

**Initial Findings of Locational Determinant of Biotechnology Firms at the State Level**

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### **ABSTRACT**

The biotechnology industry has grown rapidly, doubling in size from 1983 (\$8 billion in revenue) to 1999 (\$20 billion in revenue) (Ernst and Young LLP, 2001). Given the rapid growth of the biotechnology industry, this sector has become the focus of numerous state economic development policies.

However, the location of biotechnology firms has not been evenly dispersed in the U.S. The Ernst and Young LLP report (2001) shows that the state of California had approximately 42 percent of the nation's biotechnology firms in 2001. However, the state of Nevada has barely one percent of the nation's biotechnology firms. It seems that agglomeration may impact these locational decisions. Therefore the primary objective of this paper is to estimate factors that influence the location of biotechnology firms.

This paper estimates changes in the location of biotechnology firms and considers locational factors contributing to these location decisions. Initial results indicate that simultaneity of explanatory variables which has not been addressed in past research should be addressed. Also for states with low absolute numbers of biotechnology firms perhaps some non-market incentives should be investigated to increase numbers of firms. However the state of California has already enacted a program to assist in the funding of stem cell research which would further propel this state in biotechnology industry leadership. From the share analysis, states with amenities could influence biotechnology firms locating or relocating in their state. As for the state of Nevada which is adjacent to the state of California, Nevada may find it more difficult to locate or relocate biotechnology firms given California's initiative to fund stem cell research. However, the state does have amenity values that could be used to enhance possibility of location to the state.

## INTRODUCTION

During the 1990's, the state of Nevada was the fastest growing state in the nation with a population increase of 66.3 percent (U.S. Department of Commerce, 2001). However, the population and economic expansion during the 1990's was not evenly distributed among Nevada's seventeen counties. Developments in the gaming sector, especially in Clark County, have contributed to state of Nevada and urban Nevada (Clark and Washoe counties) population and economic growth. As for rural Nevada, expansion in the natural resource industries (mining and agriculture) has contributed to rural Nevada population and economic growth.

The economy of the state of Nevada and urban Nevada has often been depicted as recession-proof due to the legalized gaming industry (Cargill, 1979). However, with the national recessions of 1980-82 and 1990-92, along with expansion of legalized gaming throughout the nation, the state of Nevada and urban Nevada have realized that they are not immune to national recessions. With the September 11<sup>th</sup> terrorist attacks in New York City, the state of Nevada's gaming and tourism industry have become even more aware of their vulnerability. In addition, many rural Nevada county economies have realized declines in economic activity due to declining gold and agricultural prices.

Given the reliance of Nevada's urban economies upon the legalized gaming sector and Nevada's rural economies on the natural resource industries, economic development leaders have recognized the necessity for diversifying the state's economy. One area of diversification and development by the State's Commission on Economic Development and many county economic development authorities is the location or relocation of biotechnology firms within the state.

The biotechnology industry has grown rapidly, doubling in size from 1993 (\$8 billion in revenue) to 1999 (\$20 billion) (Ernst and Young LLP, 2001). Given the rapid growth of the biotechnology industry, the sector is in a relatively excellent position to bridge the current recession. Unlike the dot.com industries, the biotechnology industry is in a relatively strong financial position, has accelerated scientific discoveries, and continues to receive public policy support (Ernst and Young LLP, 2001).

The biotechnology industry is currently developing drugs to fight cancer, Alzheimer's and Parkinson's disease, AIDS, and other life-threatening conditions. Agricultural biotechnology promises to increase agricultural production by improving crop and animal resistance to natural enemies (e.g., insects, weeds, harsh growing conditions) and diseases. Environmental biotechnology products possibly would allow clean up of hazardous wastes or plant and animal waste as well as control agricultural pests and reduce chemical and pesticide use.

The Ernst and Young LLP report (2001) shows that the state of California has approximately 42 percent of the nation's biotechnology firms in 2001. However, the neighboring state of Nevada has barely one percent of the nation's biotechnology firms.

Goetz and Morgan (1995) employed Tobit procedures to investigate state level location determinants for biotechnology firms. They found that ensuring availability of venture capital and employing favorable fiscal policies is important for establishing firms within a state's borders. For states that already have biotechnology firms and are attempting to increase the number of firms per capita, public policies that include increasing Research and Development spending as well as spending on students, and raising the number of doctoral degrees awarded are significant.

However, the Goetz and Morgan (1995) article did not investigate changes in the number of biotechnology firms over time and what factors cause changes in these firms. Therefore for this paper, a state level estimation of factors that cause locational changes in biotechnology firms will be estimated.

### **OBJECTIVES**

The primary objective of this paper is to derive state level locational determinates of biotechnology firms. Specific estimates are:

1. To estimate factors which may influence location of biotechnology firms,
2. To derive factors which cause changes in numbers of biotechnology firms, and
3. To estimate locational factors that could be influenced by public policy.

### **PROCEDURES**

The Biotechnology Industry Organization defines biotechnology as "the use of the cellular and molecular processes to solve problems or make products" (Biotechnology Industry Organization, 2000). Included in this definition of the industry are firms that use cells and biological molecules for applications in medicine, agriculture, and environmental management.

For this paper, four locational variables that generally influence industry location will be analyzed. These traditional locational factors are taxes, public services provided, business-failure rates, and manufacturing wages (Coughlin, et.al, 1991). In addition, other locational variables hypothesized to influence location by a biotechnology firm will be used. Acs, et al. (1992) identified three key requirements for the success of biotechnology firms: venture capital, research and development infrastructure, and technology transfer. Capital is required "as [firms] struggle to transform their research into a commercial product and bring that product to market" (Acs, et al., 1992). Proximity to R&D facilities is important not only for generating research, results of which may be transformed into commercial products, but also for attracting federal funds.

Additionally, it is hypothesized that biotechnology firms locate where a strong preference for educational attainment is evident. Two arguments support this hypothesis. First, the biotechnology industry is education intensive in that it requires a proportionally more skilled work force than the average industry. The supply of skilled workers is higher in states where education is highly valued. The second argument assumes that the quality of the educational system is an amenity or a measure of the quality of life. It is assumed that states with better schools more readily attract top scientists, engineers, and executives who turn seek good educational systems for their children. In addition, biotechnology firms are likely to seek out

states or neighboring states that award a high number of doctoral degrees per capita so as to ensure a supply of skilled labor. Finally, biotechnology firms tend to locate company headquarters in counties with major research universities to capture agglomeration economics, although they may maintain research field sites elsewhere.

Previous locational analysis has been static in nature. However, the process of firm entry and exit are dynamic. Static threshold models cannot shed light on entry and exit decisions since these occur over time and can only be manifested by changes in firm counts between two periods.

Ericson and Parkes (1995) have developed an intricate model of firm decision making in a dynamic, stochastic environment. Firms are assumed to maximize the expected present net cash flows. At each decision period, incumbent firms can decide to exit the industry whereas potential entrants can decide to incur start-up costs and enter the industry. These decisions depend upon market environment and the number of firms in the market. Ericson and Parkes (1995) note:

“A given industry structure generates investment, exit, and entry decisions as optimal responses to the valuation of the opportunity presented by the industry. The idiosyncratic outcomes of these investment decisions, together with the evolution of the state of competition...determine the structure of the industry at the beginning of the next period, a structure that is only probabilistically related to the structure which generated it. Though all firms eventually die, entrants replenish the population of active firms, and hence the industry of making marginal changes in the number of firms given an initial state.”

For this analysis, two models will be used. One will be a log difference model of number of biotechnology firms from 1998 to 2001 and another will be the ratio of the rate of change of biotechnology firms from 1998 to 2001 for the state to that of the nation. Biotechnology establishment values were derived from County Business Patterns for 2001 and 1998 (1998 and 2001). The year 1998 was chosen as the initial period of analysis because this was the first year firm level data was reported by North American Industrial Classification System.

## **MODEL RESULTS**

Table 1 show the results of the model where the log differences of the number of biotechnology firms from 1998 to 2001 are regressed against the location factors.

Instead of following Goetz and Morgan (1995) who derived firms per capita, log of numbers of biotechnology firms' difference from 1998 to 2001 and number of firms in 1998 was employed. Log values were used because some states' large values of both factors would overwhelm those of other states making direct comparisons difficult. For the same reason, the independent variable Fund 95 was a combination of University & Federal Research and Development dollars, venture capital, and SBIR & STTR grants acquired in 1995 and these values were also in log values.

**Table 1. State Location Results for Log Differences in Number of Biotechnology Firms from 1998 to 2001.**

<b>Variables</b>	<b>Parameter estimate</b>	<b>Standard Error</b>	<b>t-value</b>
intercept	-7.5965542	2.1835792	-3.4789459
ln(firms in 1998)	0.36147684	0.16360740	2.2094161
ln (fund95)	0.31672205	0.11144788	2.8418850
closings 98	0.12273120	0.058585206	2.0949179
educational attainment 1998	0.088730359	0.023196032	3.8252386
hi-tech 98	-0.18091274	0.053901827	-3.3563379
utility patents1998	0.00010326655	2.4507613e-005	4.2136520
k-12 98	-8.5030203e-005	5.8488562e-005	-1.4537920

R-squared	0.83178234
Adj. R-squared	0.80374606
SSR/(n-k)	0.21911824

Most significant explanatory variables have the expected signs. Number of firms in 1998, funding in 1995, educational attainment (percentage of population with a bachelor's or more) in 1998, and utility patents granted in 1998 are all positively correlated. However number of establishments closing in 1998 and number of persons employed in high-technological jobs in 1998 may have signs that seem inconsistent. As for the number of biotechnology firms closing in 1998, this variable is establishment deaths as a percentage of total establishments (per state) in 1998. On the outset, a high percentage would have been believed to coincide with a poor business climate. However no information on establishment "births" is included in the analysis. States with high death percentages could very well have high birth percentages, indicating not poor economic conditions, but rather a highly competitive business climate. For high tech employment (hi-tech 98) in 1998, this was high-tech employment as a percentage of total employment (per state) in 1998. At the outset, a high percentage was believed to be coincident with a larger talented labor pool. However, given the negative coefficient, it may be that a high percentage is indicative of more competition for workers between the biotechnology sector and other high technology sectors.

Results shown in table 1 follow those by Goetz and Morgan (1995). However there may be the possibility of simultaneity between the dependent variable and number of utility patents acquired by state. Therefore to address any problem of simultaneity, an instrumental variable model was employed. The best model employed was an instrumental variable model where per capita personal income and funding in 1995 were used as an instrument for expected utility patents in 1998. The results are shown in table 2.

**Table 2. State Location Results Employing Instrumental Variables.**

<b>Variables</b>	<b>Parameter estimate</b>	<b>Standard Error</b>	<b>t-value</b>
intercept	-2.0684488	0.79427910	-2.6041838
utility patents (predicted value)	0.00014691630	6.0650802e-005	2.4223308
ln (firm 98)	0.63735465	0.11770418	5.4148854
clos 98	0.11056224	0.059406985	1.8610984
hi-tech 98	-0.19456742	0.061270391	-3.1755538
educational attainment 1998	0.084642810	0.026587093	3.1836053
k-12 98	-0.00010091367	6.2623537e	-1.6114336

R-squared	0.83839229
Adj. R-squared	0.81584238
SSR/(n-k)	0.25408266

Furthermore, a Wu test was employed to check if simultaneity had been addressed and the resultant statistic shows no simultaneity. However a results of this model shows that those states that have a large number of biotechnology firms in 1998 will potentially have larger number of biotechnology firms in the future. This is a cumulative causality result of this analysis.

Also addressing the question of “Why states with low absolute numbers of bio-tech firms might care about the results of this analysis,” an additional model was developed. For this model, the dependent variable is the ratio of state rate of change in number of biotechnology firms from 1998 to 2001 to the national rate of change in number of biotechnology firms from 1998 to 2001. The formula is shown below:

$$\frac{BiotechFirms2001_{state} - BiotechFirms1998_{state}}{BiotechFirms1998_{state}} \bigg/ \frac{BiotechFirms2001_{US} - BiotechFirms1998_{US}}{BiotechFirms1998_{US}}$$

In this manner, states with relatively smaller biotechnology sectors could be compared with states such as California. Results of this analysis could shed information as to public policies for states to potentially increase their relative share of the biotechnology sector, even if their absolute numbers might be relatively small. Table 3 shows results of the share analysis.

Table 3. State Location Results Employing Share Analysis.

<b>Variables</b>	<b>Parameter estimate</b>	<b>Standard Error</b>	<b>t-value</b>
intercept	3.5366688	1.3446983	2.6300834
hi-tech 1998	-0.17438639	0.059909101	-2.9108498
housing 90	0.18382046	0.078398012	2.3447081
manupay 98	-4.5272234e-005	2.1535372e-005	-2.1022267
sttax98	-12.978069	8.1974075	-1.5831919
edatt98	0.059335119	0.034763026	1.7068456
pc biodeg 98	-1252.2443	801.08128	-1.5631926

R-squared	0.32502604
Adj. R-squared	0.23084363
SSR/(n-k)	0.51133117

From table 3 the last three explanatory variables, state tax burden as a percentage of personal income (sttax98), percentage of populace with a bachelor's or more (edatt98), and per capita bio-tech degrees awarded (pciodeg98) were statistically insignificant at the 5% confidence level. Also from table 3, some previously relevant explanatory variables in table 2 firms in 1998, funding in 1995, establishment deaths in 1998, utility patents in 1998 and even k-12 spending in 1998 showed very low statistical significance. However two new variables were highly significant. Average annual pay in the manufacturing sector in 1998 per state (MANUPAY) had a negative sign as expected, since the larger sub-sectors of the biotechnology sector are largely manufacturing based. Median housing price as a percentage of personal income in 1990 (HOUSING 90) was expected to have a be negatively sign indicating high cost of living which would be a disincentive to business location. However, positive sign indicate that this variable is a sort of proxy for amenities and other attributes which coincide with high relative housing prices.

### SUMMARY

This was an initial analysis of estimating changes in state location of biotechnology firms and locational factors contributing to these locations. Initial results indicated that simultaneity of independent variables which has not been addressed in past research should be addressed. Also for states with low absolute numbers of biotechnology firms maybe some non-market incentives should be investigated to increase numbers of firms. However the state of California has already enacted a program to assist in the funding of stem cell research which would further propel this state in biotechnology industry leadership. From the share analysis, states with amenities could influence the biotechnology firms locating or relocating in their state. As for the state of Nevada which is adjacent to the state of California, Nevada may find it more difficult to locate or relocate biotechnology firms given California's initiative to fund stem cell research. However, the state does have amenity values that could be used to enhance possibility of location to the state.

This paper is only an initial compilation of analysis of biotechnology location by state. Further analysis is required to disaggregate the biotechnology sector to determine if location differs for different biotechnology sub-sectors. Also following procedures by Shonkwiler and Harris (1996), interdependencies among and between biotechnology sub-sectors could be estimate to determine increased probability of location. Another avenue of research would be the use of count data procedures to estimate determinants of location by biotechnology firms. This would require use of both positive and negative firm counts. Using discrete normal distribution procedures outlined by Kemp (1998, 2001), negative counts could be incorporated into a count data model. Results of this analysis would not only yield information on locational factors that increase biotechnology firm location or relocation but also factors which decrease biotechnology firm location or relocation.

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