	(0.067)	
IPL	0.216*	0.181	0.232**
	(1.959)	(1.664)	(2.458)
FI_I	0.154	0.362**	0.315***
	(1.353)	(3.228)	(4.018)
FI_II	0.029	−0.118	
	(0.280)	(−1.144)	
FI_III	0.011	−0.005	
	(0.122)	(−0.056)	
Adj. R^2	0.735	0.743	0.759

Notes: Dependent variable for Model 1 is *EA*; dependent variable for Models 2 and 3 is ln_*EA*. All independent variables are lagged one time period. Coefficients are standardised and t-statistics are given in parentheses. ***, ** and * indicate statistical significance at the 1, 5 and 10% levels, respectively.

4 Results

The results of the OLS models are shown in Table 6. Model 1 uses EA_1, untransformed, as the dependent variable. In this model, the residuals are observed to be non-normal, so Models 2 and 3 employ a log transformation of EA_1. Model 2 includes all the independent variables, while Model 3 includes a restricted set, including only the independent variables prior literature has identified as the most important. In Model 1, the untransformed base model, R&D, the number of anchor entities and the number of intellectual property lawyers are positive and statistically significant. In Model 2, R&D and anchor entities remain statistically significant, intellectual property lawyers drops out, while the size of government (FI_I_0) becomes statistically significant. In Model 3, five independent variables: the number of anchor entities, the number of technology consultants, the number of business incubators, takings and discriminatory taxation (FI_II_0) and labour market freedom (FI_III_0) are omitted; four independent variables: R&D, anchor firms, intellectual-property lawyers and the size of government represented are statistically significant.[3]

In short, R&D investment and the number of anchor firms, both measured at time 0, are positive and statistically significant in all specifications. The number of intellectual property lawyers and the smallness of government are positive and statistically significant in two of the three specifications. The numbers of anchor universities, incubators and technology consultants are not statistically significant in any specification. Likewise, tax and regulatory policies and labour market freedom do not have statistically significant effects on entrepreneurial activity.

In other words, we fail to reject *Hypothesis 1b* (a region's technology entrepreneurship activity, *EA*, is positively related to the region's R&D investment, *RND*), *Hypothesis 2b* (a region's technology entrepreneurship activity, *EA*, is positively related to the number of anchor firms, *ACF*), *Hypothesis 3c* (a region's technology entrepreneurship activity, *EA*, is positively related to the region's size of government, *FI_I*) and *Hypothesis 4a* (a region's technology entrepreneurship activity, *EA*, is positively related to the number of intellectual property lawyers, *IPL*). These suggest that the components of the entrepreneur's opportunity set, at least, partially, exist. Specifically, evidence indicates that availability of strategic resources (*ASR*, represented by R&D investment), ease of recombining resources (*ERR*, represented by the presence of anchoring firms), ease of founding a firm (*EFF*, represented by the size of the government), and the security of doing business (*SEC*, represented by the intellectual law practice) do have an impact on the technology entrepreneurship activity in the region. Although the result shows that most other representative variables of the components of the entrepreneur's opportunity set have a correct sign, they are not statistically significant in our model.

5 Discussion and implications

Research on the characteristics of individual entrepreneurs and entrepreneurial ventures is clearly important. However, it is equally valuable to study the regional elements of the entrepreneur's opportunity set. Our results suggest that these environmental characteristics do vary, systematically, across US states. Specifically, we show that:

1. R&D investment is a key strategic resource, consistent with many other studies in the area of innovative production
2. the presence of anchor firms is important to innovative entrepreneurs if such anchors are understood as a platform for both the interaction of individuals within and beyond the firm as well as the spin-off of new firms

3 a smaller size of government in terms of spending and restrictions on firms is also important for the emergence of entrepreneurship

4 the presence of intellectual property lawyers may also have some effect in providing incentives for entrepreneurial activity in technology sectors.

We look forward to exploring such details in future research.

More generally, our results imply that the institutional, legal, regulatory and competitive environments that compose the entrepreneur's opportunity set matter to the firm's location decision. Moreover, while much of the policy discussions about regional development focus on private and public R&D, other factors are equally important: anchors, limited government and property rights.

Of course, our analysis suffers from important limitations. The most important is that we lack data to perform a full structural-equations model, resulting in the 'hybrid' analysis presented in the text (a composite, latent dependent variable used in OLS regressions with individual independent variables). Our sample covers the five-year period from 2000 to 2004, which may not be representative of earlier periods of the last few years. 50 observations are adequate, but not perfect, for a CFA. And we cover only the ICT and biotech industries, which are unlikely to be representative of industrial activity more generally.

Despite these limitations, the analysis shows that complex, multifaceted concepts like entrepreneurship can be usefully treated as latent constructs in a structural equations framework. The entrepreneurship literature is rife with definitions and conceptualisations of entrepreneurship, from self-employment to new venture creation to innovation to generalised functions such as alertness, creativity, leadership and judgement (Foss and Klein, 2005; Klein, 2008). The challenges of defining and measuring entrepreneurship have left the field highly fragmented, particularly where applied, empirical work is concerned. An alternative is to employ the kind of approach used in the present study, where entrepreneurship is regarded as an abstract activity that is manifest in multiple ways. We hope other researchers will adopt this approach and focus not on what entrepreneurship *is,* but on what entrepreneurship *does.*

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References

Alvarez, S.A. and Barney, J.B. (2007) 'Discovery and creation: alternative theories of entrepreneurial action', *Strategic Entrepreneurship Journal*, Vol. 1, Nos. 1–2, pp.11–26.

Arthur, W.B. (1990) 'Silicon Valley locational clusters: do increasing returns imply monopoly?', *Mathematical Social Science*, Vol. 19, pp.235–251.

Audretsch, D.B. and Feldman, M.P. (1996) 'R&D spillovers and the geography of innovation and production', *American Economic Review*, Vol. 86, No. 3, pp.630–640.

Barney, J. (1991) 'Firm resources and sustained competitive advantage', *Journal of Management*, Vol. 17, No. 1, pp.99–120.

Barrow, C. (2001) *Incubators: A Realist's Guide to the World's New Business Accelerators*, John Wiley & Sons, Ltd.

Birch, D. (1979) 'The job creation process', MIT Program in Neighborhood and Regional Changes, Cambridge, MA.

Birch, D. (1987) *Job Creation in America: How Our Smallest Companies Put Most People to Work*, The Free Press, New York.

Bjørnskov, C. and Foss, N.J. (2008) 'Economic freedom and entrepreneurial activity: some cross-country evidence', *Public Choice*, Vol. 134, No. 3, pp.307–328.

Byrne, B.M. (1998) *Structural Equation Modeling with LISREL, PRELIS and SIMPLIS: Basic Concepts, Applications and Programming*, Lawrence Erlbaum Associates, New Jersey.

Casson, M. (1982) *The Entrepreneur: An Economic Theory*, Barnes & Noble Books, Totowa, New Jersey.

Fairlie, R.W. (2006) *Kauffman Index of Entrepreneurial Activity (State Report 2005)*, Ewing Marion Kauffman Foundation, Kansas City, Missouri.

Feldman, M.P. (1994) *The Geography of Innovation*, Kluwer Academic Publisher, Dordrecht.

Feldman, M.P. (2001) 'The entrepreneurial event revisited: firm formation in a regional context', *Industrial and Corporate Change*, Vol. 10, No. 4, pp.861–891.

Feldman, M.P. (2003) 'The locational dynamics of the US biotech industry: knowledge externalities and the anchor hypothesis', *Industry and Innovation*, Vol. 10, No. 3, pp.311–328.

Feldman, M.P. and Francis, J. (2001) 'Entrepreneurs and the formation of industry clusters', paper presented at the *Meeting of Complexity and Industrial Clusters – Dynamic, Models, National Cases*, Milan, Italy.

Feldman, M.P. and Francis, J. (2004) 'Homegrown solutions: fostering cluster formation', *Economic Development Quarterly*, Vol. 18, No. 2, pp.127–137.

Foss, K., Foss, N.J. and Klein, P.G. (2007) 'Original and derived judgment: an entrepreneurial theory of economic organization', *Organization Studies*, Vol. 28, No. 12, pp.1893–1912.

Foss, N.J. and Klein, P.G. (2005) 'Entrepreneurship and the economic theory of the firm: any gains from trade?', in S. Alvarez, R. Agrawal and O. Sorenson (Eds.): *Handbook of Entrepreneurship: Disciplinary Perspectives*, Kluwer.

Gartner, W.B. and Shane, S.A. (1995) 'Measuring entrepreneurship over time', *Journal of Business Venturing*, Vol. 10, pp.283–301.

Hagen, E. (1962) *On the Theory of Social Change: How Economic Growth Begins*, Dorsey Press, Homewood, IL.

Henderson, J.V. (1994) 'Externalities and industrial development', NBER Working Paper No. 4370.

Hyde, A. (2003) *Working in Silicon Valley: Economic and Legal Analysis of a High Velocity Labor Market*, M.E. Sharpe, Inc., New York.

Kihlstrom, R. and Laffont, J. (1979) 'A general equilibrium entrepreneurial theory of firm formation based on risk aversion', *Journal of Political Economy*, Vol. 87, No. 4, pp.719–748.

Kirzner, I.M. (1973) *Competition and Entrepreneurship*, The University of Chicago Press, Chicago.

Kirzner, I.M. (1979) *Perception, Opportunity and Profit: Studies in the Theory of Entrepreneurship*, The University of Chicago Press, Chicago.

Kirzner, I.M. (1997) 'Entrepreneurial discovery and the competitive market process: an Austrian approach', *Journal of Economic Literature*, Vol. 35, No. 1, pp.60–85.

Klein, P.G. (2008) 'Opportunity discovery, entrepreneurial action and economic organization', *Strategic Entrepreneurship Journal*, Vol. 2, No. 3, pp.175–190.

Klein, P.G. and Cook, M.L. (2006) 'T.W. Schultz and the human-capital approach to entrepreneurship', *Review of Agricultural Economics*, Vol. 28, No. 3, pp.344–350.

Knight, F.H. (1921) *Risk, Uncertainty and Profit*, Houghton Mifflin Company, Boston and New York.

Kreft, S.F. and Sobel, R.S. (2005) 'Public policy, entrepreneurship and economic freedom', *Cato Journal*, Vol. 25, No. 3, pp.595–616.

Krugman, P. (1991a) *Geography and Trade*, MIT Press, Cambridge, Mass.

Krugman, P. (1991b) 'Increasing returns and economic geography', *Journal of Political Economy*, Vol. 99, pp.483–499.

Lazear, E.P. (2004) 'Balanced skills and entrepreneurship', *American Economic Review*, Vol. 94, No. 2, pp.208–211.

Marshall, A. (1890) *Principles of Economics*, 8th ed., Macmillan, London.

McClelland, D.C. (1961) *The Achieving Society*, van Nostrand, Princeton, NJ.

McClelland, D.C. (1987) *Human Motivation*, Cambridge University Press, Cambridge.

Pakes, A. and Griliches, Z. (1980) 'Patents and R&D at the firm level: a first look', Working paper, National Bureau of Economic Research, October.

Parker, S.C. (2004) *The Economics of Self-Employment and Entrepreneurship*, Cambridge University Press, Cambridge.

Porter, M.E. (1990) *The Competitive Advantage of Nations*, Macmillan, London.

Porter, M.E. (1998) *On Competition*, Harvard Business School Publications, Boston.

Schultz, T.W. (1975) 'The value of the ability to deal with disequilibria', *Journal of Economic Literature*, Vol. 13, No. 3, pp.827–846.

Schumpeter, J.A. (1911) *Theorie der Wirtschaftlichen Entwicklung*, Duncker & Humblot, Leipzig, english translation published in 1934 as *The Theory of Economic Development*, Harvard University Press, Cambridge, MA.

Wernerfelt, B. (1984) 'A resource-based view of the firm', *Strategic Management Journal*, Vol. 5, No. 2, pp.171–180.

Witt, U. (1999) 'Do entrepreneurs need firms? A contribution to a missing chapter in Austrian economics', *Review of Austrian Economics*, Vol. 11, pp.99–109.

Notes

1 Kreft and Sobel (2005) find a positive correlation between overall economic freedom scores and start-ups using US state-level data. Bjørnskov and Foss (2008) use the international version of the economic freedom index to study the effects of the institutional environment on entrepreneurial activity, finding statistically significant effects for the size of government and 'sound money'.

2 We include only those having operations before 2000 and scale the number by population in millions.

3 Some variables are conceptually similar, so we checked carefully for multicollinearity; tolerance values (defined by 1/VIF, where VIF is the variance inflation factor) for the parameter estimates are all less than 1, within the acceptable level.