GEOGRAPHIES OF PATENT INNOVATION AMONG FLORIDA'S METROPOLITAN AREAS

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The creation and diffusion of innovations has a long and illustrious history among geographers. Innovations are important measures of the capacity of countries, regions, and firms to create, compete, and surf the waves of change that typify capitalist economies; thus, they are intimately linked to gains in productivity, human capital, and public policy. The capacity to innovate is often held to differentiate high and low points in the spatial division of labor, distinguishing dynamic cores from stagnant peripheries, regional and national leaders from laggards (Grossman and Helpman 1991; Acs 2000).

This paper examines the geography of innovative activity among Florida's cities as measured by patents granted. It begins with a brief overview of the relations between innovation, and regional competitiveness, including the geography that underlies and accompanies this activity. Studies of innovation by economists are typically spaceless, despite the voluminous literature indicating the deeply place-bound nature of this process. Patents, which grant the exclusive right to investors to manufacture and sell a product with the force of national and international law, are the most widely used measure of innovation in time and space. Second, using federal patent office data, the paper traces the uneven spatiality of innovations across the state of Florida, attempt-

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ing to explain these through correlations with labor market and demographic variables. It points to the relationship between patent activity and higher education, and the conclusion raises concerns about the state's economic future in light of its reductions in funding for higher education.

Innovation, Patents, and Regional Competitiveness

How and why some regions construct new techniques, methods, products, and technologies more rapidly than others lies at the core of the question as to how places compete. Innovations, whether in the forms of novel production processes, radical breakthroughs, or incremental improvements in efficiency, have long lay at the core of capitalism's dynamism. In the late twentieth century, spurred by the fantastic rounds of technological change that erupted in the wake of the microelectronics revolution, the analysis of innovations has assumed renewed importance as many places seek to acquire a competitive capacity in "high technology" sectors. Concerns about the rise of "knowledge economy" in which the bulk of skilled labor involves the processing of ideas has contributed to the recognition that learning, creativity, and innovation are central to regional economic health. Much of this literature has focused on the role of endogenous variables, such as human capital, particularly as they are manifested in key metropolitan areas - the paramount example being, of course, Silicon Valley - in the development of new products and techniques. Other innovative places such as Massachusetts's Route 128, North Carolina's Research Triangle, and Italy's Emilia-Romagna have played major roles in reconfiguring the economies of industrialized countries. The emphases of the French and Japanese governments on attempting to cultivate technopoles also indicate the significance of innovation to public policy.

Patents serve as the most widely used measure of innovation (Judd 1985; Pavitt 1988; Griliches 1990; Crosby 2000;

Brunk 2003). Patent activity reflects the efforts of entrepreneurs and firms eager to obtain legal protection for their intellectual property rights, and hence monopoly rights to the royalties for seven years. Much patent activity reflects corporate research and development, and is closely tied to temporal and spatial trends in industrial R&D (Federal Reserve Bank of San Francisco 2003). The literature on the geography of innovation has examined spatial discrepancies in patent formation in considerable detail (Malecki 1991; Jaffe, Trajtenberg, and Henderson 1993; Feldman 1994; Feldman and Florida 1994; Acs and Varga 2002).

Whereas neoclassical approaches to this topic typically assume a spaceless world, geographers emphasized the constitutive role of place in co-ordination and learning. The geographical literature long centered upon exogenous growth and the interregional and international transmission of ideas and methods. Traditional product-cycle models held that innovative firms tend to cluster in the cores of metropolitan areas, where they relied extensively upon urban agglomeration economies (Vernon 1966; Norton and Rees 1979). As their markets expanded and production became capital-intensive and standardized, many moved "out" (to the suburbs), "down" (the urban hierarchy), or "across" (to developing countries) (Scott 1988). Thus, research and intellectual activity has traditionally been concentrated in or near large metropolitan areas, whereas peripheries in the national division of intellectual labor are consigned to low wage occupations that involve little creative activity (e.g., branch plants, back offices). Seedbed theories of innovation, derived from traditional product cycle models, maintain that small firms agglomerated in dense urban cores are most likely to be responsible for new technologies (Grossman and Helpman 1991). This view stresses the determining role of the division of labor and the propulsive effects of export-led growth. Such a view holds that the largest urban areas tend to be the most innovative, and that increasingly more capital-intensive, less skilled functions disperse to smaller towns lower in the hierarchy. O'hUallachain (1999), for example, found that patent rates reflected city size and levels of industrialization.

Endogenous growth theories, in contrast, emanating from the influential work of Krugman (1991), emphasize local pools of skills and economies of scale (Romer 1990; Acs and Varga 2002). Given the rising inputs of knowledge necessary for almost all production processes today, endogenous growth theory typically focuses upon human capital formation the creation of local pools of skills - as the point of departure in the stimulation of technological change. Porter's (1990) famous notion of competitive advantage uses human capital as its point of departure in prescribing the trajectory that leads places to escape the confines of producing low-wage, low value-added goods and move into high wage, high value-added ones. In this reading, the productivity of firms in a given region is a function of the capital stock, labor, and returns to scale in the production process (Krugman 1991). Productivity gains unleashed through innovations can offset diminishing returns so long as the marginal gains in output per labor hour exceed the marginal costs.

In the context of global post-Fordism, the central importance of skilled labor to the process of innovation has led to sustained concentration on the formation of so-called "knowledge regions" in which innovation is a continuous and sustained phenomenon (Howells 2000), a central feature of the new industrial geography (Barnes and Gertler 1999). Indeed, a large body of research in economic geography has pointed to formal and informal linkages among individuals as key to the creation and sustenance of knowledge spillovers, as Saxenian (1996) demonstrated in her famous study of Silicon Valley. Contemporary theoretical concerns focus upon the roles of "untraded dependencies" in the innovation process, linking an essentially economic phenomenon to its local cultural context (cf. Storper 1997; Antonelli 2000). Tacit knowledge is held to be critical for innovation to take

Table 1: Patents Granted per Million Residents for Selected States, 1996-2001.

U.S. average	4,412
Delaware	31,749
Connecticut	16,452
Georgia	6,691
Florida	1,569
South Carolina	1.220

Source: calculated by author from U.S. Patent and Trademark Office www.uspto.gov/patft

place. The growing popularity of this approach is consistent with the recent "cultural turn" in economic geography that emphasizes the embeddedness of economic activities within broader constellations of culture and power (Thrift and Olds 1996).

The Geography of Innovation in Florida

The geography of patents in Florida is both a mirror of the state's intellectual division of labor, i.e. the uneven distribution of creative capacities and conjunctions of structural constraints (economic, cultural, educational, etc).

Data for this paper were drawn from the website of the U. S. Patent and Trademark Office, www.uspto.gov/patft, which allows searches by inventor's state and city of residence for five year periods between 1976 and 2000. Compared to other states, Florida is less innovative than the country as the whole (Table 1): the national average of patent applications in 1996-2000 was 4,412 patents per million residents, whereas in Florida it averaged 1,569. In contrast, several northeastern states had considerably higher rates of innovation, including Delaware (31,749), Connecticut (16,452), New Jersey (9,692), and New York (8,942). Indeed, the entire South dominates the list of relatively less innovative states, a reflection in large part of the relatively

Table 2: Patents Awarded by Residence of Applicant, 1976-2000.

MSA	1976-80	1981-85	1986-90	1991-95	1996-00	Total
Daytona Beach	30	42	51	82	99	254
Fort Lauderdale	271	248	227	391	614	1,751
Fort Myers-Cape Coral	91	79	132	238	335	875
Fort Pierce-Port St. Lucie	20	25	58	86	115	304
Fort Walton Beach	13	8	17	13	23	74
Gainesville	189	295	411	666	1,271	2,832
Jacksonville	222	256	378	552	1,079	2,487
Lakeland- Winter Haven	114	188	196	271	760	1,529
Melbourne- Titusville-Palm Bay	606	742	1,066	1,149	2,606	6,169
Miami-Fort Lauderdale	1,067	1,211	1,669	2,102	4,053	10,102
Naples	101	129	247	321	583	1,381
Ocala	28	36	77	130	170	441
Orlando	442	504	780	1,303	4,081	7,110
Panama City	96	50	111	121	290	668
Pensacola	107	124	130	149	277	787
Punta Gorda	5	6	19	51	96	177
Sarasota-Bradenton	257	279	410	484	997	2,427
Tallahassee	67	52	91	122	266	598
Tampa-St. Petersburg-Clearwater	631	857	1,095	1,629	3,241	7,453
Total metro areas	4,357	5,131	7,165	9,860	20,956	47,469
Nonmetro Florida	820	1,020	1,176	1,877	4,120	9,013
Total Florida	5,177	6,151	8,341	11,737	25,076	56,482

Source: calculated by author from U.S. Patent and Trademark Office www.uspto.gov/patft

high degrees of poverty and inadequate educational systems to be found there. Yet Florida lags behind in patent activity even compared to other Southern states such as Georgia (6,691), Virginia (1,944), and North Carolina (1,736), although it ranks ahead of South Carolina (1,220).

Why is the rate of innovation so low in Florida? In part, the state shares many characteristics of other states with similarly low rates of patent applications, i.e., an inadequately developed human capital infrastructure. Florida also is home to large numbers of the elderly, a group not generally characterized by innovativeness; similarly, other states with large proportions of residents over age 65 had low rates of patent activity, including, for example, Arizona (1,188 per million).

Given that patent activity reflects the underlying spatial dynamics of entrepreneurs and their milieu, one might well expect that innovative capacity would be unevenly distributed across the state. Table 2 summarizes the distribution of patents generated by residents living in different cities in Florida over the period 1976 to 2000. Prospective inventors filed more than 56,000 patents over this time, and the volume of patents grew markedly: indeed, the half-decade 1996-2000 saw five times as many patents filed (25,076) than the comparable period 1976-1980, when only 5,177 were filed. Clearly, Florida as a whole has seen significantly increased patent activity as its population has grown and as certain sectors stimulate rounds of innovation. These activities, however, varied markedly among cities. As might be expected according to seedbed theories of innovation, the largest metropolitan areas were the primary generators of patents, including Miami-Fort Lauderdale (10,102), the Tampa metropolitan region (7,453), Orlando (7,110), and the Melbourne regiqn (6,169). Metropolitan regions generated 85 percent of the state's patents, an observation in keeping with the broader literature on patent activity. When standardized by population, however, the rate of innovative activity acquires a new light. Table 3 reveals the number of patents per million inhabitants, with a statewide average of 799. Gainesville is the state's most innovative city, with 2,840 patents per million residents, followed by Melbourne (2,726), Naples (1,414), and Sarasota (1,073). Table 3 also indicates that the rate of innovation has increased steadily over time, with sharp increases in the late 1990s. Gainesville - home of the University of Florida, the inventor of Gatorade - exhibited particularly sharp increases, from 926 patents per million people in 1976-1980 to 2,840 in 1996-2000. Melbourne-Titusville likewise exhibited a marked rise, from 1,519 in 1976-2000 to 5,540 in 1996-2000. This increase reflects statewide and

Table 3: Patents per Million Residents, Florida Metro Areas.

MSA	1976-80	1981-85	1986-90	1991-95	1996-00	Average
Daytona Beach	81	113	107	173	209	137
Fort Myers-Cape Coral	272	236	330	594	836	453
Fort Pierce-Port St. Lucie	80	100	193	287	383	209
Fort Walton Beach	52	32	100	76	135	79
Gainesville	926	1,445	2,071	3,355	6,404	2,840
Jacksonville	245	282	358	523	1,021	486
Lakeland- Winter Haven	281	464	429	593	1,662	686
Melbourne-Titusville-Palm Bay	1,519	1,860	2,266	2,443	5,540	2,726
Miami-Fort Lauderdale	334	379	450	566	1,092	564
Naples	664	848	1,193	1,551	2,816	1,414
Ocala	144	185	313	529	691	372
Orlando	412	470	508	849	2,659	979
Panama City	756	394	750	818	1,960	936
Pensacola	311	360	322	369	687	410
Punta Gorda			139	372	701	404
Sarasota-Bradenton	925	1,004	745	880	1,812	1,073
Tallahassee	287	223	350	469	1,023	470
Tampa-St. Petersburg-Clearwater	305	414	481	715	1,423	668
Total metro areas	404	476	551	758	1,612	974
Nonmetro Florida	381	474	547	872	1,383	731
Total Florida	400	475	645	907	1,569	799

Source: calculated by author from U.S. Patent and Trademark Office and census data.

local variations in demographics, the growing complexity of the state's division of labor, and the rise of business services to the fore of the regional economy, including the demand for specialized expertise they engender.

Why are some cities more innovative than others? Data were gathered on likely determinants of relative patent innovation, including demographic variables such as population size and age and economic variables such as median family income, percent of adults with a university degree, and percent of the labor force employed in professional and managerial occupations. As Table 4 indicates, there are marked variations among the state's metropolitan areas: cities with the highest proportion of

Table 4: Determinants of Patent Productivity.

MSA	2000 Population	2000 % Professionals[1]	2000 Median Income[2]	2000 % BA or Higher[3]	2000 % Pop. > Age 65[4]
Daytona Beach	474,711	23.9	24,818	14.8	22.6
Fort Myers-Cape Coral	400,542	22.2	28,448	16.4	24.8
Fort Pierce-Port St. Lucie	299,967	21.6	29,417	16.1	23.5
Fort Walton Beach	170,049	27.6	27,941	21.0	9.0
Gainesville	198,484	35.1	22,279	31.2	9.3
Jacksonville	1,056,332	25.1	29,514	18.6	10.9
Lakeland- Winter Haven	457,347	20.5	25,216	12.9	18.5
Melbourne- Titusville-Palm Bay	470,365	29.0	30,534	20.4	16.5
Miami-Fort Lauderdale	3,711,102	25.1	28,503	18.8	16.6
Naples	207,029	23.4	34,001	22.3	22.2
Ocala	245,975	20.0	22,452	11.5	22.1
Orlando	1,535,004	26.5	31,230	21.6	10.9
Panama City	147,958	24.5	24,684	15.7	11.8
Pensacola	403,384	24.5	25,736	18.3	11.3
Sarasota-Bradenton	550,077	20.8	29,919	21.9	32.0
Tallahassee	260,003	34.5	26,209	32.4	9.0
Tampa-St. Petersburg-Clearwater	2,278,169	25.4	26,036	17.3	21.5
Total metro areas	12,866,498	25.3	27,466	19.5	17.2

1. % of metropolitan labor force composed of managers, executives, and professional workers
2. median family income ($ thousands)
3. % of adults over age 25 holding college or university degrees
4. % of metropolitan population over age 65
Source: County Business Patterns.

professional workers include Gainesville (35 percent, compared to 25.3 percent state-wide) and the state capital, Tallahassee (34.5 percent), both of which are homes to the state's most research-oriented universities. The wealthiest cities in the state include Naples ($34,000 compared to $27,466 state-wide in 2000) as well as Orlando ($31,000). Gainesville emerges as the state's best-educated metropolis, in which 31 percent of adults hold college degrees (compared to 19.5 percent state-wide). The state's proportionately oldest city is Sarasota-Bradenton (32 percent over age 65, compared to 17.2 percent state-wide), while the youngest demographically are Fort Walton Beach and Tallahassee, with nine percent each.

Table 5: Correlations of Patent Activity and Determinants.

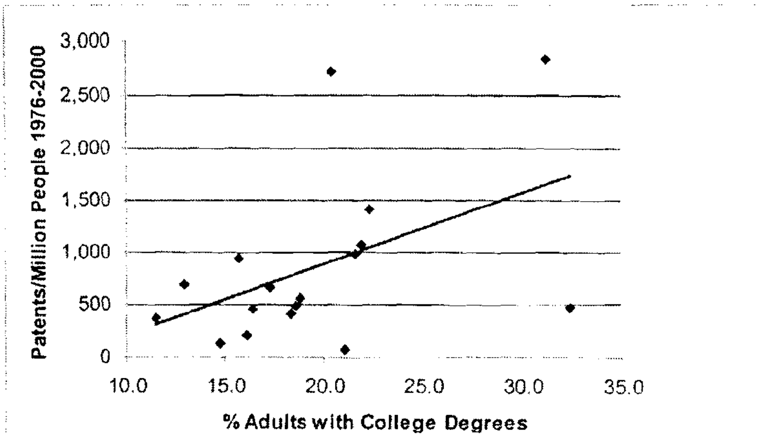
	2000 Population	2000 % Professionals[1]	2000 Median Income[2]	2000 % BA or Higher[3]	2000 % Pop. > Age 65[4]
Patents/Million	-0.120	0.493*	0.074	0.475*	-0.134

1. % of metropolitan labor force composed of managers, executives, and professional workers
2. median family income ($ thousands)
3. % of adults over age 25 holding college or university degrees
4. % of metropolitan population over age 65

* significant at .05 fudicial level

To assess the degree to which these variables were related to patent activity, as simple correlation analysis was performed (Table 5). Notably, demographic factors such as total population or percent elderly were unrelated to patent activity, as was median income. However, the proportion of workers in professional occupations and percent of adults holding college degrees did exhibit statistically significant relationships at the .05 level, offering support for endogenous, human capital theories of innovation. The role of universities is interesting here. Mansfield (1991) demonstrated that universities are frequent contributors to patent activity, generating significant knowledge spin offs locally and regionally. Among Florida's cities, as Figure 1 reveals, the proportion of college-educated adults varies consistently with patent activity (r = .475): Gainesville is both the best-educated and most innovative city in the state; Tallahassee, while possessing a reasonably well educated workforce, exhibits low degrees of innovativeness, reflective of a local economy centered on state government and legal services. The Melbourne- Titusville-Palm Bay region is an anomaly, with high rates of innovation but average levels of education among its adults. Finally, several cities exhibited low proportions of college-educated adults and low degrees of patent generating activity (e.g., Ocala, Daytona Beach, Fort Pierce, and Lakeland).

Figure 1: Regression of Patents/Million People and Percent of Adults with Coll Degrees.

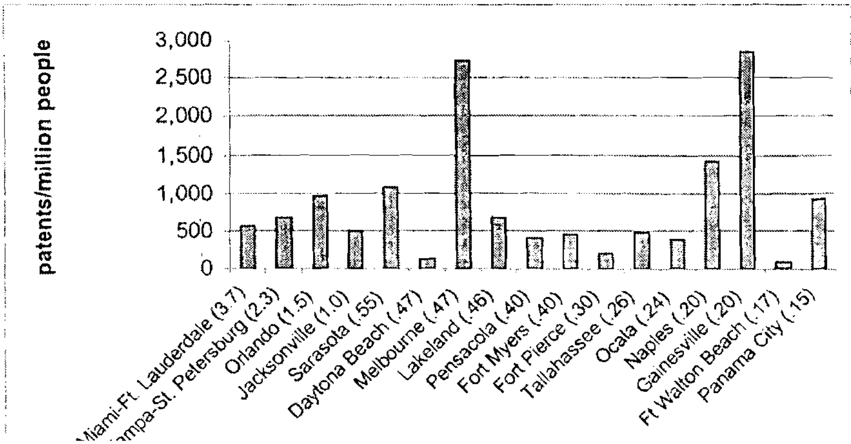


If seedbed theories of innovation are correct, patent activity should decrease down the tiers of the urban hierarchy. When patents granted are graphed against the population of Florida's metropolitan regions (ranked from largest to smallest in Figure 2), however, little support for this thesis is found no obvious relation between urban size and innovativeness is evident, hinting that patent activity is not tied to agglomerative economies. This pattern – or more accurately, the lack of one – indicates that endogenous human capital approaches are more likely to reflect the causes of patent activity in the state.

Concluding Thoughts

Geographers have long sought to explain why some places are more innovative than others. In an era of significant technological and regulatory change, the generation of new ideas lies at the crux of local competitive advantage. Patents are the best and most widely used measure of this activity, and as this paper has shown, patent activity has increased across the face of

Figure 2: Patent Activity Across Florida's Urban Hierarchy, 1976-2000



Florida, albeit unevenly in space and time. In contrasting seedbed and endogenous theories of innovation, this paper found little evidence for the former - that is, patent activity is unrelated to urban size - and consistent support for the latter, particularly with regards to the critical role played by human capital.

A significant body of literature has demonstrated the intricate linkages between innovation and human capital, much of which is generated in universities. Indeed, a well educated labor force emerges consistently in the locational preferences of companies engaged in the production of high value-added goods and services and the generation of skilled, well paying jobs. Obviously, universities are not a panacea for local economic problems, and it is possible to exhibit a glut of educated workers relative to the demands of the labor market.

Florida, however, is unlikely to experience such a predicament. With a relatively undereducated population (19 percent of adults hold college degrees compared to 24 percent nationwide) and a long history of miserly funding for education, Florida lacks the infrastructure to generate the human capital necessary to become a national center of innovation. In contrast, states such as North Carolina, Kentucky, Texas, and Georgia, which have taken pains to invest in higher education, exhibit relatively diversified economies and higher proportions of jobs in skilled occupations. Moreover, Florida's problems in this regard may get worse. The state legislature of Florida repeatedly mandated reductions in the budget for higher education, leaving the state last in the nation in funding per student, and 49th in average university tuition rates. These actions may have serious, if unintended consequences. Inasmuch as a well educated labor force is a key requisite to the attraction of high wage, high value-added activities, the impoverished higher education system of Florida is not likely to contribute to future rounds of innovative activity. Indeed, Florida may suffer long-term harm to its economic future by refusing to invest in human capital.

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