The Growth of Research Triangle Park

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ABSTRACT. In light of the history of Research Triangle Park, we develop an analytical model to characterize the Park's growth. The model is based on the hypothesis that the Park's growth can be thought of as the adoption of an innovation, where the innovation is the new innovative environment created by the Park and its infrastructure.

I. Introduction

> In the heart of North Carolina there exists one of the Nation's most important industrial resources . . . the Research Triangle (Link, 1995, p. 1).

Over the past fifty years the term "Research Triangle" has been used in a number of ways, but generally it has been used to refer to the geographic area defined by Duke University in Durham, North Carolina State University in Raleigh,[1] and the University of North Carolina at Chapel Hill.[2,3] Within Research Triangle is Research Triangle Park, a well-defined area of 6,900 acres, and within its incorporated boundaries are 137 organizations with over 41,600 employees, including 104 research companies with over 40,000 research employees. Certainly the largest research park in the United States both in terms of employees and acreage, and arguably the most notable, the Park began with only a vision, survived financially turbulent times, and then it slowly grew toward its current eminent status.

The remainder of this paper is outlined as follows. In the following Section II, we briefly chronicle the history of Research Triangle Park.[4] In Section III, we develop an analytical model to characterize the growth of the Park over time. We hypothesize that the growth of the Park can be thought of as the adoption of an innovation as new companies adopted over time the Park's innovative environment. Our model fits the data quite well. Then, in Section IV, we set forth one explanation for why the Park has grown as successfully as it has. There, we hypothesize the Park's successful growth may have been because of the continuity of entrepreneurial leadership that the Park enjoyed for more than 30 years. Section V of the paper offers some concluding observations.

II. A brief history of Research Triangle Park

After World War II, the North Carolina economy was very unstable. Historically, the state's economy had relied almost exclusively on three traditional industries: furniture, textiles, and tobacco. The furniture industry was leaving the state and expanding into the northeastern United States; the textile industry was beginning to face growing competition from Asian producers; and tobacco manufacturing employment was on the decline, in part because of automation and in part because of decreasing demand.

North Carolina's per capita income had long been one of the lowest in the Nation,[5] and the decline in its traditional industries made it even more difficult for the state to employ its own college graduates. During the early 1950s, the academic community was becoming increasingly concerned about the out migration of its better

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college graduates and began a dialogue with the state's economic development leaders about ways to attract new industries to North Carolina. The idea of using the three triangle universities to attract research companies into a park area central to the universities quickly emerged from the dialogue.

In early 1954, Brandon Hodges, the state treasurer of North Carolina, Robert Hanes, the president of Wachovia Bank and Trust Company, and Romeo Guest, a Greensboro building contractor who some say gave birth to the idea of a research park in the triangle area, met to discuss North Carolina's need for industrial growth. Hanes, an extremely influential citizen, was not immediately sold on the idea. In the fall of 1954, Hodges and Guest enlisted the support of key deans and faculty at North Carolina State, and in December 1954, the group convinced Chancellor Carey Bostian to take the triangle idea to Governor Luther Hodges. While the governor, like Hanes, did not immediately see the potential of the idea for North Carolina, he was willing to commission a concept report. The 10-page document, written by William Newell, director of the Textile Research Center at North Carolina State, was delivered to the governor on January 27, 1955, and soon thereafter the triangle idea became known as the "Governor's Research Triangle" (Link, 1995, p. 20).

In April 1955, having solicited the support of Gordon Gray, president of the University of North Carolina, and Hollis Edens, president of Duke University, Governor Hodges organized the Research Triangle Development Council with Hanes as chairman.[6] During the next year the Council and its various subcommittees agreed that the Research Triangle project should be maintained as a private effort and that the universities, "by the research atmosphere that their very existence creates," will act as a magnet to attract industry "by providing a wellspring of knowledge and talents for the stimulation and guidance of research by industrial firms" (Link, 1995, p. 29). Soon thereafter, George Simpson, professor of sociology at Chapel Hill, agreed to take a one-year leave of absence to be director of the organization that, on September 25, 1956, would be named the Research Triangle Committee, Inc. His task was to attract research companies to the triangle.

While the leaders in the state believed that the Research Triangle was a good idea, a number of obstacles immediately stood in the way. First, North Carolina was in the South, although it did have a progressive reputation; it had reacted relatively well to the Supreme Court's 1954 *Brown v. Board of Education* decision. Second, there was a tendency for large companies to maintain their research facilities near their manufacturing sites. And third, there was a folk wisdom that Route 128 around Boston and Stanford Research Park were not planned but rather just happened, so there was no clear path to follow.

Simpson realized that university cooperation would be essential for the park idea to succeed, so he assembled a team of faculty to develop brochures documenting the research expertise of the three universities in selected fields and to travel to visit companies and tell them about the park idea.[7] By the end of 1957, over 200 companies were visited, but the faculty really had nothing to "sell" but a concept. Land would be needed.

As early as January 1957, Governor Hodges, anticipating the need for land, had tried to identify investors in North Carolina in the Research Triangle but had not been successful. However, William Saunders, director of the state's Department of Conservation and Development, had the idea to approach New Yorker, Karl Robbins. Robbins had retired to New York in the 1950s, but because he had previously owned textile mills in North Carolina he was familiar with the areas and was a friend of Guest's. Robbins was interested and made a commitment to invest up to $1 million but began with an investment of only $30,000.

Separate and apart from the planning and marketing of the Research Triangle Committee, Guest took the lead in creating a private land venture. By July 1957, he and those helping him had acquired options to purchase nearly 800 acres at an average price of $161 per acre in what would eventually become Research Triangle Park. Operating secretly and without fanfare, Guest and his associates had acquired options under the name of Pinelands, Inc. for 3,430 acres of an identified 4,000 acres by September when the press began to publicize the park idea. Most of the options were due at the end of November, but Robbins was

reluctant to invest any more than the $109,000 he had invested to date because no North Carolinians had yet invested.

By early 1958, Pinelands, the private land development group, and the Research Triangle Committee, the state and university planning and marketing group, realized that there were problems and that they could no longer rely on Robbins for sufficient financial capital to assemble the land while the Committee tried to identify and attract research companies to the area. In August 1958, Governor Hodges and Hanes approached Archibald (Archie) Davis, also of Wachovia Bank and Trust, to help attract North Carolina investors for the Pinelands Company. Davis recognized that the Research Triangle had the potential to be extremely important for the future economic direction of the state, and he realized that if the Triangle was designed for public service rather than for private gain it would be much easier to raise money from corporations and institutions that were interested in serving the state of North Carolina. Thus, he agreed to raise contributions, as opposed to solicit financial investments, under the condition that the pledged funds would be used to pay the Pinelands Company's borrowed debt ($415,000), to finance the establishment of a research institute ($500,000 estimated), and to construct a building ($250,000 estimated). In October, Davis presented this proposal to the Committee and it was accepted. He began his fund raising efforts on December 1, and on January 9, 1959, Governor Hodges announced that Davis had raised $1.425 million and that these funds would be used to acquire the land assembled by Pinelands and to pass control of this enterprise to the recently constituted nonprofit Research Triangle Foundation of North Carolina. Further, the funds would be used to establish as a centerpiece for the Park the Research Triangle Institute for the purpose of doing contract research for business, industry, and government as well as for a building to house the Foundation and Institute in the center of the Research Triangle Park.

The Park moved forward rather slowly. In May 1959, Chemstrand Corporation announced its decision to relocate from Decatur, Alabama, to the Park. Thus, Chemstrand and the Research Triangle Institute became the anchors for the Park. But, for the next five years the Foundation had little success in attracting companies. In fact, the Foundation borrowed $1.3 million to redeem outstanding shares in Pinelands, to purchase additional tracts of land, and to sustain Park operations.

Nineteen hundred and sixty five marked the turning point for the Park. On January 6, Governor Terry Sanford announced that the U.S. Department of Health, Education, and Welfare had selected the Research Triangle Park for its $70 million National Environmental Health Sciences Center. And, on April 14, Governor Dan Moore announced that IBM would locate a 600,000-square foot research facility on 400 acres in the Park.[8] As clearly seen from Figure 1 and Figure 2, the sustained growth of the Park began in that year.

While new tenants continued to enter the Park over the ensuing decades, there was one key event that distinguishes the Park from all other science parks both in the United States and in other countries.[9] In early 1974, Davis, in his role as president of the Foundation, charged the leadership of Duke University (President Terry Sanford) and the University of North Carolina (President William Friday) to formulate a plan to ensure the continued presence of the three sister institutions in the Park, for the Park began with those institutions at its core and their continued presence would be needed for its ultimate prosperity. What evolved from committee discussions was the decision to set aside a campus of approximately 120 acres, to be donated by the Foundation, for the purpose of housing organizations that could bring together faculty from the three universities and Park scientists to work collaboratively. The "park within a park" was to be called the Triangle Universities Center for Advanced Studies, Inc. (TUCASI).

Thanks to the vision of Davis and his leadership and that of Sanford and Friday (and others over the years), there are today six organizations on the TUCASI campus: the National Humanities Center, the Microelectronics Center of North Carolina, the North Carolina Biotechnology Center, Sigma Xi, the National Institute of Statistical Sciences, and the Burroughs Wellcome Fund. These organizations are an outward reflection of the universities' core values and as such, TUCASI is an intangible asset that makes

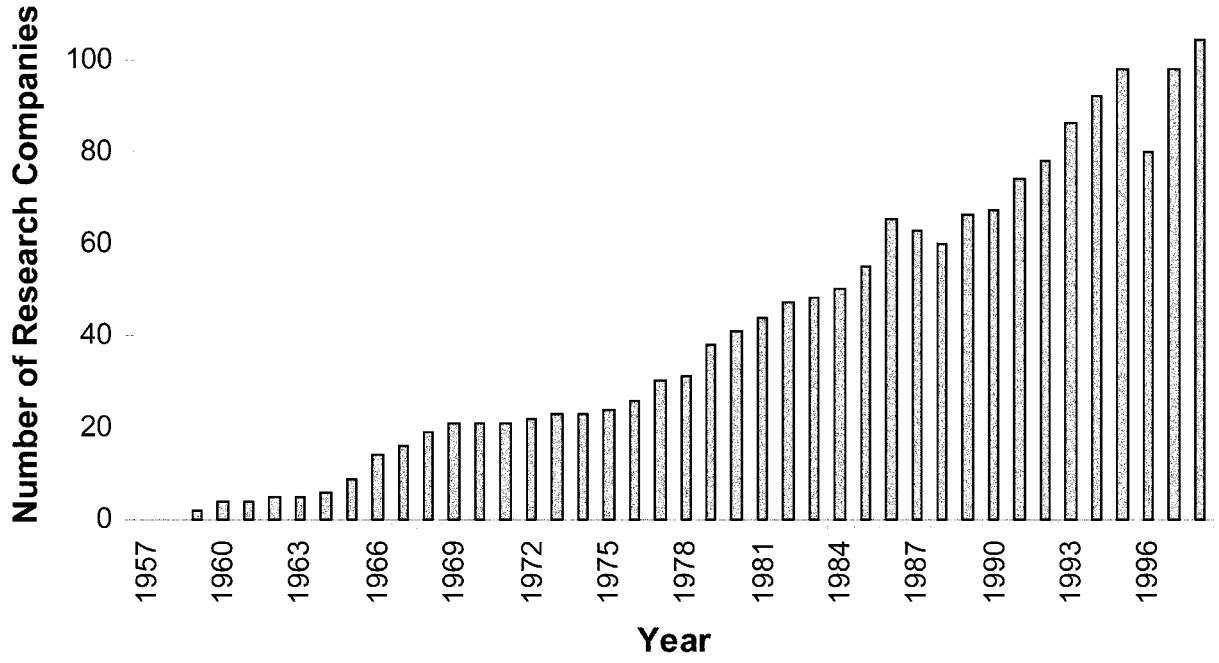

Figure 1. Number of research companies in Research Triangle Park from 1957 through 1998.

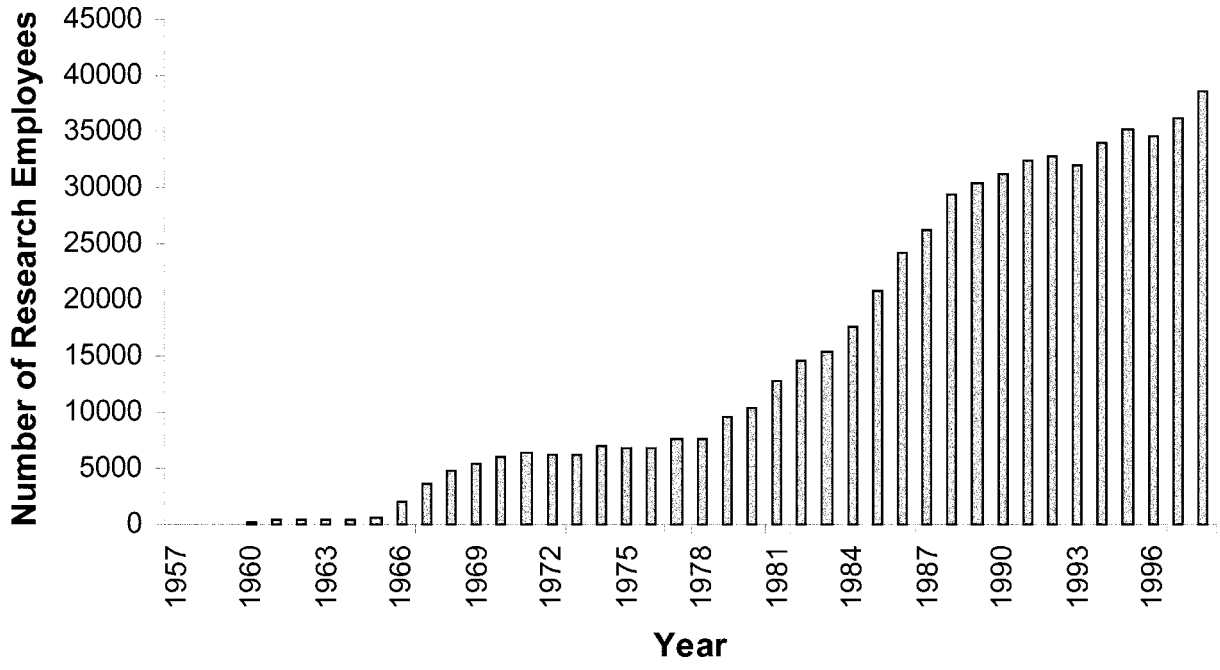

Figure 2. Number of research employees in Research Triangle Park from 1957 through 1998.

Research Triangle Park unique and helps to attract new organizations into the area.

III. Characterizing the growth of Research Triangle Park

In this section we offer an analytical model to characterize the seemingly S-shaped pattern of growth in the Park as illustrated in Figure 1.[10] We argue that the observed pattern of growth in the Park can be interpreted in terms of a model of the adoption of an innovation. Specifically, we posit the appearance of a new research company in the Park as another company adopting the Park's innovative environment. As such, we demonstrate below that we can indeed estimate the Park's growth in terms of a simple model of diffusion, thereby offering support for this conceptualization and for how one might think of, and possibly forecast the growth of, a science park in general.

We have chosen a Gompertz survival-time model for our analytical demonstration because the model is quite simple and yet more general than a model using the exponential distribution that has a constant hazard rate. Geroski (2000) discusses many distinct reasons for S-shaped diffusion curves, and he observes that different reasons suggest different distributions for describing adoptions of innovation. For example, when there are asymmetries in the speed of diffusion among different groups in the population of adopters, the Gompertz distribution has been used.[11] The Gompertz survival-time model allows the data to represent a monitonically increasing or decreasing hazard rate for the adoption of the innovation – the appearance of research companies in the innovative environment of the Research Triangle Park. We hypothesize that as understanding of the science park innovation and the importance of interaction between industry and university science increased over the last half century, the hazard rate (described fully below) for adopting the science park innovation has increased.

The Gompertz model we estimate describes the adoption of the Research Triangle Park by research companies as a stochastic diffusion process with an increasing hazard rate. Alternatively, the Weibull distribution could be used with the survival time model and also allow estimation of a hazard rate that increases or decreases through time. The lognormal or log-logistic distributions can be used for data with hazard rates that initially increase and then decrease, and the generalized gamma model allows for even more flexibility in the hazard function.[12] For our purposes, the Gompertz model offers the appropriate flexibility with a simple functional form to describe the S-shaped diffusion curve where the hazard rate for the population of adopters of the innovative environment increased over time.

The time series of adoptions of the science park innovation in the United States begins in 1951 when the first park was established. In the absence of any particular event that precipitated the awareness of the concept of a science park, we assume that in 1950 potential adopters of the science park concept are made aware of the possibilities. Then, through time, science parks appear with appearances being most likely in the environments most favorable to the success of a science park. The first research companies appeared in the Research Triangle Park in 1959, and starting with two research companies in that year, the Park grew to include 104 research companies by 1998.

Implementing the diffusion model, the probability that the establishment of a particular research company in Research Triangle Park will have occurred by time t is:

$$F(t) = 1 - S(t). \tag{1}$$

$S(t)$ is the probability that for a particular adopter, the adoption has not occurred by time t:

$$S(t) = e^{(-e^{\lambda}/\gamma)(e^{\gamma t}-1)}. \tag{2}$$

Deriving the hazard rate for the model explains the descriptive roles for the two parameters of the model, lambda (λ) and gamma (γ). The hazard rate for the adoption is:

$$h(t) = F'(t)/(1 - F(t)) \tag{3}$$

where

$$F'(t) = -S'(t) = e^{(\lambda+\gamma t)-(e^{\lambda}/\gamma)(e^{\gamma t}-1)}. \tag{4}$$

Substituting (1), (2), and (4) into (3), the hazard rate for adoption is then:

$$h(t) = e^{\lambda+\gamma t} = e^{\lambda}e^{\gamma t} \tag{5}$$

and the hazard rate is increasing, decreasing, or constant as γ is $>$, $<$, or $= 0$.

The hazard rate is the conditional probability density for adoption. Conditional on a company not yet having adopted the innovative environment of Research Triangle Park, the probability that it will adopt the innovation and move into the Park during the small interval of time dt is given by $h(t)dt$. The parameter lambda determines the base level of the hazard rate throughout the history of Research Triangle Park, while the parameter gamma determines the rate at which that base level grows through time. The survival-time model could treat the parameter lambda as a constant plus a linear combination of explanatory variables, but here we just estimate the constant term to establish our point that the entry of research companies into Research Triangle Park can be described as the diffusion of an innovation.

We have data on the net number of research companies in Research Triangle Park in each year. Using the time at which each net arrival of a research company occurs, we have a list of the 104 research companies' arrival times starting with company one and company two appearing in 1959, and ending with companies 99 through 104 appearing in 1998. With that information, we can estimate λ and γ for the diffusion model showing the adoption of the Research Triangle Park environment by research companies. Table I provides the estimates. We see that λ is estimated to be –6.30 and γ is estimated to be 0.109 for the diffusion of research companies into the Research Triangle Park. Thus, from equation (5), in 1950 at $t = 0$ the hazard rate is $e^{-6.30} = 0.00184$, and the hazard rate grows at the rate of 10.9 percent per year.

Figures 3, 4 and 5 use the estimates of lambda and gamma and the number of companies as of 1998 and simulate the hazard rate, the probability of entry, and the expected number of research companies in the Research Triangle Park over the period 1950 through 2010. Figure 3 shows the hazard rate increasing exponentially; Figure 4 shows that the probability of entry follows an S-shaped curve; and Figure 5 shows the model's estimation of the diffusion path for research companies entering Research Triangle Park. Clearly the only historically accurate part of the description is for the period through 1998, but the projection for the additional few years shows the S-shaped diffusion curve clearly.

From the analytical exercise of fitting the Gompertz survival-time model, we conclude that it is reasonable to characterize the growth of Research Triangle Park as research companies adopting the Park's innovative environment. An alternative approach, and one that would work very well with a set of explanatory variables to show the determinants of lambda across different companies rather than simply describing the overall diffusion path, would be to define a set of potential entrants to the Park a priori. Then, the model would be estimated not just with the set of firms that actually entered, but with the entire population of potential entrants. Not all subjects

TABLE I
Gompertz diffusion model for research companies entering Research Triangle Park

Gompertz Regression – log relative-hazard form*

No. of subjects = 104
No. of observations = 104
No. of "failures" = 104
Time at risk = 3391
Log likelihood = –34.340818

	Coefficient	Std. error	z	$P > \|z\|$	95% Confidence interval	
Lambda	–6.297894	0.3369615	–18.690	0.000	–6.958327	–5.637462
Gamma	0.1091215	0.0098872	11.037	0.000	0.089743	0.1284999

* Estimated using Stata (1999). The term "failure" refers to traditional applications of the survival-time model and the "survival" function, S (see Stata, 1999). As long as a company has not adopted the Park's innovative environment, it "survives" in the data, but on adoption it ceases to "survive" and leaves the set of potential adopters.

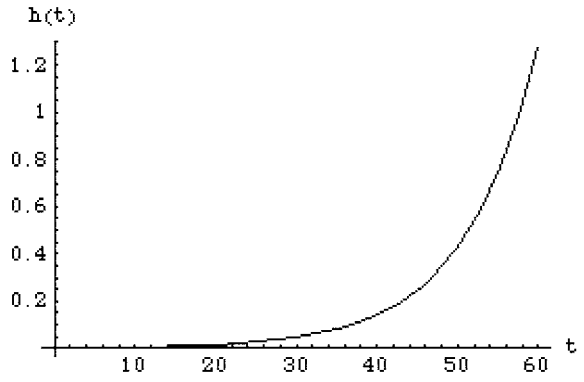

Figure 3. Estimated hazard rate for research companies entering Research Triangle Park from 1950 through 2010.

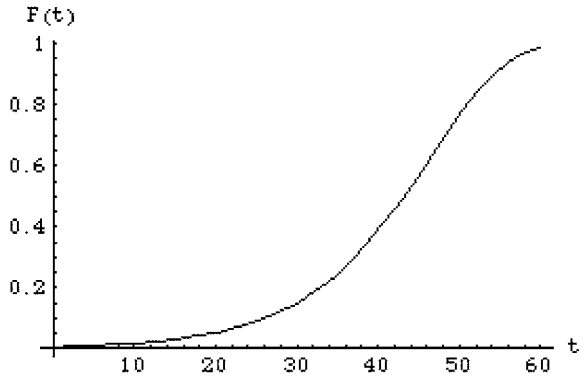

Figure 4. Estimated probability that the typical research company has entered Research Triangle Park by year *t* from 1950 through 2010.

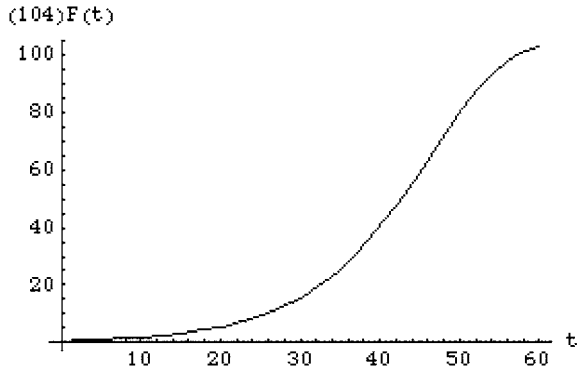

Figure 5. Estimated expected number of research companies in Research Triangle Park in year *t* from 1950 through 2010 using just the population of established companies as of 1998.

would enter, and we would have a model illustrating not just the diffusion path for the actual entrants, but a model explaining the selection of potential entrants as actual entrants over time.

IV. Entrepreneurial leadership and the growth of Research Triangle Park[13]

Why has Research Triangle Park grown as successfully as it has? We set forth in this section the idea that the successful growth of the Park may have been because of the continuity of entrepreneurial leadership that the Park has enjoyed for more than 30 years.

What is entrepreneurial leadership? The answer rests of course on who an entrepreneur is and what an entrepreneur does. The history of economics holds diverse opinions on the nature and role of the entrepreneur. Contemporary economic theory recognizes the entrepreneur as an independent factor of production that is important for producing outputs just as the factors land, labor, and capital are important.

The entrepreneur has been associated with many roles as intellectual thought about entrepreneurship has developed. At least twelve themes, often overlapping, have surfaced in the literature over the years:

1. The entrepreneur is the person who assumes the risk associated with uncertainty.
2. The entrepreneur is the person who supplies financial capital.
3. The entrepreneur is an innovator.
4. The entrepreneur is a decision maker.
5. The entrepreneur is an industrial leader.
6. The entrepreneur is a manager or superintendent.
7. The entrepreneur is an organizer and coordinator of economic resources.
8. The entrepreneur is the owner of an enterprise.
9. The entrepreneur is an employer of factors of production.
10. The entrepreneur is a contractor.
11. The entrepreneur is an arbitrageur.
12. The entrepreneur is an allocator of resources among alternative uses.

Theories of entrepreneurship may be either static or dynamic, but only dynamic theories of entrepreneurship deal directly with change and

uncertainty. For example, the role of the entrepreneur as a superintendent would be consistent with a static environment, but the role of the entrepreneur as innovator brings the dynamic environment important for understanding the history of the Research Triangle Park to the fore.

Dismissing static theories as irrelevant for understanding the successful growth of Research Triangle Park, the taxonomy of entrepreneurial theories can be condensed into three major intellectual traditions, each tracing its origin to Cantillon (c. 1680–1734). These traditions are the German Tradition (Thünen and Schumpeter), the Chicago Tradition (Knight and Schultz), and the Austrian Tradition (Mises, Kirzner, and Shackle).

Without tracing the development of the ideas that underlie these three traditions, one synthesis of these bodies of thought would define an entrepreneur as an individual *who perceives opportunity and has the ability to act upon it*. Given this definition, one could embrace the idea that the history of Research Triangle Park has been a history of entrepreneurial leadership guided primarily by one individual, Archie Davis.

Recall that it was Davis who perceived the importance of the Park developing not as a for-profit company (i.e., Pinelands) but rather as a nonprofit organization designed for the common weal. And, guided by that generosity of spirit, Davis was able within 30 days to raise nearly $1.5 million dollars for the betterment of the Park and the state. While this event does combine *perception* and *action*, Davis' vision and energies continued to influence the growth of the Park for more than 30 years. It was Davis who best understood the importance of there being a research institute in the Park. The institute would be a symbol to the corporate research community that the Research Triangle leaders had enough faith in the park concept to establish first their own research facility. And, it was Davis who raised the initial money for an institute and encouraged the Foundation to allocate increasing amounts of land for it. Finally, it was Davis' vision that lead to the creating of the TUCASI campus, and it was Davis who was instrumental in persuading the American Academy of Arts and Sciences to locate their National Humanities Center there.

In other words, time and time again, Davis provided the entrepreneurial leadership that guided the growth and development of Research Triangle Park. He not only demonstrated perception about what the Park could become, but also he was directly active in bringing those visions to reality.

V. Concluding observations

Arguably Research Triangle Park is the most notable and successful of all science parks in the United States, and that success suggests questions. Why has Research Triangle Park grown successfully?[14] Can other parks (existing parks or new parks) imitate its successful growth? Certainly, the Park has a number of obvious advantages such as three outstanding universities,[15] a world-class research institute, and a favorable geographic location and climate. But also, the Park has benefited from the continuity of entrepreneurial leadership by Archie Davis.

While we are only now in the process of documenting the historical development of the growth of other notable science parks and investigating why other science parks transformed themselves into industrial parks,[16] our preliminary opinion is that:

> The most successful science parks are those that have benefited from a continuity of entrepreneurial leadership. Thus, companies are eager to adopt the park's innovative environment and as a result the park grows.

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Notes

[1] North Carolina State College became North Carolina State University in 1965.

[2] North Carolina State and the University of North Carolina at Chapel Hill are part of the consolidated University of North Carolina.

[3] It is traditional when referring to these three sister institutions to list them alphabetically.

[4] The historical discussion of the Research Triangle Park draws on Link (1995, 2002).

[5] In 1952, only two states, Arkansas and Mississippi, had per capita incomes lower than that of North Carolina.

[6] The minutes of the first formal meeting of the Council on May 27, 1955, record that the members agreed on an important vision statement: "Research Triangle is an effort to make use of the triangle educational institutions . . . in the development of a research center which will attract business investment and which will give aid to North Carolina industry."

[7] Five brochures were developed to emphasize expertise in pharmaceuticals, chemistry, electronics, engineering, and forestry.

[8] IBM had been courted for seven years, and much of that process had been kept a secret.

[9] Herein, we use the term science park and research park synonymously.

[10] This section of the paper was supported by a research grant from the National Science Foundation, Division of Science Resources Studies.

[11] See Geroski (2000); in particular, see his discussion there of Dixon (1980) and Davies (1979).

[12] Stata (1999, pp. 432–454) describes the alternative distributions, and the implementation of the Gompertz distribution for use as an estimable parametric survival-time model is described in StataCorp (1999, p. 439). Rather than using maximum likelihood techniques to estimate survival-time models using various distributions as we do here, the early literature on the diffusion of innovations imposed the logistic S-curve for the diffusion of an innovation using appropriate transformations to reach a functional form that could be estimated with relatively simple estimation techniques. See Geroski (2000) for a tracing of the literature from the pioneering studies to the later ones that have modeled hazard rates.

[13] This section draws directly from Hébert and Link (1988, 1989).

[14] We realize that tenant growth is only one metric by which to measure the success of a science park. Attendant regional economic growth and development is yet another important metric, but we have not addressed it in this paper.

[15] There are no other science parks in the United States that are juxtaposed with three major research universities. We have anecdotal evidence that there are important research synergies among the three universities that not only enhance the reputation of the Park but also serve to attract research companies to the area. However, the primary vehicle that enhances these synergies is the TUCASI campus and the interactions that occur there.

[16] We are pleased to acknowledge the support of the National Science Foundation's Research and Development Statistics Program for this project.

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