

Albuquerque: Technology City of Contrasts

Andres C. Salazar, Phd
PNM Chair in Microsystems, Commercialization and Technology
Anderson Schools of Management
School of Engineering
Mailstop MSC 05-3090
University of New Mexico
Albuquerque, NM 87131

Introduction

Technology has been a significant driver in the US economy since World War II and it is generally claimed that it remains as the only sustainable business advantage (Thurow 1999). Hence, in the face of global competition and a recent substantial loss of manufacturing jobs, recent attention has been drawn to those metropolitan areas in the US in which technology or knowledge creation is a dominant industry. Knowledge workers give rise to discoveries in science and high technology which may result in intellectual property ("IP") such as a patent. Drucker (1999) defined such effort as "...work requiring highly advanced and thoroughly theoretical knowledge -- that includes manual operations." In normalized measures associated with high technology or knowledge work, Albuquerque ranks among the top US cities -- 5th in high tech growth for small cybercities (AEA 2000), 9th among cities with population greater than 250K in the high tech index, a measure of a region's high tech industrial output (Florida 2002, Table 2), and 17th among 70 cities surveyed for percent of population with advanced degrees according to the US Census Bureau American Community Survey in 2004. As a state, New Mexico has the No. 1 ranking in federally funded Research and Development (R&D) on a per capita basis (Devol 2000).

The amount of scientific research and development in a region has become an important factor in determining the economic competitive advantage of regions and nations (Porter 1990). This observation has led to regional and national policies that call for the establishment and support for science and technology parks, regional "technology centres," "technology clusters," "science cities" or "technopoles" as several authors have defined such nomenclature (Castells and Hall 1994;

Dicker and Snyder 2000; Cooke 2001). The motivation for such governmental policies is planned economic development of a region or nation for maintaining or strengthening its respective economic advantage. In addition, jobs in high technology pay well. For example, in 1997 Albuquerque's average high tech job paid \$46,031 compared to the city's average private sector job at \$27,382. (AEA 2000).

The review of Albuquerque's history does not substantiate that its stature as a technology city evolved from a vision of economic development. Rather, the location of the scientific laboratories in Albuquerque's environs came from a desire to establish them in a remote area without any significant regard for their subsequent economic impact on the surrounding region. In the taxonomy used by Castells and Hall (1994), this probably qualifies the Albuquerque region initially in the 1940's as a "science city." However, today the city, indeed the state, have both recognized the economic potential of these important factories of intellectual capital and, together, seek to commercialize the knowledge being created there. To date, the city and the state have not developed a private economic sector from its knowledge factories. This result has been observed before in other science cities (Castells and Hall 1994).

This paper presents a comprehensive view of the city from a business perspective focused on exploiting its technological resources. By first reviewing the three hundred year history, demographics and infrastructure of the city, one gets a better appreciation of the challenges that have confronted the policymakers who have sought to accomplish the laudable goal of regional economic development through commercialization of high technology. During this review, several notable features of the city are highlighted that may explain a few of the reasons for the lack of success in creating a larger commercial and industrial sector in the city from technology.

City's History 1706-1942

Settlement and Dominion¹

Founded in 1706 on the banks of the Rio Grande as a Spanish settlement on the 1500 mile "Camino Real" between Mexico City and the colonial capital of Santa Fe, Albuquerque soon became a trading post for Spanish settlers and several Indian pueblos in close proximity -- Isleta, San Felipe, Cochiti and Santo Domingo. Settlers took advantage of the fertile valley of the Rio Grande River for ranching and growing native corn, squash and a pepper crop called chile. The valley is reportedly the oldest continuously settled part of North America. What is now New Mexico became part of Mexico after that country's independence from Spain in 1821 until 1848 when The Treaty of Guadalupe Hidalgo ceded the territory to

1. Unless otherwise specified, all demographic, employment and business specific data in this paper are extracted from US Bureau of the Census (USBOC).

TABLE 1 Albuquerque Population Growth in Relation to State and US Data, 1940 - 2000

		1940	1950	1960	1970	1980	1990	2000
Albuquerque	Population in thousands	49	97	109	225	333	385	449
	Growth Rate% per decade		98	12	106	48	16	17
New Mexico	Population in thousands	532	681	951	1,020	1,300	1,500	1,800
	Growth rate% per decade		28	40	1	27	15	20
US	Population in millions	132.2	151.3	179.3	203.3	226.5	248.7	281.4
	Growth rate% per decade		14	19	13	11	10	13

the US. The settlement grew slowly through the territorial period which ended in January 1912 when New Mexico became a state. Throughout this period, the population of what is now New Mexico was predominantly Hispanic and Native American and today these ethnic groups still constitute 42 % and 9 % of the state's population respectively. The heritage of early Spanish settlement of Albuquerque remains visible in the "Old Town" section of the city where pueblo Indians still offer artisan ware of hand-made jewelry, beadwork and pottery beside the old Spanish mission church of San Felipe de Neri.² The pueblo and Spanish cultural heritage as well as the picturesque landscape of the state and the city encouraged an "arts" community from the 1920's and tourism remains an economic driver for the state today representing 6 % of the GSP.

Transportation infrastructure contributed to the growth of the city in the first half of the 20th century. The railway line connecting Chicago with Los Angeles used Albuquerque as a major rail centre for repair and storage. The advent of the automobile brought additional growth to the city as it became the major stopping point on the fabled transcontinental highway "Route 66." In 1940, at the pre-atomic age, the population of the city stood at 49,000 (Table 1).

The Atomic Boom 1942-1970

But when Robert Oppenheimer visited a boy's ranch in Los Alamos in November 1942, approximately 70 miles due north from the city, and chose it to become the site of an atomic research laboratory, the future of Albuquerque was cast in becoming a technology centre. An important factor in the choice of Los Alamos for the laboratory was the remote nature of the site. At that time, the state had a population of less than half a million. As the work at Los Alamos progressed in the design of nuclear weaponry, Albuquerque became important as a site for manufacturing and testing such ordnance components as well as a site for developing and testing airborne vehicles for transporting and deploying the atomic arsenal. Federal dollars poured into New Mexico in the 1940s and decades after for research, development and testing of atomic weapons. National research laboratories were developed in Los Alamos and Albuquerque and military bases (Manzano, Sandia and Kirtland) were built in the city to protect the defense work being conducted.

2. For a history of the city see Albuquerque Dept. of Planning (1969) (Oppenheimer Report).

A testing range for the nuclear armaments was established in a remote desert region in the southern part of the state near Alamogordo about 200 miles south of Albuquerque. Thousands of knowledge workers from out of state were brought in to conduct the top secret work. Top scientists working on the atomic program were led by Oppenheimer and included Hans Bethe, Leo Szilard, Richard Feynman, Stanislaus Ulam and many others. The University of California was brought in to manage the laboratory at Los Alamos while Western Electric from AT&T was eventually asked to manage the Sandia facility. The student enrollment at the University of New Mexico also grew in response to the need for additional knowledge workers and as a result of the GI Bill dedicated to educating WWII and Korean War veterans. Albuquerque experienced a housing boom and most of the sprawling northeast heights sector of the city was built out during this period. By 1950, the population of Albuquerque had mushroomed to 109,000 and reached 225,000 in 1970 (Table 1). During the period 1942-1970, the city's growth was based on military oriented research and associated support with no linkage to commercialization of technology. In fact, much of the R&D conducted during the period was classified and not available to the public.

Transition and Second Stage Growth 1970-2000

During the late 1960s and into the 1970s, the cold war with Russia, nuclear disarmament and military budget cuts adversely affected the city's economy that had come to depend greatly on armament research and military bases. Although the US Department of Energy (DOE) did assist urban areas following "reduction in force" or RIF events, metropolitan areas such as Albuquerque's with narrow economies were challenged to find jobs for laid-off employees. In addition, the DOE did begin in earnest to find non-military projects for the Los Alamos and Sandia research facilities while installing a commercialization of technology activity as well. The latter activity was conducted with few local industrial and commercial parties since the city had never really developed private enterprise that was not defense related.

The state and the city did set up economic development policies and incentives for attracting other industries. Among these incentives are tax credits for technology jobs, manufacturing investment and job training. Industrial Revenue Bonds formed another type of incentive. Apparel factories, call centers and semiconductor manufacturing were attracted to Albuquerque through some of these policies and incentives. Such policies and incentives are common in the "arms race" between cities in attracting new industry (Feiock and Cable 1992; Fleischman et al 1992). Due to the disproportionate number of educated workers in the metro area, the city also encouraged new business creation through "knowledge spillover" (see Jacobs 1969; Glaeser et al 1995; and Jovanovic and Rob 1989). The city's population surged again to 333,000 in 1980 and reached 449,000 in 2000 within its boundaries which encompassed 181 square miles. Its land area ranks the 30th largest among all cities in the US. New suburban growth in neighbouring Valencia County to the south and in Sandoval County to the north accommodated

some of this population surge. The metro area's population in 2000 stood at over 700,000 spread out over 5943 square miles and included over a third of the state's entire population. The flight from the inner city to the suburbs was typical in American cities during this era (Kingley 1957).

Infrastructure

The city is several hundred miles from any other sizable metro area (>250K pop.) and this isolation has contributed to challenges in pacing its infrastructure growth to the needs of industry and its residents. This isolation had been considered an advantage back in 1942 during the early stages of the top secret research work of atomic scientists in the state. Compared to other cities of similar size,³ Albuquerque has not had to contend with those infrastructure problems created by "smoke-stack" industries that demand high volumes of material transport, energy and water and at times create air, sight, noise and water pollution. However, these benefits have been at the price of not having a manufacturing base to diversify its economy. In the development of technopoles, Castells and Hall (1994) indicate that an industrial component is critical in transferring research discoveries into the commercial world. The city's Planned Growth Strategy has been cited in Colombo (2003) as one that follows "carefully considered principles" instead of being reactive. The research laboratories, associated military installations and the subsequent "recruited" industries have been relatively "clean" businesses. Perhaps the only exception has been the extra care that the state has taken in assuring itself of safe disposal of relatively small amounts of radioactive material waste created by the defense installations resident in the state.

However, infrastructure has been a limiting factor in the development of companies that aspire to commercialize technology from the scientific laboratories. Transportation, public education and industrial supplier networks did not develop in the Albuquerque region to the extent that other more populous regions experienced. To date, Albuquerque still lags the US average in manufacturing jobs and the development of a supporting commercial sector. An example of this difference can be seen today in the neighbouring state of Arizona that has a similar land area and was created as a state only one month after New Mexico in 1912. The population growth in Arizona (currently its population is several times larger than New Mexico's) has assisted in drawing a larger industrial base and supporting infrastructure — such as a more ample water supply and airport hubs.

Transportation

I-25 and I-40 are two major interstate highways that meet at the geographic centre of the city. I-25 bisects the state as it carries traffic from El Paso to the Colorado

3. See Table 2 for a listing of cities of similar size to Albuquerque.

border along most of the Rio Grande valley. Possibly the heaviest traffic flow along I-25 is seen between Albuquerque and the state's capital – Santa Fe – some fifty miles to the north. I-40 is the successor artery to US 66 and connects the Texas panhandle to the mid-section of Arizona. It is the only major east-west interstate in the state except for I-10 which follows an extreme southern route along the Mexican border from El Paso to the southern section of Arizona.

The railroad never fully developed in the state partly because of its low population density and lack of a manufacturing base.⁴ Mining output and forest products in the nineteenth century and the first half of the twentieth were extracted from mountainous regions where rail was either briefly available or not available at all. Single track rail infrastructure is still prevalent even in the venerable east-west "Atchison, Topeka and Santa Fe" line that started in Chicago and terminated in Los Angeles.

The Albuquerque airport known as the "Sunport" is located in the southern end of the city adjacent to Kirtland Air Force Base. The airport is not a hub to any major airline but it still handles over 6 million passengers per year with 600 flights scheduled on the average day. Half of the passenger traffic is handled by Southwest Airlines, five times more than any other airline. Unlike many major US cities, the airport has relatively few air terminal warehouses or heavy industrial parks in its immediate vicinity. Several major airlines offer several flights/day service to their respective major hubs located in Houston, Dallas, Salt Lake City, Phoenix and Denver. Hence, passengers bound for the eastern or western coasts of the US often have to change planes at the carrier hub cities before reaching their destinations. To date there is no regularly scheduled flights to Mexico despite the fact that the state has many Mexican or Latin American nationals in its workforce.

City Utility Infrastructure

New Mexico ranks second in the nation as a natural gas producer so the fuel is relatively inexpensive in Albuquerque despite having to be shipped long distances from gas fields in the northwest corner of the state. Electric power available in the city is produced by the state's major utility -- PNM -- using gas or coal-fired plants. The utility is experimenting with alternative energy generation from wind turbine farms located in the eastern part of the state. To date there has been no significant investment in solar generated power despite the fact that the entire state enjoys cloudless sunshine for most of the year. PNM reports that it generates excess power for the state and actually exports some of its power to neighboring states.

Telecommunications services have been supplied in major cities and towns in New Mexico including Albuquerque by the old Bell System operating company -- Mountain Bell -- then by the RBOC, US West, formed after divestiture of the Bell System in 1984. After its merger with Global Crossing, US West became

4. For a treatment of the state's railroad history see Myrick (1990).

Qwest which is headquartered in Denver. Comcast offers cable television services and broadband internet connectivity in major cities like Albuquerque and Santa Fe.

Water is possibly the greatest infrastructure concern of the city. Albuquerque sits atop a huge aquifer that has been charged by the natural flow of the 1900 mile long Rio Grande River with headwaters in the Colorado mountains. The city operates over 200 wells that tap the aquifer and supplies the residents with potable water. Recent scientific findings have shown that the river is not replenishing the aquifer at the same rate that it is being tapped. The city had the foresight to purchase 49,000 acre feet/year of water supplied to the Rio Grande from the San Juan basin in compliance with the San Juan/Chama River Compact signed in 1960. The agreement allows water to be redirected to the Rio Grande basin from the San Juan River that would normally flow into the Colorado basin. The city uses this water to recharge the aquifer. However, the city's growth has motivated city planners to look at using surface water as another supply for future needs. Recent droughts and concerns about the city's growth rate have caused Albuquerque officials to institute conservation measures and water remains a critical issue in accommodating future city growth.

Demographics, Education and Social Services

The city, located in the geographic centre of the fifth largest US state, has demonstrated prodigious population growth (Table 1) in the last half century with few adverse effects on its environment (except for concerns for water supply) or its citizens such as traffic congestion, high housing costs or persistent pollution problems. It ranks as 45th among the 330 most populous cities in the US as a desirable place to live (Sperling and Sanders 2004).

According to the 2000 US census, New Mexico's population is partitioned into the major groups of 41.6 % of Hispanic descent, 9.5 % Native American and 48.3 % White/non-Hispanic. The City of Albuquerque has a slightly lower percentage of Hispanic (40 %) because it attracted a significant proportion of its current population from out of state during the growth decades of the 1950s, 1960s and 1970s. In general, Albuquerque's population is older, better educated and enjoys a higher income than the rest of the state.

Geography and Climate

Approximately 5000 feet above sea level, the metropolitan area of over 5943 square miles is spread out over the Rio Grande river valley in the entire county of Bernalillo and small portions of the much larger counties of Valencia to the south of the city and Sandoval to the north. The river's west bank area of the city sits over ancient lava flows while the opposite bank rises to the foothills of the Sandia and Manzano mountains that hem the city in from the east and their rugged 10,000 foot high terrain prevent further expansion in that direction. Indian reservation lands border the city on the northeast and southeast quadrants and prevent expansion

sion in either direction. Hence, newer growth has occurred on the west bank of the Rio Grande mostly in a northerly direction that encompasses sections of Sandoval County. The older, southwest section of the city borders the downtown area and consists of semi-rural neighborhoods with some farming and ranching households. This section has a higher percentage of Hispanic households with lower per capita income.

Albuquerque enjoys a temperate, semi-arid climate with precipitation averaging about 8 inches per year. The city basks in sunshine for most of the year with few high winds and almost no tornado or earthquake activity. Mild temperature highs in the 1960s and 1970s are normal for the fall and spring seasons. A world famous "Balloon Festival" is hosted during late autumn within the city limits partly due to the mild, tranquil weather experienced during that time.

Poverty and Per Capita Income

While the US average poverty rate was just over 11 %, the state had a poverty rate (17.9%) second only to Arkansas's 18 % in 2002. The state's Hispanic population traditionally has suffered from a high poverty rate (25 % or more in 2000) as has the Native American population.⁵ These two large ethnic groups, constituting in aggregate about half of the state's population, have not closed the gap with their White counterparts in education, training, employment and income. The size of the two groups, normally considered "minorities," in the lexicon of the US Bureau of the Census, makes New Mexico a "majority minority" state. As a result, the state ranks last or nearly last annually in per capita income in the nation. This economic status of this segment of the state's residents is in sharp contrast to the high wages paid to knowledge workers employed in the region's research laboratories. Until the education and training gap of the state's minorities is closed it is unlikely that a technology city's needs for a "knowledge" workforce will be met from the native population.

Crime

According to the latest crime statistics (Table 2), Albuquerque experiences higher rates in felony crimes and robberies than cities of similar size in other states. The state continues to be plagued with a high poverty rate and Albuquerque has not been immune to the effects often associated with a significant disparity in income among its residents. According to Porter (1997) "Crime, with its associated fears and costs, is one of the greatest barriers to inner-city economic revitalization."

5. The latest available USBOC figures for Native Americans in New Mexico. A 1995 report gives figures as high as 40 % poverty rate for some tribes.

TABLE 2 Cities of Comparable Population to Albuquerque, NM

City	Tech. Index - Florida Ref.	Pop. Metro Area	% change 90-2000	State Pop.	% of State Pop.	US Census Hispanic	White	Median Age	Per Capita Income	National Center for Education Statistics - Exp/pupil	Amer. College Test Svc. SAT Score	% Taking SAT in State	FBI Uniform Crime rpts Violent Crime	Property Crime
Albany, NY	68	875,583	1.6	18,976,457	4.61	2.5	92.3	37.8	\$25,085	8386	1006	79	289.7	2737.2
Tucson, AZ	18	843,748	28.5	5,456,453	15.46	27.3	81.3	36.0	\$22,341	4632	1049	36	671.6	6927.4
Tulsa, OK	55	803,235	13.3	3,493,714	22.99	3.0	78.8	35.4	\$24,323	4635	1131	8	692.8	4357.3
Syracuse, NY	93	732,117	-1.4	18,976,457	3.86	1.9	92.4	36.5	\$22,343	8011	1006	79	329.0	2878.4
Omaha, NB	37	716,998	12.1	1,729,180	41.46	3.5	92.6	34.0	\$26,188	5382	1151	8	476.0	5224.4
Albuquerque, NM	9	712,738	21	1,855,059	38.42	40.0	73.4	35.2	\$23,392	4869	1088	14	1022.1	5992.2
Knoxville, TN	111	687,249	17.3	5,797,289	11.85	0.7	91.8	37.8	\$23,163	5334	1128	14	553.8	3695.2
El Paso, TX	133	679,622	14.9	21,779,893	3.12	72.6	76.9	30.1	\$13,867	5293	993	55	698.7	4153.7
Bakersfield, CA	117	661,645	21.7	35,116,033	1.88	31.3	73.2	30.8	\$15,901	5319	1018	52	485.9	3549.3
Allentown, PA	75	637,958	7.2	12,335,091	5.17	3.3	94.9	39.1	\$24,171	6369	1002	72	297.8	2674.1
Harrisburg, PA	44	629,401	7	12,335,091	5.10	1.7	92.1	28.6	\$24,287	6189	1002	72	319.2	2383.6
US Average						12.5	75.1	35.5	\$23,420	5894	1020	46	456.0	3950.0

Source: 1. Data from Florida, Richard, (2002) *The Rise of the Creative Class*; US Bureau of the Census (2000);

2. National Center for Education Statistics; American College Testing Service; FBI Uniform Crime Reports.

Education

The state has been lagging in primary and secondary education performance despite significant investment in that area. Fourth graders rank higher than those from only four other states in both reading and math (NCES, 2002, 2000). The National Center for Education Statistics (NCES) reports the high school dropout rate for the state in 2001 to be 5.1%, although improving in percentage over the last 10 years, is still among the highest in the nation. Public schools in the city of Albuquerque, with a 50 % Hispanic population, have fourth graders performing somewhat better but its dropout rate is disappointingly high. This educational gap between Hispanics and whites has been noted by education scholars and is symptomatic of the racial and ethnic educational divide prevalent in the US (Thernstrom and Thernstrom 2003). This gap constitutes another contrast in that the city features a high concentration of PhD's (1.9 % of the population compared to the US average of 1 %) but the children in the city are among the poorest performers in standardized tests.

Founded in 1889 as the flagship institution of higher learning of the state, the University of New Mexico (UNM) has supplied the state with a professional workforce in education, engineering, law and architecture. In 1960, UNM's enrollment was 8000 students and today it provides instruction to 33,000 students over the main campus and four branch campuses. It remains the second largest employer in the city. The UNM medical school was founded in 1963 and was located at the site of Bernalillo County Indian Hospital. In spite of being a young medical school, the *US News and World Reports* ranks two of its programs -- Family Medicine and Rural Medicine -- among the top ten in the country.

Today, the UNM Health Center which includes the hospital and the university's medical, pharmacy and nursing schools accounts for about half of UNM's \$1.8B budget, employs almost half of the university's workforce of 16,000 and brings in about half of the university's research budget of nearly \$400M. Like many other universities UNM established a tech transfer office in hopes of realizing licensing revenues from its intellectual property by virtue of the Bayh-Dole Act of 1980. After ten years, the office remains a cost centre for UNM and few companies have been spun off from university research.

Another large employer in the higher education sector is the Technical and Vocational Institute (TVI), a city sponsored community college that serves about 22,000 students and employs about 12,000. TVI has provided the technician level workforce for the region's research laboratories and technology based companies.

Medical Facilities

Major medical facilities in the state are concentrated in the City of Albuquerque. Presbyterian, St. Joseph's and Lovelace Clinic (the latter two since merged into other entities) are large private hospitals while UNM Hospital is the largest hospital that receives public funds. Many small clinics, medical testing facilities and doctor's offices are clustered around the University of New Mexico main campus

in the heights section near downtown.

Major Employers and Trade

Of the ten largest city employers in 2000, nine are either funded by governmental sources or constitute government divisions at the city, state or federal level. The top ten employers employ 22 % of the metro area's workforce while 94 % of those workers are largely supported by tax dollars. Only those positions that are supported by federal tax dollars can be considered as "export" generated since that is the only revenue external to the state. These statistics illustrate the major economic challenge that the city and perhaps the state faces -- the need for diversification of its economy and lessened dependency on tax dollars to support its workforce. It is true that a large segment of the remaining workforce in the city belongs to the commercial sector but that sector consists mostly of service establishments that merely cater to the needs of the city's residents and do not generate income from sources outside the state. The exception, of course, is tourism and it is estimated that tourist expenditures constitute about 6 % of the Gross State Product, estimated to be \$55B in 2003.

Military Installations

Kirtland Air Force Base (KAFB) is the largest single employer in the city with over 18,000 civilian employees. Its operations include Kirtland Air Force Research Lab which conducts research and development for two (Space Vehicles and Directed Energy) of the thirteen Air Force Directorates in the country. In addition, KAFB has over 6,000 military personnel associated with its operations. Aircraft assigned to KAFB share some airport facilities with the City of Albuquerque.

Science and Engineering Laboratories

Sandia National Laboratories (SNL), currently managed by Lockheed Martin Corporation, conducts technology-related functions for the Department of Energy primarily in the areas of ordnance development, testing and monitoring. Due to reductions in defense spending and international nuclear disarmament agreements, SNL has increasingly devoted more of its budget to non-ordnance technology areas but that are still pertinent to national defense or homeland security. Recently it has become a global centre for Microsystems research and development having invested several hundred million dollars in facilities that are considered world class in that discipline. Microsystems, an outgrowth of semiconductor process technology, includes the miniaturization of actuators, sensors, pumps and control devices. SNL currently employs about 7700 and ranks as the fifth largest employer in the city. Both SNL and the Los Alamos National Laboratory each have an annual operating budget exceeding \$2 billion. Despite efforts to commercialize

technology from either laboratory, in the last ten years, few companies have been created and none have had an initial public offering of stock.

Government Work

The City of Albuquerque is the largest governmental employer in the city with 11,600 employees in its public school system and an additional 8,000 employees in its various service departments. The State of New Mexico has 6500 employees and is one of the top ten employers in the city in its own right. As of 2002, nearly 13,000 civilian workers were employed by the Federal government in Albuquerque.

Intel

The largest employer not associated with government work is Intel Corporation with 5400 employees. Its plant is located in the newer section of the metro area on the west river bank. Although Intel has nearly 20 manufacturing plants throughout the globe, the one in the Albuquerque metro area is reportedly the largest in semiconductor production value. Shipments from this plant, although high in value, do not really constitute exports for the state since the headquarters of Intel is located in California. The true value of exports for the state is more accurately the budget of the Albuquerque Intel plant for servicing its payroll, employee benefits and the supplies and materials purchased in the state. Although the Intel plant has been in the Albuquerque area since 1984, it has had little interaction with the local university (UNM) or with small local companies as service or material providers. This interaction has been shown to be important in the development of technology clusters in a region (Castells and Hall 1994; Cooke 2001).

Trade

The decline in several of the state's extraction industries -- lumber, minerals and coal -- has led to a decline in exports. The exception is petroleum and natural gas, whose production has led to lucrative income from license fees for the extraction on state and federal lands. The state has maintained a trust fund valued over \$10 billion in cumulative income from these fees. Nearly a quarter of the state's annual budget is funded from such fees or interest income from the trust fund. New Mexico was only one of two states in the union that experienced a budget surplus in 2003 and the only one that approved a tax cut. Due to the state's small manufacturing sector, the majority of which is located in Albuquerque (4.5 % of the workforce compared to the US's 17 %), there has been little to export from that sector. Also, the state's isolated geographic location and lack of transportation infrastructure are not conducive to developing trade relations with Asian or European countries. Of the states that border Mexico, New Mexico is last in exports to that

country.

Albuquerque: Technopole of the Future?

An expectation of technology-based urban economies is that private businesses can be created from the intellectual property (IP) or knowledge being developed. With notably small commercial and industrial sectors in its economy, New Mexico is seen as not having exploited that knowledge to create new jobs. The absence of an entrepreneurial culture may be one of the factors contributing to this failure. Among the eight "Rocky Mountain" states, New Mexico has one of the lowest business starts index and highest business termination rate. The high percentage of government sponsored jobs, as indicated earlier, is not conducive to creating an entrepreneurial spirit among workers. The contrast is evident -- high investment in R&D but little output in commercial ventures from that R&D. According to the 2000 AEA Report "Cybercities" Albuquerque was 56th among the top 60 US technology cities in venture capital investments in 1999 and 54th in percent change in such investments since 1993. The state has since instituted a program that matches funds from a venture capital firm for investing in New Mexico based companies. This has attracted venture capital firm representatives from other states to establish offices in the state. The availability of capital, venture capital to be specific, is probably no longer an issue. A complaint heard from the VC firms now is that "deal flow" is lacking, indicating a scarcity of "fundable" business plans and entrepreneurial teams.

Factors Inhibiting Commercialization

There are several factors that have been identified by several authors as being critical in the development of technopoles or technology clusters. Indeed, the absence of these factors will almost always lead to disappointing results. It is with these observations made by other researchers (including Castells and Hall (1994)) relative to the study of technopoles that we compile the following Table (Table 3) specifically for Albuquerque. The table identifies factors that may explain the difficulty it has experienced in growing an industrial base from the sizable investment in federally funded R&D made there over a sixty year period.

- A. *Industrial Participation in Development of IP.* This factor is central to the successful development of IP with economic value. This aspect is cited in studies by Castells and Hall (1994). The interaction of the researcher with the needs of industry has been found to be of significance in science parks that have enjoyed success in creating companies and businesses of lasting value. The opposite appears to be significant as well. Namely, the absence of industry input into the research activity has had disappointing results in creating IP of commercial value.

TABLE 3 Albuquerque: Possible Factors Underlying the Difficulty in Developing an Industrial Base from the Federally funded R&D

No	Factor	Contributing Conditions	Result	Remedy
A	Industrial participation in development of IP (intellectual property)	Little industry in the city or state	Few commercial applications of research	Involve more companies in the R&D at laboratories and universities
B	University participation in development of commercially viable IP	University policy of owning IP; no or little formal involvement of university in industry, lab partnerships	Few students, faculty involved in commercially viable discoveries; Few students, faculty involved in starting companies	Modify university IP policy to allow sharing ownership; Hire students and faculty in lab activities with industry.
C	Workforce Availability and Entrepreneurship	Educational system does not address education and training gap of Hispanic and Native American groups;	Difficulty in recruiting companies to city and state due to perceived weak educational systems; Disenfranchised minorities	Establish technology focused programs in public schools; Target minorities for engagement in technology careers & starting companies;
D	Transportation	No airport hub; No international flights; Few if any non-stop flights to major east or west coast markets;	City lacks plan to establish airport hub;	Focus efforts to recruit major airline to establish western hub in city
E	Population and Market Size	Insufficient population for market establishment;	No state or city campaign to encourage population growth;	Develop plan to keep pace with population growth of western states.
F	Manufacturing	Scarce supplier networks	No focused plan to integrate manufacturers to technology development	Attract manufacturing due to proximity of technology in state

- B. *University Participation in Development of IP.* The University plays a central role in creating IP since research is normally conducted within its sphere by faculty and graduate students. However, since the Bayh-Dole Act of 1980 universities have adopted the narrow attitude that any IP created on campus belongs to the university whether it is funded by public or private funds. This

policy is unacceptable to any company who wishes to use the IP it has funded for competitive advantage.

- C. *Workforce Availability.* Regardless of the potential value of IP creation, if the workforce in the industrial setting is not positioned to transition the finding into a commercial product or service, the expected business growth will not happen. (Castells and Hall 1994) This has been observed in studies of technology parks in the US or other countries. The quality of education is important not only in preparing residents for available jobs but also in attracting out-of-state talent to the city and the state. A focus on creating an entrepreneurial culture and supporting small technology businesses in the city would complement the effort being made to recruiting companies to the area.
- D. *Transportation.* Commerce in the form of transporting products and goods to other markets and in transporting business people between customer firms and suppliers is dependent on timely and convenient carriers. Although the internet today facilitates commerce, important business transactions are still dependent on person to person contacts. Examples of these transactions include investments in business starts, contracts of large value between supplier and customer and the hiring of key employees.
- E. *Population and Market Size.* The proximity of markets aids in the development of firms. A company operates at a disadvantage if it is required to transport its goods over a great distance compared to one operating amidst its target market. Albuquerque has the only metro area of any size in New Mexico. One study (Vias 1999) suggests that jobs follow population increases and not the other way around.
- F. *Manufacturing.* Although the US economy has experienced significant growth in the services sector, the manufacture of goods still represents and will likely represent far into the future a large segment of businesses. Albuquerque lags the US urban average in manufacturing jobs (4.5 % versus 17 %) although such businesses are rich in process and material complexity and have benefited greatly from technological advances.

Conclusions

Albuquerque has experienced substantial population and economic growth in the last sixty years primarily due to continued federal investment in nearby national laboratories and associated military installations. A number of state and city economic incentives have successfully attracted a few industries in the last twenty years to supplement job creating opportunities. However, the city is still heavily dependent on government sponsored jobs. In recruiting companies, care must be exercised as outlined in Bartik (1994) and Bartik (1996) so that incentives do pay off and they do provide jobs for residents at reasonable recurring cost. The city's aggressive marketing campaign -- the type of policy cited as a critical component in urban economic development in Porter (1997) -- speaks of its strengths and has evidently been successful in attracting companies to the area. In the same citation, the city could consider supporting minority owned businesses and facilitating

entrepreneurship since Porter (1997) considers them equally important for urban viability. The city has enviable advantages of federally funded scientific research laboratories, affordable housing, a temperate climate, scenic beauty and an arts-oriented culture. Its challenges in exploiting technological discoveries from its laboratories include its small market, relative geographic isolation, and limited transportation infrastructure. In addition, the city faces issues about its water supply, an inordinately high crime rate, ethnic groups with significant gaps in education and economic level, and a solid plan for continuing to diversify its economy.

References

- Albuquerque Dept. of Planning. 1969. *Historical Background of Albuquerque*. Albuquerque: A report by A. J. Oppenheimer to the Department of Planning.
- AEA (American Electronics Association). 2000. *Cybercities*, Washington, D.C.: AEA.
- Bartik, T.J. 1994. "Jobs, Productivity, and Local Economic Development: What Implications Does Economic Research Have for the Role of the Government?" *National Tax Journal*, 47: 847.
- Bartik, T.J. 1996. "Eight Issues for Policy Toward Economic Development Incentives". *The Region*, 10: 43.
- Castells, M. and P. Hall. 1994. *Technopoles of the World*. London: Routledge Press.
- Colombo, L.J. 2003. "Implementing the Vision: Impact Fees and the Albuquerque Metropolitan Planned Growth Strategy". *National Resource Journal*, 43: 887.
- Cooke, P. 2001. "From Technopoles to Regional Innovation Systems: The Evolution of Localised Technology Development Policy". *Canadian Journal of Regional Science*, 24: 21-40.
- Devol, R.C. 2000. *Blueprint for a High-Tech Cluster*. Brief no. 17. Santa Monica, CA: The Milken Institute Policy.
- Dicker, J. and G. Snyder. 2000. *Technopole Milwaukee*. Working paper. Milwaukee: University of Wisconsin.
- Drucker, P. 1999. "Knowledge-Worker Productivity: The Biggest Challenge". *California Management Review*, 41: 79-94.
- Feiock, R. and G. Cable. 1992. "Need, Institutional Arrangements and Economic Development Policy". *Journal of Public Administration Research and Theory* 2 : 307-398.
- Fleischman, A., G.P. Green and T.M. Kwong. 1992. "What's a City to Do? Explaining Difference in Local development Policies." *Western Political Quarterly* 45: 677-699.
- Florida, R. 2002. *The Rise of the Creative Class*. New York: Basic Books.
- Glaeser, E.L., J.A. Scheinkman and A. Shleifer. 1995. "Economic Growth in a Cross-section of Cities". *Journal of Monetary Economics*, 36: 117-143.
- Jacobs, J. 1969. *The Economy of Cities*. New York: Vintage.
- Jovanovic, B. and R. Rob. 1989. "The Growth and Diffusion of Knowledge". *Review of Economic Studies*, 56: 569-582.
- Kingley, J. D. 1957. "The Problems of Tomorrow's City". *Journal of Educational Sociology*, 31: 4-7.
- Myrick, D.F. 1990. *New Mexico Railroads -- A Historical Survey*. Albuquerque: New Mexico Press.
- NCES (National Center for Education Statistics). 2002. US Dept. of Education. State Report on Reading no. 2003-526NM, <http://www.nces.ed.gov>.
- _____. 2000. US Dept. of Education. State Report on Mathematics no. 2001-519NM, <http://www.nces.ed.gov>.
- Porter, M.E. 1990. *The Competitive Advantage of Nations*. NY: Free Press
- _____. 1997. "New Strategies for Inner-city Economic Development". *Economic Development Quarterly*, 11: 11.
- Sperling, B and P. Sander. 2004. *Cities: Ranked and Rated*, Hoboken. NJ: Wiley Publishing.
- Thernstrom, A and S. Thernstrom. 2003. *No Excuses -- Closing the Racial Gap in Learning*. NY: Simon and Shuster.
- Thurow, L.C. 1999. *Building Wealth*. New York City: HarperBusiness.
- USBOC (US Bureau of the Census). 2000. <http://www.census.gov/>.
- Vias, A. 1999. "Jobs Follow People in the Rural Rocky Mountain West". *Rural Development Perspectives*, 14: 24-31.