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The effect of the triple helix system and habitat on regional entrepreneurship: Empirical evidence from the U.S.

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ABSTRACT

The 'triple helix' of the university–industry–government relationship and habitat are accepted as important determinants of innovation and entrepreneurship. However, empirical explorations of the effects of these variables and their interrelationships on regional entrepreneurial activities are highly limited. To fill this gap, we investigate the effect of the triple helix system and habitat on birth and death rates of U.S. firms at the state level. As expected, we find that industrial R&D expenditure plays an important role in promoting regional firm birth. However, university and government R&D also generate a synergistic effect that indirectly influences regional firm birth rates. In addition, we find that the synergy between university and industrial R&D enhances the sustainability of firms, while the interactions between (1) university and government R&D and (2) government and industrial R&D are associated with an increase in firm death. Other factors linked to more favorable conditions for firm formation include higher educational attainment in a region, lower tax rate, and habitat factors affecting quality of life, such as lower housing prices and higher rates of health insurance coverage. In regions with high entrepreneurial activity, we find positive synergistic effects of the interactions between (1) university and government R&D and (2) university and industrial R&D on firm birth rate, suggesting that university R&D plays an important role as an 'entrepreneurial mediator' among the three spheres in the triple helix system. In low entrepreneurial regions, the only triple helix system factors significantly influencing firm birth rate were tax rate. This finding suggests that the independent and interdependent components of the triple helix system and habitat are less powerful in low entrepreneurial regions.

1. Introduction

The importance of entrepreneurship in economic growth has been a major topic in economics since Schumpeter's (1942) seminal work. Scholars from disciplines such as accounting, finance, management, marketing, political science, psychology, and sociology have also engaged in explorations of the relationship between entrepreneurship and economic growth (Ireland and Webb, 2007). Among these studies, research on determinants of entrepreneurial activity – new firm formation and firm dynamics, specifically – has been highly valued from the perspective of public policy, because of the insights it lends to policymakers and the policy contributions they can make as a result. Potential determinants of entrepreneurship that have been presented in the literature include population (e.g., size), income, number and type of R&D employees, educational degrees, university R&D, creativity, foreign population, political structure, land costs, taxes, natural amenities, and others (Armington and Acs, 2002; Audretsch and Lehmann, 2005; Brixy and Grotz, 2007; Kirchhoff et al., 2007; Lay, 2003; Lee et al., 2004; Spilling, 1996; Wang, 2006; Woodward et al., 2006). Although these factors might interact with one another to synergize entrepreneurial activities, to date most investigators have treated the factors as independent, rather than considering the effects of their potential interrelations and interdependency.

As far as factors influencing entrepreneurship, since evolutionary economists introduced the concept of a 'knowledge-based society' (Abramowitz and David, 1996; Foray and Lundvall, 1996), the triple helix model of university–industry–government relationships has been developed to study the knowledge infrastructure in networks of bonds among the institutional constituents of a regional innovation system (Etzkowitz et al., 2000; Leydesdorff et al., 2006; Powell and DiMaggio, 1991). Specifically, the model provides important insights into understanding innovation in the context of the supportive relationships among university–industry–government players (Etzkowitz, 2003; Etzkowitz and Leydesdorff, 2000). However, despite its

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valuable contributions to understanding regional innovation and economic growth, comprehensive empirical explorations of the role of the triple helix model and the interrelationships among university–industry–government constituents in regional entrepreneurial activities are rare.

To address this lacuna, we investigate the determinants of entrepreneurial activity using a structural and holistic framework focusing on the interrelationships among university–industry–government in the triple helix model. In addition, we consider the role of habitat in our exploration, as this factor represents the highly important ecological environment for both entrepreneurial activities and the evolution of the triple helix that influences regional innovation (Goldstein and Drucker, 2006; Lee et al., 2004).

Specifically, we consider regional variations in firm birth and death in the U.S. during the period between 2000 and 2004 as regional entrepreneurial activity. As habitat variables, we consider quality-of-life factors such as healthcare, housing, crime rate, and demographic status (e.g., population, income, and ethnic groups). We also examine the interdependent relationships among triple helix and habitat factors.

Therefore, the following questions represent our specific interests in this study: What are the important determinants of regional entrepreneurial activities from the perspective of the triple helix system? How important are the interaction and synergy among the spheres or sub-dynamics of the triple helix in entrepreneurial activities at the regional level? How important is the habitat's role in regional entrepreneurial activities? Answering these questions will reveal the different roles of each sphere of the triple helix, as well as their interrelationships and the habitat, with regard to entrepreneurial activity. Thus we have taken a more structural and holistic point of view that considers the collaborative and systematic interaction of key factors related to regional innovation than past investigators have. Consequently, this study deepens our understanding of the determinants of regional entrepreneurial activity and contributes to the entrepreneurship policy literature. For example, our findings could enable more structuralized entrepreneurship policy based on the co-evolutionary relationship among university, industry, and government, along with the habitat, in promoting regional entrepreneurial activity.

2. Entrepreneurship, firm dynamics, and the triple helix model

Perspectives on and definitions of entrepreneurship have been multifaceted, thus attracting researchers from diverse disciplines: economics, marketing, management, operations, regional science, and others (Ireland and Webb, 2007; Tamasy, 2006). Those emerging literatures have been focused largely on determinants of entrepreneurship, and the subjects under study may be categorized into three broad groups: individual, regional or national, and international. Individual-level studies investigate the characteristics of successful entrepreneurs by exploring individual characteristics such as personality, education, and ethnic origin (Bergmann and Sternberg, 2007; Levie, 2007; Storey, 1994; Wagner and Sternberg, 2004). At the regional level, factors associated with regional variation in new firm formation at an aggregated (regional) level have been explored through studies of structural differences in geographical, industrial, and organizational variables (Armington and Acs, 2002; Audretsch and Lehmann, 2005; Brixy and Grotz, 2007; Kirchhoff et al., 2007; Lay, 2003; Lee et al., 2004; Love, 1996; Reynolds et al., 1993, 1995; Saxenian and Hsu, 2001; Spilling, 1996; Wang, 2006; Woodward et al., 2006). At the international level, determinants of entrepreneurial activities have been examined through the lens of inter-country differences in GDP, regulation, immigration, and other measures (Djankov et al., 2002; Ho and Wong, 2007; Kanniainen and Vesala, 2005; Reynolds et al., 1994; van Stel et al., 2007).

Among the varied attempts at defining entrepreneurship and identifying its determinants to date, regional-level studies have attracted many researchers because these investigations' findings and outcomes can suggest more direct insights into regional and national entrepreneurship policies by answering a crucial question policymakers face: Which factors are more important in promoting entrepreneurial activities and increasing firm creation? (Tamasy, 2006) Regional-level studies are also attractive to researchers because entrepreneurial activity and resulting firm creation has been recognized as one of the most important drivers of regional economic growth (Acs and Armington, 2004; Audretsch and Keilbach, 2005). In addition, the phenomenon of "geographical inertia" (i.e., the tendency of a given firm to stay in the region where it was first established, due to the resources it has established and/or utilized there), which highlights the importance of geographically localized networks of contacts for entrepreneurial activities and firm creation, has been found to be empirically significant (Sorenson and Audia, 2000) in entrepreneurship research (Tamasy, 2006), further reinforcing the value of regional-level entrepreneurship research.

Nevertheless and surprisingly, the selection of factors that affect regional entrepreneurial activities has been within a *situational* and *partial* context that considers each in isolation, rather than representing a *structural* and *holistic* approach that posits and examines a *co-evolutionary relationship* among the factors. In other words, previous studies have been limited in their analysis of the determinants of entrepreneurial activities and firm creation by considering only a partial group of those potential factors, such as population, income, R&D employees, educational degrees, university R&D, creativity, foreign population, political structure, and others in a specific situational context (Armington and Acs, 2002; Audretsch and Lehmann, 2005; Brixy and Grotz, 2007; Kirchhoff et al., 2007; Lay, 2003; Lee et al., 2004; Spilling, 1996; Wang, 2006; Woodward et al., 2006).

However, an important characteristic that should be considered in understanding regional entrepreneurial activities is that firm birth and death are highly dependent on regional characteristics and entrepreneurial environments including habitat, as the co-evolutionary theory has demonstrated. The theory suggests that the business entities and environments influence each other and reciprocally co-evolve together, not that the entities simply adapt to their environments, as suggested by studies of the adaptation-selection of an organization (Lewin and Volberda, 1999; Lewin et al., 1999; Porter, 2006; Tsai et al., 2009). In addition, regional factors in previous studies can be categorized into demographic, economic, geographic, industrial, and institutional environments with structural recognition of their reciprocal relationship, an idea that has not been well embraced in the extant literature. Therefore, we consider those factors that affect regional entrepreneurial activities, as informed by structural and co-evolutionary perspectives that take into account the interrelationships among those factors.

Among structural interpretations of regional factors, the 'triple helix', or university–industry–government interaction, has been increasingly recognized as the source of regional innovation that drives the transformation of scientific and technological outcomes into economic outcomes. In addition, multiple lines of thought suggest that innovation is increasingly based upon the interaction among the components of the triple helix model, which is growing in acceptance as a promising structuralized regional approach in a knowledge-based economy (Etzkowitz, 1994, 2003; Etzkowitz and Leydesdorff, 2000; Etzkowitz and Zhou, 2007; Leydesdorff and Van den Besselaar, 1994).

Although the triple helix model and co-evolutionary theory have been widely recognized as providing a heuristic for studying

the complex dynamics of institutional networks and interactions among the spheres regarding innovation in a knowledge-based economy, empirical studies examining the interaction among the three components and its contribution to regional or national innovation have been limited. Most empirical studies to date on the triple helix have studied the relationship and interaction between university and industry, thus failing to explore determinants of innovation with a more holistic and structural framework, often due to methodological limitations such as constrained means of data acquisition.

For example, existing studies on the triple helix have used the citation of academic research papers by industry (firms) or university scholars' participation in industrial R&D activities as a measure of the relationship between university and industry (Mansfield and Lee, 1996; Tijssen, 2006; Welsh et al., 2008; Zucker et al., 2002), while they used industrial support (grants) for university R&D as a measure for industrial influence on the university domain (Campbell and Guttel, 2005; Fritsch, 2004; Landry et al., 2006; Mansfield and Lee, 1996; Mueller, 2006; Welsh et al., 2008). Some studies have highlighted other modes of information and knowledge exchange, such as conferences and informal contacts, beyond academic research papers (Cohen et al., 2002; Ostergaard, 2009). Researchers have suggested that a university–industry interaction positively affects the performance of both entities, as measured by commercial spin-offs of university research (Landry et al., 2006; O'Shea et al., 2005; Shane, 2004), patents (Zucker et al., 2002), and economic performance (Mueller, 2006). However, few if any empirical studies have attempted to investigate the synergistic effects of the university–industry–government relationship, encompassing both the university–government and the industry–government relationships, on regional entrepreneurial activities including firm formation.

2.1. Triple helix and entrepreneurial activities

In order to investigate the role of the triple helix in regional entrepreneurial activities, we first need to consider the micro-level relationships among the three spheres of the helix. Fortunately, Campbell et al. (2004) and others[2] have examined the relationships and found that consulting relationships (88% of overall relationships),[3] research grants or contracts (59%), and researcher trainings (38%) represent major points of intersection between university and industry. Between government and industry, consulting, public financing, and equity positions related to R&D have been documented as major linking activities. Therefore, it is important to analyze the role of the triple helix and its interrelation centering on R&D-related factors such as grants or contracts, which play important roles across different spheres. On the other hand, our analysis must also consider those factors that represent the inherent function of each sphere in regional entrepreneurship, in order to understand their distinct role in this activity.

Consequently, in the case of the university sphere, two factors can be considered related to R&D and inherent characteristics that affect regional entrepreneurship based on the previous literature and our statistical examination of those factors;[4] *university and college R&D expenditures per capita* and *number of people of who attained a university degree* in the region.[5] In the case of university and college R&D (university R&D), firms are created through university spin-offs as a result of research outputs of professors and other researchers, even though the proportion of basic research in university R&D is higher than that of industrial R&D (Landry et al., 2006; O'Shea et al., 2005). In addition, a supportive environment and policies for academic entrepreneurship also promote firm creation within a university (Shane, 2004; Welsh et al., 2008). Previous studies have also suggested the positive effect of university R&D on firm creation (Acs et al., 2002; Goldstein and Drucker, 2006; Kirchhoff et al., 2007; Woodward et al., 2006). Therefore, we expect that university and college R&D expenditures per capita have a positive effect on the entrepreneurial activities of a region. However, university R&D does not seem to safeguard against firm death in a region; because, for a firm to survive in a market, various other factors such as capital investment, human resource management, marketing, and supply chain management beyond R&D-based technology typically play important roles (Bates, 1990; Carson, 1985; Cooper et al., 1994; Fawcett et al., 2009). Therefore, the effect of university R&D on firm survival will be limited.

In the case of university degree, it has been suggested that well-educated people have higher capability to identify viable business opportunities and to take the risk of launching a new firm. In addition, they seem to have the ability to sustain their business longer than individuals with less education (Acs and Armington, 2004; Armington and Acs, 2002; Lee and Wong, 2004; Saxenian, 2002). Multiple studies support this positive relationship between the proportion of highly educated people in the region and firm births (Goldstein and Drucker, 2006; Kirchhoff et al., 2007; Lee et al., 2004). Therefore, we suggest the following hypotheses regarding the effect of the university sphere of the triple helix on regional entrepreneurship:

Hypothesis 1a. As the university sphere spends more on R&D, a higher number of firms will be created in a region. However, university R&D expenditure does not affect the region's rate of firm death.

Hypothesis 1b. As the number of people with higher education increases, a higher number of firms will be created and fewer firms will fail in a region.

In the case of the government sphere, the *government R&D* and *tax rate* of a region can be considered.[6] Here, government R&D is the measure of the federal obligations for R&D and for R&D plants per capita, and is mixed between direct investment in technology development with industry, such as military technology and equipment, and indirect investment in universities and research institutions. Therefore, we cannot expect a consistent and significant effect of government R&D on firm birth or death rate (Malecki, 1990; Spilling, 1996).

On the other hand, tax-related variables have been used in previous studies that examined the determinants of entrepreneurial activity (Audretsch and Fritsch, 1999; Blau, 1987; Bruce, 2000; Bruce and Mohsin, 2006; Cullen and Gordon, 2002; Gentry and Hubbard, 2000; Goetz and Rupasingha, 2009; Parker, 1996; Robson,

[2] For similar studies on the relationship between university and industry R&D-related activities, see the related references (Campbell and Guttel, 2005; Fritsch, 2004; Landry et al., 2006; Mansfield and Lee, 1996; Mueller, 2006; Ostergaard, 2009; Shinn and Lamy, 2006; Tijssen, 2006; Welsh et al., 2008).

[3] These factors in the relationship are not mutually exclusive. For example, consulting, research grants, and researcher training relationships can be established and operated simultaneously depending on the university and industry relationship.

[4] We also analyzed and selected those relevant variables considered in the previous literature based on the correlation and the multicollinearity tests and the estimation performance of the various regressions of our models.

[5] In the university sphere, we also considered the *number of degree-granting four-year postsecondary institutions and branches per one million people*. However, we excluded it because it refers only to the accessibility of educational institutes, while failing to capture the quality of education offered. Nonetheless, Audretsch and Lehmann (2005) and Audretsch et al. (2005) used this factor in their studies.

[6] In the government sphere, we also considered the *total tax burden per capita*. However, we ultimately excluded it because *tax burden* and *tax rate* are highly correlated with high Variance Inflation Factor (VIF) and low tolerance values in the regression models. Though these two factors represent similar constructs, *tax rate* is a ratio-type variable, so it is more applicable to our model than *tax burden* is.

1998; Woodward et al., 2006). Among the tax-related measures considered in previous literatures, *ratio of total tax burden per capita to average annual pay* can be considered a major factor affecting regional entrepreneurship because taxes such as corporate tax and property tax collectively affect firm formation and termination (Bruce and Mohsin, 2006; Goetz and Rupasingha, 2009).[7] It is commonly accepted that a high corporate income tax rate hinders business formation, and that a high individual income tax rate promotes entrepreneurship among wage-and-salary employees or self-employed people. However, in some countries, such as the U.S., corporate income is taxed at *both* the corporate and the individual levels (Fullerton et al., 1981). Therefore, results provided for tax effects on regional entrepreneurship by previous studies, which used various types of tax measures, are not consistent (Cumming and Li, 2009; Nofsinger and Reca, 2009; van Stel et al., 2007; Wennekers et al., 2005). However, if the burden of whole tax types, including corporate tax and industrial tax, is considered, the effect of tax rate on firm birth rate is expected to be negative. Therefore, based on this rationale, we hypothesize that the lower the tax rate is, the higher the firm birth rate of a region will be. The predictions above are formalized in the hypotheses below:

Hypothesis 2a. Government R&D expenditure does not significantly affect the firm birth and death rate of a region.

Hypothesis 2b. However, if the government lowers the tax rate (ratio of total tax burden per capita to average annual pay), firm birth rate increases.

In the case of the private sector, the *industrial R&D expenditures per capita* and *venture capital investment per capita* can be considered.[8] Industrial R&D and venture capital focus on applied and practical researches that can be commercialized, rather than basic research, so that their R&D outputs lead to the creation of new firms or corporate spin-offs. In addition, industrial R&D and venture capital can make the firm sustainable amidst severe market competition by enabling product differentiation. The previous literature has confirmed that these two factors encourage entrepreneurial activity in a region (Acs and Varga, 2005; Florida and Kenney, 1988). Based on this thinking, we suggest the following hypotheses:

Hypothesis 3a. As industrial R&D expenditure increases, a higher number of firms will be created and fewer firms will fail in a region.

Hypothesis 3b. As venture capital investment increases, a higher number of firms will be created and fewer firms will fail in a region.

Despite its strong overall value for accounting for regional innovation, the triple helix concept is limited in that it does not consider habitat factors including residential, environmental, and geographical variables in its interpretation of regional innovation systems. Such habitat-related features have been documented to be among the most important factors affecting regional innovation, especially entrepreneurial activities (Lee et al., 2004; Tamasy, 2006). Habitat can be thought of as the ecological environment, where the three spheres of the triple helix evolve and develop, interacting with the habitat in line with concepts advanced by co-evolutionary theory (Porter, 2006; Tsai et al., 2009). Thus distinct habitats can produce different evolutionary paths for the triple helix with regard to regional innovation.

2.2. Habitat and entrepreneurial activities

Habitat factors can define an entrepreneurial environment in which the triple helix is created and evolves, and in which its spheres interact. Previous studies have considered habitat factors such as creativity and diversity (including the proportion of homosexual residents in the population) indices (Lee et al., 2004), ratio of immigrants or foreigners (Kirchhoff et al., 2007; Saxenian, 2002), crime, health care, and climate indices (Goldstein and Drucker, 2006), and natural amenities (Woodward et al., 2006). However, *quality of life* seems to be the most important factor among habitat-related variables. Regions with lower quality of life cannot attract potential entrepreneurs and talented workers as easily. Therefore, factors related closely to quality of life have been discussed by some researchers examining regional entrepreneurship and economic growth (Goldstein and Drucker, 2006). In the previous literature, housing prices, crime, and health care index have been generally accepted as measures of quality of life (Goldstein and Drucker, 2006) together with several demographic variables (Armington and Acs, 2002; Brixy and Grotz, 2007; Lee et al., 2004; Spilling, 1996). Therefore, we suggest the following hypothesis regarding the effect of the habitat on regional entrepreneurial activities:

Hypothesis 4a. The higher the quality of life (i.e., lower housing prices, lower crime rate, and higher health care coverage rate) is, the higher the firm birth rate will be in a region.

In addition, previous studies highlighted another interesting variable among habitat factors in the promotion of entrepreneurial activity: *racial diversity*, which represents the contributions of skilled immigrants and foreigners, along with the creativities generated from communications among people from different contexts in entrepreneurial activities. Racial diversity has been considered one of the main causes of the success of Silicon Valley. For example, Saxenian (2002) found that the most successful entrepreneurs of Silicon Valley rely heavily on ethnic resources. Kirchhoff et al. (2007) also concluded that a foreign population has a positive effect on new business formation. Therefore, we consider a *melting pot* factor, or the percentage the foreign-born population represents of the total population in a region. Lee et al. (2004) used this factor in their regional analysis of new firm formation. We expect that the firm birth rate of a state will be higher if the melting pot index is higher (i.e., meaning greater racial diversity), suggesting the following hypothesis:

Hypothesis 4b. The greater the racial variety is, the higher the rate of firm birth will be in a region.

Hypothesis 4c. Greater racial variety reduces the rate of firm death in a region.

2.3. Interaction within triple helix and entrepreneurial activities

One of the important aspects of the triple helix model is that it emphasizes the interrelations among the three spheres influencing a regional innovation system. Sysko-Romanczuk and Platonoff (2005) explained conceptually that the close cooperation of the research and business communities, based on an effective transfer of knowledge, might unlock the hidden entrepreneurial potential of regions, and an efficient local government might stimulate development of that potential. In other words, the combination of intellectual potential in the world of science (universities) and economic capacity in the business world (companies) heightens

[7] Bruce and Mohsin (2006) used the top income tax rate, top capital gains tax rate, top corporate income tax rate, wage-and-salary payroll tax rate, self-employment payroll tax rate, and estate tax exclusion as tax policy variables. In addition, Goetz and Rupasingha (2009) selected total government revenue from its own source as a percentage of GDP, top marginal income tax rate and the income threshold at which it applies, indirect tax revenue as a percentage of GDP, and sales taxes collected as a percentage of GDP. We unified various tax-related factors into one composite, representative factor (*total tax burden per capita*) to identify the aggregated effects of various types of tax in our analysis.

[8] In the industry sphere, we also considered the *number of patents issued*. However, we excluded it because patents are highly correlated with *industrial R&D* (0.617). In addition, previous studies found that there is no relationship between number of patent and entrepreneurial activity (Goldstein and Drucker, 2006; Lee et al., 2004).

thinking and activity related to potential entrepreneurship (e.g., commercialization-worthy innovations), while entrepreneurship stimulants based in the world of politics (government) induce the potential entrepreneur to actually create a business.

Although there are few empirical examinations of the effect of interaction within the triple helix on entrepreneurial activities, we can infer the effect from the previous literature on this interrelationship. First, in the case *between university and government*, both entities focus on basic research in science and technology innovation, and the government generally provides R&D funding for university in order to promote basic research, rather than applied research, across different areas of science and technology disciplines. However, basic research cannot be easily transformed into or applied to technology or products that can serve as a platform for a start-up business (Archibald and Finifter, 2003; David et al., 1992; Salter and Martin, 2001). On the other hand, some of those R&D outcomes such as patents are transferred to existing firms and commercialized after significant transformation (Di Gregorio and Shane, 2003; Markman et al., 2005), which can enhance the sustainability of existing firms. Therefore, we hypothesize that the effect of the interrelationship between university and government in regional entrepreneurship is indirect and limited, as follows:

Hypothesis 5a. The interaction between university and government does not significantly affect firm birth rate in a region.

Hypothesis 5b. However, the interaction between university and government significantly reduces firm death rate in a region.

In the case of the interaction *between government and industry*, however, government generally provides R&D subsidies or tax incentives to boost socioeconomic impact on a given industry when that sector is in its early stage of development and requires public support before it can take advantage of independent and internal driving forces to become a more sizable industry. The U.S.'s Small Business Innovation Research Program (SBIR) is a good example of this relationship between government and industry.[9] Therefore, the interaction of government and industry in the triple helix model can be more direct and positive in promoting regional entrepreneurial activities, especially when we consider the situation of start-ups representing the early stage of an industry. Therefore, we can hypothesize the effect of the interrelationship between government and industry on regional entrepreneurial activities as follows:

Hypothesis 6a. The interaction between government and industry significantly and positively affects firm birth rate in a region.

Hypothesis 6b. The interaction between government and industry also significantly reduces firm death rate in a region.

Finally, the *university–industry relationship* in the triple helix seems to be highly collaborative, especially when we consider the findings of Campbell et al. (2004) and other studies, which highlighted the close relationship between university and industry through consulting, research grants, and contracts. In addition, universities make many efforts to commercialize and license their research outputs through their own technology licensing offices (TLO) or university incubation centers (IB), which collaborate closely with industry partners (Di Gregorio and Shane, 2003; Hisrich and Smilor, 1988; Landry et al., 2006; Markman et al., 2005; O'Shea et al., 2005; Smith, 1991). In addition, industry supplements its technological capability through R&D outsourcing or by hiring valuable human resources from university, which enables firms to survive longer in a market. Furthermore, entrepreneurship centers have been established and promoted by universities globally, in order to increase the number and quality of university start-ups (Finkle et al., 2006). One of key activities of entrepreneurship centers is to enable close collaboration with industry partners to enhance the center's activities including business plan competitions, incubation, and mentoring programs, in order to deliver wide-ranging practical knowledge of doing business to potential entrepreneurs (Finkle et al., 2006; Friar and Meyer, 2003). Therefore, the collaborative relationship between university and industry should positively affect the entrepreneurial activities of a region, as formalized by the hypotheses below:

Hypothesis 7a. The interaction between university and industry significantly and positively affects the firm birth rate of a region.

Hypothesis 7b. The interaction between university and industry will also reduce the firm death rate of a region.

In order to examine these hypothesized effects of the triple helix, university–industry–government system, we analyzed empirical data from the U.S. – specifically, measures of the independent variables and state-level firm birth and death rates.

3. Data, variables, and methods

We collected triple helix and habitat factors at the state level in the U.S. In addition, based on the previous literature, we used data on firm birth and death rates as our measure of entrepreneurial activity. Our data are from the period between 2000 and 2004, except for R&D-related factors,[10] with a total of 250 year-state panel observations ($n = 250$). In order to reduce heterogeneous effect in our empirical analysis, we divided the states into four major geographical regions according to U.S. Census Bureau statistics: the West (13 states), the Midwest (12 states), the South (16 states), and the Northeast (9 states).

3.1. Dependent variables

We consider *firm birth* and *firm death* rates our measure of entrepreneurial activity in each state (Table 1). Our data on the number of firm births and deaths are from the *Small Business Economy*, the annual report to the President made by the Small Business Administration (SBA). These two factors are divided by the number of incumbent firms in the state.

3.2. Triple helix variables

As shown in Table 1, in each sphere – university, industry, and government – we consider one R&D related variable and another important variable that represents the inherent characteristics of the sphere in regional entrepreneurship, as described in the previous section.

[9] The U.S. Small Business Administration (SBA) Office of Technology administers the Small Business Innovation Research (SBIR) Program and the Small Business Technology Transfer (STTR) Program. Through these two programs, the SBA ensures that small, high-tech, and innovative businesses remain a significant part of U.S. R&D efforts. Eleven federal departments participate in the SBIR program; five departments participate in the STTR program, awarding $2 billion to small high-tech businesses in 2009.

[10] Because the effect of R&D expenditure on firm creation is not instant, R&D-related factors have time-lags in the regression model for entrepreneurial activity. Many researchers have used time-lags of R&D-related factors in empirical studies that explain the relationship between R&D factors and new firm formation (Kirchhoff et al., 2007; Reynolds et al., 1995; Woodward et al., 2006). In our study, we used two-year lags for the variables of university, government, and industrial R&D expenditure. Therefore, the period of data for these three factors extends from 1998 to 2002.

Table 1
Variable and descriptive statistics ($N = 250$, year-state panel observations).

Variable	Description	Source	Mean				
			Overall	West	Midwest	South	Northeast
BIRTHRATE	Number of new firm created per 100 existing firms	SBA	14.41	18.17	10.86	14.54	13.49
DEATHRATE	Number of firm terminated per 100 existing firms	SBA	15.26	18.24	12.50	14.96	15.15
DEGREE	% of 25+ population with bachelor's degree	Census	25.88	26.03	25.62	23.73	29.86
UNIVRD_R	University and college R&D expenditures per capita (dollars), $t-2$	NSF	105.49	110.18	100.93	95.18	123.12
GOVRD_R	Federal obligations for research and development and for R&D plant per capita (dollars), $t-2$	NSF	251.43	307.32	122.36	284.35	284.29
TAXRATE	Ratio of total tax burden per capita to average annual pay	Census, BLS	5.74	5.99	5.81	5.49	5.73
INDUSTRYRD_R	Industrial R&D expenditures per capita (dollars), $t-2$	NSF	516.70	513.43	481.34	335.60	890.51
VCINVEST_R	Venture capital investment per capita (dollars)	MoneyTree™	85.73	108.23	31.84	55.40	178.98
MELTINGPOT	% of foreign-born population	Census	7.53	10.32	4.62	5.95	10.16
ln_POP	Log of Population estimates	Census	15.08	14.69	15.15	15.38	15.01
ln_INCOME	Log of Average Annual Pay	BLS	10.42	10.41	10.39	10.38	10.57
HOUSEPRICE	Median housing value of all (2003–2004) or specified (2000–2002) owner occupied housing units (thousand dollars)	Census	136.01	167.89	109.80	108.27	174.22
CRIME	Total crime rate (violent and property crime rate) per 1000 people	FBI	39.38	44.67	35.89	43.74	28.62
HINSUCOV	% of private or government health insurance coverage	Census	86.23	83.79	89.14	84.50	88.93

Notes: SBA = Small Business Administration; BLS = Bureau of Labor Statistics; Census = U.S. Bureau of the Census; NSF = National Science Foundation; MoneyTree™ = MoneyTree™ Reports by Price Waterhouse Coopers; FBI = Federal Bureau of Investigation.

In the case of the university sphere, the two variables are *university and college R&D expenditures per capita (UNIVRD_R)* (Acs et al., 2002; Goldstein and Drucker, 2006; Kirchhoff et al., 2007; Woodward et al., 2006) and *degree*, which represents the rate of people who attained university degrees in a region (Acs and Armington, 2004; Armington and Acs, 2002; Goldstein and Drucker, 2006; Kirchhoff et al., 2007; Lee and Wong, 2004; Lee et al., 2004; Saxenian, 2002). In the case of government, we use *government R&D (GOVRD_R)* and *tax rate (TAXRATE)*. Here, government R&D is the measure of the federal obligations for R&D and for R&D plants per capita (Malecki, 1990; Spilling, 1996). On the other hand, tax rate is represented as *ratio of total tax burden per capita to average annual pay* (ratio type). In the case of the private sector, we use *industrial R&D expenditures per capita (INDUSTRYRD_R)* and *venture capital investment per capita (VCINVEST_R)*. Venture capital investment per capita has been obtained by *MoneyTree™ Report*, which is a popular quarterly study of venture capital investment activity in the U.S. (Brander and De Bettignies, 2009; Gulbranson and Audretsch, 2008; Sohl, 2003). In order to normalize the factors, all triple helix variables with absolute values, such as R&D and VC investment, have been divided by state population in order to avoid bias originating from state size.

3.3. Habitat variables

Based on the previous studies, we use housing prices, crime, and health care index as a measure of quality of life (Goldstein and Drucker, 2006). Descriptions and sources of habitat variables are presented in Table 1. *HOUSEPRICE* represents the median housing value of owner-occupied housing units in the state, and *CRIME* is the total crime rate, which is the sum of the violent and property crime rate per 1000 people. *Health insurance coverage (HINSUCOV)* is the level of coverage of basic health care in a region. We also use the *natural log of state population*[11] estimates *(ln_POP)* and the *natural log of state average annual pay (ln_INCOME)* as demographic factors in the analysis (Armington and Acs, 2002; Goldstein and Drucker, 2006; Lee et al., 2004). Finally, we include a *melting pot* variable *(MELTINGPOT)* in our analysis, representing the percentage of the population that is foreign-born.

3.4. Method

In order to examine the effects of triple helix and habitat variables and their interrelationships on firm birth and firm death, we conduct three empirical analyzes. First, we calculate descriptive statistics for the variables of entrepreneurial activity, triple helix variables, and habitat factors for each of our four U.S. regions. Second, through a multivariate panel Feasible General Least Squares (FGLS) regression analysis, we examine the regional factors that affect entrepreneurial activity (i.e., firm birth and death rates) within the framework of triple helix and habitat, considering the collaborative and systematic interaction of R&D expenditures among the spheres. Finally, we divide our sample into two groups based on firm birth rate and identified the determinants of high and low entrepreneurial activities of a region through the panel FGLS method.

Before applying the panel FGLS model, we tested whether serial correlation exists in each panel data model using the Wooldridge test for autocorrelation. In addition, we tested for panel data heteroscedasticity: we first conducted iterated panel FGLS regression with and without panel heteroscedasticity for each panel; then we tested for heteroscedasticity using a likelihood-ratio test between the two iterated regressions. Based on the test results, we assume AR(1) autocorrelation and heteroscedasticity across the panels in each panel regression model.[12]

4. Empirical results

4.1. Descriptive statistics for U.S. regions

Table 1 shows descriptive statistics for the level of entrepreneurial activity (firm birth and death rates), triple helix, and habitat variables. We made several interesting observations. For example, averages for firm birth and death rates are highest in the West region, which includes California, Washington, and Colorado, confirming that the West has the most entrepreneurial activities of any region. The Midwest region, which includes Illinois, Ohio, and Iowa, shows the lowest firm birth and death rates.

[11] Regarding the population of our study, we consider all 50 states except the District of Colombia. We excluded the District of Columbia (DC) because we were missing data for several variables.

[12] We apply a 5% significance level to assume AR(1) autocorrelation and heteroscedasticity across panels in each panel regression model. We do not assume correlation across panels (cross-sectional correlation) because the time period needs to be at least as large as the number of panels, for the GLS results to be valid. In our panel data, the time period is only five years, while our panels have 50 states.

The Northeast region, which includes New York, Massachusetts, and Pennsylvania, has firm birth and death rates that are lower than average. This range in level of entrepreneurial activity across regions helps to yield insights regarding the role of triple helix spheres and interaction and habitat on regional innovation.

Regarding triple helix and habitat variables, the Northeast region has the highest level of education, by proportion. The percentage of the 25-and-over population with a bachelor's degree is 3.83% higher than in the West region. In addition, the Northeast region has far more in university R&D and industrial R&D (123.12 and 890.51 dollars per capita invested, respectively) than any other region. But for government R&D, the West region surpasses the Northeast region. The Midwest region surpasses the South region in industrial R&D, although the absolute value of this variable is lower than those for the West and Northeast regions.

Interestingly, the West region, with relatively worse triple helix conditions (relatively low university and industrial R&D), has a high level of entrepreneurial activity compared to the Northeast region. However, the melting pot index, which reflects racial diversity, is highest in the West region. Additionally, that region's population has grown rapidly, which is likely one of the reasons for its high level of entrepreneurial activity. In the case of housing costs, the West region shows lower prices than those of the Northeast region. Therefore, the descriptive statistics make clear that the habitats for entrepreneurial activity vary widely by region, suggesting a robust setting for our analyses.

4.2. Results from the basic models

In this section, in order to examine the importance of collaborative and supportive relationships among the university–industry–government components of the triple helix and habitat for the entrepreneurial activities of a region, we estimate our model of the triple helix and habitat, including the interaction terms among those variables for our pooled sample of data from the years 2000 to 2004. The results of the correlation analysis among the variables, except for the interaction terms, are presented in Appendix A. In our multivariate panel FGLS regression analysis, firm birth and death rate are used as dependent variables, and the results are reported in Table 2. We also tested endogeneity of the habitat factors with a Durbin–Wu–Hausman test considering their co-evolutionary effect on the triple helix system, but did not find any endogeneity in our model.[13]

In the case of firm birth rate, regional variables are significantly related to this variable. In addition, firm birth rate increases by year, with the number of new firms increasing by 0.23% annually. As we expected from the descriptive statistics, the West region shows a 5.53% higher in firm births than the rate for the Northeast region. The South region has a lower firm birth rate than the West region, but a higher firm birth rate than the Northeast region. The Midwest region shows the lowest firm birth rate.

In the case of triple helix variables, degree (Armington and Acs, 2002; Goldstein and Drucker, 2006; Lee et al., 2004; Tamasy, 2006) and tax rate are positively and negatively related to firm birth rate, respectively, confirming our Hypotheses 1b and 2b. These results help meet our general expectation that the attainment of higher education enhances firm creation and low tax rates also stimulate entrepreneurship. In addition, industrial R&D expenditure is positively related to firm birth rate, consistent with previous studies and our Hypothesis 3a. However, university R&D negatively affects firm birth rate, contrary to Hypothesis 1a. This negative effect of university R&D seems to be related to the focus of university R&D, which, in comparison to industrial R&D, tends to favor basic research over applied research (Campbell and Guttel, 2005). In addition, high levels of university R&D may be associated with the absorption of much of the highly educated labor pool of a region by academia, leading to diminished entrepreneurial activity. We found that government R&D does not affect firm birth rate, confirming our Hypothesis 2a; we explain this based on the fact that government R&D is mixed between direct investment in industrial technology development (e.g., military technology and equipment) and indirect investment in universities and research institutions. However, the government usually distributes more R&D funds to universities than to industry, and more to national defense than to other sectors, which might be other contributors to our failure to link government R&D to firm birth rate.[14]

Regarding habitat factors, we show partial confirmation of our overarching hypothesis. Specifically, we can confirm our hypothesis for housing price and health insurance but fail to confirm our hypotheses for melting pot rate and crime factors. In the case of housing price, as we predicted, higher housing price is associated with lower firm birth rates, partially confirming Hypothesis 4a. If the average housing price increases by 10,000 dollars in a given U.S. region, the number of firm births per 100 existing firms is reduced by 0.09 firms. Health insurance coverage is also positively and significantly related to firm birth rate: a 1% increase in rates of coverage is associated with an increase of 0.15 new firms per 100 incumbent firms. However, melting pot rate and crime do not demonstrate significance. When we consider previous studies (Kirchhoff et al., 2007; Saxenian, 2002) on the melting pot index, which suggested that racial variety can provide vitality and flexibility in the environment of firm creation, our finding suggests that the effect of racial diversity on regional entrepreneurship might be a phenomenon specific to the West region.

In the case of the interrelationships within the triple helix, as represented by interaction terms between R&D expenditures of university, industry, and government, we find significant and positive coefficients for the interaction term between university and government R&D on firm birth, thus rejecting our Hypothesis 5a. In other words, the result suggests that the interrelationship between university and government through R&D activity promotes regional entrepreneurship. If we consider that university and government R&D generally focus on basic research, the contradictory result might be explained by the concept that technology transfer and licensing of the R&D outcomes from universities and government institutions promote regional entrepreneurship activity (Di Gregorio and Shane, 2003; Landry et al., 2006; Markman et al., 2005).

On the other hand, industrial R&D has no synergistic effect with university and government R&D, rejecting our Hypotheses 6a and 7a. If we consider that private firms generally provide research grants for universities as part of requests for specific technology development (Campbell et al., 2004), it can be explained that the synergy between industry and university R&D investment may not encourage regional firm birth. In addition, as Welsh et al. (2008) pointed out in their exploration of the university–industry research relationship, university scientists believe that university–industry research relationships are valuable for increasing contact with scientists, but are problematic because working with industry can

[13] From the results of a Durbin–Wu–Hausman test, we did not find any endogeneity problems for all habitat variables at the 5% significance level in models of the firm birth rate and firm death rate.

[14] The amount of R&D expenditure of the U.S. Federal Government was $97.701 billion in current U.S. dollars in 2006. The federal government funded $24,304 million to industry (24.9%) and funded $28,784 million to universities and colleges (29.5%). In addition, national defense and health were allotted 59.3% and 21.9%, respectively, of the federal R&D budget. (Source: National Science Foundation (NSF)).

Table 2
Regression results of birth rate and death rate.

Variables	(1) BIRTHRATE		(2) DEATHRATE	
	Coefficient	Standard error	Coefficient	Standard error
Trend	0.227**	0.099	−0.330***	0.092
West	5.533***	0.652	2.896***	0.794
Midwest	−2.418***	0.423	−2.384***	0.622
South	1.434***	0.469	0.649	0.767
University Sphere				
DEGREE	0.103***	0.035	−0.100**	0.044
UNIVRD_R	−0.011*	0.006	0.014**	0.006
Government Sphere				
GOVRD_R	−0.001	0.001	−0.003*	0.002
TAXRATE	−0.391***	0.138	−0.174	0.149
Industry Sphere				
INDUSTRYRD_R	0.002*	0.001	0.004***	0.001
VCINVEST_R	0.001	0.001	−0.001**	0.001
Habitat				
MELTINGPOT	0.054	0.046	0.064	0.049
ln_POP	0.329	0.201	0.124	0.275
ln_INCOME	1.290	1.833	−1.410	2.141
HOUSEPRICE	−0.009*	0.005	−0.001	0.006
CRIME	0.014	0.018	−0.023	0.021
HINSUCOV	0.147***	0.049	0.059	0.052
Interactions				
UNIVRD_R × GOVRD_R	0.000020***	0.000005	0.000015**	0.000007
UNIVRD_R × INDUSTRYRD_R	−0.000001	0.000009	−0.000028***	0.000009
GOVRD_R × INDUSTRYRD_R	−0.000003	0.000002	0.000003*	0.000002
Constant	−18.588	17.405	25.654	20.919
Wald Chi2	516.770		256.820	
Autocorrelation Coeff.	0.513		0.565	

Heteroscedasticity across panels and AR(1) autocorrelation within panels are fitted.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

restrict communication among academic researchers. Therefore, they concluded that the effects of enhanced university–industry relationships and increased proprietary behavior on the part of university is complicated, which indirectly supports our non-significant finding for the relationship between university and industry for regional entrepreneurship.

In the case of the synergy between industry and government R&D, similar constraints requested by industry partners for developing specific technology or products (e.g., military technology or products), seem to render the effect of the R&D interaction on regional entrepreneurship non-significant as well. However, we should note that this result does not mean that the interrelationship between industry and university R&D or government R&D does not contribute to regional economic performance. As Mueller (2006) pointed out, universities are a source of innovation, and the more firms draw from knowledge generated at universities, the more those regions should experience economic growth.

Overall, in the case of the model for firm birth, we find that industrial R&D expenditure is important in terms of direct effects on firm formation, compared to university and government R&D. However, industry involvement does not create synergistic effects on regional entrepreneurial activity when it collaborates with university and government through R&D activities. On the other hand, the R&D collaboration between university and government has a positive and significant effect on regional firm birth, while these factors do not have a direct effect on regional firm birth individually. We find that some triple helix and habitat factors have significant effects on regional firm birth, especially the educational attainment, tax reduction and deduction, lower housing price, and the percentage of health insurance factors, which create favorable conditions for firm formation.

We also analyze the case for firm death rate, as presented in Table 2. We find that firm death rate decreased significantly over the period under study, as suggested by the coefficient of trend. Interestingly, as was the case for firm birth rate, the West region has the highest firm death rate and the Midwest region has the lowest, which means that the West region has the most volatile firm dynamics and economic turbulence, as suggested by the high firm birth and death rates, while the Midwest is relatively stable, with low economic turbulence.

In the case of triple helix variables, we find some interesting results. While university and industrial R&D increase firms' death rate, government R&D and venture capital investment reduce it. Therefore, our Hypotheses 1a, 2a, and 3a are rejected partially, while Hypothesis 3b is accepted in the case of venture capital investment. Of special note, we find that university R&D is associated with an increase in firm death rate. A possible explanation is that university R&D does not yield effective processes of technology commercialization and transfer, thereby increasing firms' failures. On the other hand, it is also possible that university R&D is effective in helping specific firms expand their market power by supporting their technological competitiveness, which may cause competing firms to fail relatively sooner, boosting the death rate. Although further examination is required, the former explanation seems more plausible for our finding.

In the case of government R&D, although it does not contribute to firm birth, it enables firms to be more sustainable with the negative sign of government R&D on firm death rate. For example, if we consider the case of the U.S.'s SBIR (Small Business Innovation Research) effort, through which the government provides R&D funds to small, high-tech, innovative firms in order to stimulate high-tech innovation and entrepreneurial spirit as it meets specific R&D needs, then our result seems reasonable. In addition, the types of government R&D investment in industry generally aim to

promote high socioeconomic impact, including funding for innovations in defense and other security technology, energy and nuclear power, health and human services, and transportation.[15] Therefore, it is necessary that those firms which receive government R&D investment become more sustainable and fulfill the mission that the government requests, which supports our result.

In the case of industrial R&D, it is associated with increases in both firm birth and death rates, suggesting that it is a key driver of regional entrepreneurial activities. On the other hand, our finding that venture capital investment significantly reduces firm death corresponds with our expectation suggesting that venture capital investment functions effectively in its role of enabling venture companies to sustain themselves longer in the market.

The significant, negative coefficient of degree variable is also of note, and supports the notion that having a larger proportion of the population hold higher degrees reduces the rate of firm death and increases firm birth rate, supporting our Hypothesis 1b. A 1% increase in the number of people with university degrees is associated with 0.1 fewer firms terminated per 100 incumbent firms. This finding highlights the importance of higher education to the entrepreneurial activity of a region. Habitat-related variables, in contrast, were unrelated to firm death rate.

Among the interaction terms between the R&D expenditures, the interactions between university and government R&D and government and industrial R&D are associated with higher firm death rates, rejecting our Hypotheses 5b and 6b, respectively. In other words, government R&D, when it interacts with university and industry R&D investment, is not effective in sustaining existing firms. When we think of the positive effect of the interaction of government R&D with university R&D, the collaborative government R&D seems to play a more important role in the early stage of the entrepreneurial process, including firm creation, rather than in later stages of firm growth, which confirms the government's role in supporting and vitalizing an industry in its nascent phase. In addition, we cannot interpret this result as meaning that government R&D has a negative effect on regional entrepreneurship, thus raising firm death, because the specific characteristics of those terminated firms have not been considered here. For example, if those firms with less socio-economic impact or inferior market competitiveness exit earlier from the market, enabling the establishment of a more desirable entrepreneurial ecosystem due to the interaction between government R&D and university or industrial R&D, the effect of the interaction associated with firm death can be considered positive for regional entrepreneurship.

On the other hand, the interaction of university and industrial R&D is associated with reduced firm death, creating a positive effect on the sustainability of existing firms, which supports our Hypothesis 7b. Previous studies highlighting the benefits of collaboration and interaction between university and industry also support our finding (Cohen et al., 2002; Landry et al., 2006; Mansfield and Lee, 1996; Mueller, 2006; Ostergaard, 2009; Shinn and Lamy, 2006; Tijssen, 2006; Welsh et al., 2008; Zucker et al., 2002).

Through our results for the firm death rate model, we find that university and industrial R&D increase the firm death rate, while government R&D and venture capital investment reduce the rate of firm termination. On the other hand, the combination of university and industrial R&D enhances firm sustainability. Lastly, educational attainment plays an important role in reducing the rate of firm death as well as increasing their rate of birth.

Table 3
The top 20 and bottom 20 states in firm birth in the U.S.

Group of high firm birth rate (HIGH) (20 states)		Group of low firm birth rate (LOW) (20 states)	
State	Firm birth rate	State	Firm birth rate
Washington	25.2	Mississippi	12.8
Nevada	22.6	Maine	12.5
Utah	22.1	Alabama	12.3
Colorado	20.5	Arkansas	12.2
Idaho	20.0	Michigan	12.1
Florida	19.5	Kentucky	12.1
Maryland	19.4	Indiana	11.9
New Mexico	18.3	Louisiana	11.8
California	18.1	West Virginia	11.7
Tennessee	16.8	Minnesota	11.5
Georgia	16.4	Kansas	11.5
Delaware	16.2	Connecticut	11.5
New Jersey	16.2	Vermont	11.4
Virginia	15.9	Illinois	11.2
Oregon	15.8	Nebraska	11.1
Arizona	15.7	Wisconsin	10.9
Wyoming	15.1	Ohio	10.7
Hawaii	14.8	North Dakota	9.1
Montana	14.5	Iowa	8.8
Texas	14.4	South Dakota	8.1

Note: Firm birth rate means the average number of new firm created per 100 existing firms in year 2000–2004.

4.3. Results from firm birth segmentation

In order to investigate our findings further on the dimension of regional heterogeneity, we divided our sample into two groups based on firm birth rate: high entrepreneurial region with high firm birth rate (HIGH) and low entrepreneurial region with low firm birth rate (LOW), as shown in Table 3. Each group has 20 states, as we excluded the 10 states with intermediate rates of firm birth in order to enhance the likelihood of finding a statistical difference between the averages of the two groups. Among the HIGH group are the states Washington, Nevada, Utah, Colorado, and California, with a total of 100 year-state panel observations. For the LOW group's states, including Illinois, Nebraska, Wisconsin, Ohio, and Iowa, we also made 100 year-state panel observations.[16]

Table 4 shows the estimated results with the original variables of the triple helix, habitat, and interaction terms. In the case of the HIGH group, the absolute values of those significant coefficients are larger than those of the model for the whole sample, except for the West dummy. Contrary to the case of the whole sample, the South region has a lower firm birth rate than the Northeast region. No Midwest-region state fell among the top 20 states for firm birth rate.

As was the case of the whole sample, the HIGH group shows that the degree variable significantly and positively affects firm birth, while university R&D has a negative effect on firm birth. In addition, housing price and health insurance coverage are significant factors for regional entrepreneurial activities, consistent with our previous findings here. However, tax rate does not affect firm birth rate, and industrial R&D has a negative effect on birth rate, contrary to the case for the whole sample. Instead, venture capital investment significantly enhances firm birth rate in this group. Therefore, results from the HIGH group suggest that rather than R&D investments such as university and industrial R&D, direct investment (e.g., venture capital) in firm creation and sustainability, coupled with

[15] 'Federal Funds for Research and Development: Fiscal Years 2005,' Master Government List of Federally Funded Research and Development Centers, National Science Foundation of U.S.

[16] We statistically compared the means of the birth rate of the HIGH group and the LOW group. The average firm birth rate of the HIGH group is 17.87 while the LOW group is 11.27. The difference between the averages of the two groups is statistically significant (F-statistic: 81.786, $p < 0.001$).

Table 4
Regression results from firm birth segmentation.

Variables	(1) HIGH[a]		(2) LOW[b]	
	Coefficient	Standard error	Coefficient	Standard error
Trend	0.782***	0.182	0.319*	0.176
West	2.999**	1.484	–	–
Midwest	–	–	−2.020**	0.818
South	−2.742**	1.377	−1.467	0.900
University Sphere				
DEGREE	0.158**	0.071	−0.030	0.062
UNIVRD_R	−0.087***	0.016	−0.010	0.011
Government Sphere				
GOVRD_R	0.001	0.002	0.001	0.005
TAXRATE	−0.246	0.379	0.477**	0.236
Industry Sphere				
INDUSTRYRD_R	−0.007***	0.002	−0.000	0.003
VCINVEST_R	0.004***	0.001	0.002	0.003
Habitat				
MELTINGPOT	0.115	0.090	0.043	0.117
ln_POP	0.789	0.576	0.793	0.489
ln_INCOME	−0.392	4.439	0.352	5.141
HOUSEPRICE	−0.025***	0.008	−0.018	0.016
CRIME	0.011	0.034	0.038	0.031
HINSUCOV	0.339***	0.087	−0.051	0.094
Interactions				
UNIVRD_R × GOVRD_R	0.000042***	0.000010	0.000009	0.000051
UNIVRD_R × INDUSTRYRD_R	0.000100***	0.000023	0.000012	0.000025
GOVRD_R × INDUSTRYRD_R	−0.000015***	0.000003	−0.000003	0.000004
Constant	−15.476	49.608	−0.657	46.212
Wald Chi2	258.71		59.74	
Autocorrelation Coeff.	–		0.426	

[a] Heteroscedasticity across panels and no autocorrelation within panels are fitted.
[b] Homoscedasticity across panels and AR(1) autocorrelation within panels are fitted.
* Significant at 10%.
** Significant at 5%
*** Significant at 1%.

habitat factors related to quality of life (e.g., housing price, health insurance) are more important in high entrepreneurial regions.

Interestingly, we find a positive synergistic effect of university and government R&D on firm birth rate, as in the case of our pooled states estimation. The coefficient of this interaction variable is larger than that of the pooled estimation result, suggesting that the synergy is higher in high entrepreneurial regions. On the other hand, we find a positive interaction effect of university and industrial R&D, which is contrary to the pooled sample case, while the interaction effect between government and industrial R&D has negative interaction effects on firm birth. Therefore, these results suggest that university R&D plays an important role as an 'entrepreneurial mediator' in the collaboration among the three spheres and their co-evolution in the triple helix system, for firm birth in high entrepreneurial regions.

On the other hand, in the case of the LOW group, we do not find any significant factors for firm birth rate, except for tax rate, which, unexpectedly, has a positive effect on firm birth in this group. In addition, there is no significant interaction effect among the R&D expenditures of university–industry–government. Therefore, these results suggest that independent and interdependent functions of the triple helix and habitat are not influential in low entrepreneurial regions, or there is little entrepreneurial synergy associated with university–industry–government there.

These findings strongly suggest that we can use different approaches to promote and accelerate regional entrepreneurial activities, depending on the entrepreneurial status and habitat features of specific regions. In high entrepreneurial regions, more 'direct' approaches such as venture capital investment seem to be more effective for promoting entrepreneurial activity. In addition, enhancing a region's quality of life (e.g., habitat features such as lower housing prices and wider health insurance coverage) is important for promoting entrepreneurship. Importantly, university R&D plays an important mediating role in the R&D collaboration among the triple helix's three spheres for the promotion of entrepreneurial activities in high entrepreneurial regions. However, in the case of low entrepreneurial regions, the bases of supportive functions of university–industry–government and habitat need to be established first, and the synergistic effects among university–industry–government can be expected to be observed as entrepreneurial activities increases. Therefore, our finding suggests that we need to develop region-specific and more structural entrepreneurship policies that take into account the status and habitat environments of regions. More diverse and specific policy implications regarding regional entrepreneurial activities may be derived through finer-grained segmentation of regions, as well.

5. Conclusion

In this paper, we examined the effect of the triple helix of university–industry–government relationships and habitat factors on U.S. entrepreneurial activity at the state level. We used firm birth and death rates as measures of entrepreneurial activity. We selected triple helix variables and their interrelationships, centering on R&D-related factors such as university, government, and industrial R&D investment, which play important roles across different spheres based on the micro-level relationships among the helix's three spheres. We also considered those factors which represent the inherent function of each sphere in regional entrepreneurship, including the proportion of the population holding higher degrees, tax rate, and venture capital investment. In addition, we examined habitat variables representing the quality of life for a region, such as melting pot index, housing price, crime rate, and health insurance coverage.

Descriptive statistics showed that the average firm birth and death rates are highest in the West region, which has higher levels of entrepreneurial activity, as represented by these measures, than other regions. Interestingly, the West region, notwithstanding the relatively low R&D conditions (relatively low university and industrial R&D) associated with the triple helix, has higher firm dynamics than the Northeast region. However, the West region shows the highest melting pot index and its population has grown rapidly, which seems to be one of the key drivers of these trends.

In our multivariate panel FGLS estimation of our model with triple helix and habitat variables, we found some interesting and important results. In the case of firm birth rate, industrial R&D expenditure is relatively more important than university and government R&D, in terms of direct effects on firm formation. However, university and government R&D seem to affect firm birth indirectly, because their interaction positively affects regional firm birth rate, while the variables exert no independent effects on this measure. In contrast, higher educational attainment, lower tax rate, lower housing prices, and wider health insurance coverage enhance conditions for firm formation in a region.

In the case of firm death rate, we found that university and industrial R&D are associated with increases on this measure, while government R&D and venture capital investment reduce the number of terminations, suggesting that they enhance firm sustainability. In the case of industrial R&D, the variable simultaneously increases both firm birth rate and death rate, suggesting that it is a key driver of regional entrepreneurial activities. Regarding synergistic effects, we found that the interaction between university and industrial R&D is associated with greater firm sustainability, supporting the findings of previous studies, while the interaction between university and government R&D and government and industrial R&D is linked to more firm deaths. Educational attainment plays an important role in reducing the rate of death as well as increasing the rate of birth.

By dividing our sample into two groups based on firm birth rate, we investigated the effects of regional heterogeneity. In a high firm birth region, the results suggest that rather than R&D investments such as university and industrial R&D, more direct investment (e.g., venture capital) in firm creation and sustainability, coupled with habitat factors related to quality of life (e.g., housing prices, health insurance), are more important to promoting entrepreneurship. Interestingly, we found positive synergistic effects for the interaction between university and government R&D and between university and industrial R&D on firm birth rate. In addition, the synergy effect is greater for high entrepreneurial regions than for the broader, pooled sample. These results suggest that in high entrepreneurial regions, university R&D plays an important role as an 'entrepreneurial mediator' among the three spheres, at least in regard to firm birth.

However, in low firm birth regions, we found no significant factors and interaction effects on firm birth rate among the R&D expenditures of university–industry–government, except for tax rate. This suggests that independent and interdependent functions of the triple helix and habitat are less influential in low entrepreneurial regions.

The results suggest that we can use different approaches to promote and accelerate regional entrepreneurial activities for different regions, depending on their baseline levels of entrepreneurial activity and habitat features. In high entrepreneurial regions, more 'direct' approaches such as boosting venture capital investment and enhancing quality of life seem to be more effective in promoting entrepreneurial activity. In addition, university R&D expenditure, which plays an important mediating role in the R&D collaboration between the three spheres of the helix for new firm creation, should be expanded. However, in low entrepreneurial regions, basic supportive functions of university–industry–government components and habitat features should be established initially, after which we may expect to observe synergistic effects among university–industry–government as entrepreneurial activities increase.

Our results suggest that the roles of universities, government, industry, and habitat vary in the promotion of entrepreneurial activity across regions, depending on specific regional characteristics. In addition, the heterogeneous effects of interaction among the spheres of the triple helix on regional entrepreneurship suggest that systematic policy approaches are required in making effective regional entrepreneurship policy. The role of university is especially important, in that it mediates the interaction among the spheres in the triplex helix system and creates synergy effects on regional entrepreneurial activity. In addition, the positive and significant effect of higher educational attainment of a region on entrepreneurial activity further emphasizes the important role of university in entrepreneurial development.

Our study contributes to the entrepreneurship policy literature by suggesting the value of a more structural entrepreneurship policy emphasizing the co-evolutionary relationship among university, industry, and government, as well as habitat, in promoting regional entrepreneurial activity. However, our study is also limited because our geographic sample unit (i.e., U.S. states) is large and can include heterogeneous components (e.g., cities with very different entrepreneurship patterns). As such, analysis at the MSA (Metropolitan Statistical Areas) or county level would give us finer-grained results for the effects on regional entrepreneurship of micro-level relationships in the triple helix, by allowing for models testing the specific effects of each sphere in the triple helix, as well as their interaction effects. In addition, the role of habitat has been found to be important in regional entrepreneurship, although we have only limited current information about it. A sharper focus on the effects of habitat on entrepreneurial activity will provide even deeper insights into the factors that promote or discourage economically vital entrepreneurship and innovation.

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Appendix A.

Correlations between explanatory variables.

Variables		1	2	3	4	5	6	7	8	9	10	11	12
1	DEGREE	1.00											
2	UNIVRD_R	0.58**	1.00										
3	GOVRD_R	0.42**	0.61**	1.00									
4	TAXRATE	−0.23**	−0.09	−0.13*	1.00								
5	INDUSTRYRD_R	0.49**	0.27**	0.13*	−0.10	1.00							
6	VCINVEST_R	0.40**	0.27**	0.20**	−0.14*	0.39**	1.00						
7	MELTINGPOT	0.45**	0.20**	0.24**	−0.22**	0.37**	0.37**	1.00					
8	ln_POP	0.16*	0.05	0.10	−0.55**	0.22**	0.26**	0.49**	1.00				
9	ln_INCOME	0.68**	0.45**	0.29**	−0.38**	0.65**	0.39**	0.66**	0.51**	1.00			
10	HOUSEPRICE	0.64**	0.45**	0.28**	−0.02	0.49**	0.36**	0.72**	0.17**	0.69**	1.00		
11	CRIME	−0.13*	0.03	0.12	−0.20**	−0.12	−0.07	0.22**	0.29**	−0.04	0.01	1.00	
12	HINSUCOV	0.26**	0.12	−0.13*	0.26**	0.22**	0.09	−0.27**	−0.22**	0.06	0.09	−0.44**	1.00

* Correlation is significant at 5%.
** Correlation is significant at 1%.

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