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Job Creation and the Knowledge Economy: Lessons From North Carolina's Life Science Manufacturing Initiative

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Knowledge-intensive industries are expected to provide long-term economic prosperity for their host regions. The question persists whether these industries can also generate quality, stable jobs for a wide range of workers in these regions, particularly those with limited academic training. This article examines North Carolina's effort to respond to this challenge by integrating workforce and economic development functions in an effort to anchor life science manufacturing establishments in the state. By coordinating training, recruitment, and research activities, state agencies are influencing the location and employment strategies of life sciences firms in ways that are helping to foster a more socially inclusive transition to the knowledge economy.

Keywords: *workforce development; life sciences; workforce intermediaries; North Carolina*

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Knowledge-intensive industries—including biotechnology and information technology—are expected to provide long-term economic prosperity for their host regions. The question persists whether these same industries can also generate quality, stable jobs for a wide range of workers in these regions, particularly those with limited education and academic training. This challenge is especially pronounced in regions that are struggling to cope with large job losses in traditional manufacturing or low-end services. Although knowledge-intensive industries provide crucial employment opportunities for the region's highly educated residents, they often function in isolation from traditional industry resources and workforces.

As policy makers and practitioners grapple with the distributional limits of knowledge-intensive industries, there has been a strong push to develop transitional training supports for less educated and disadvantaged job seekers. In their early iteration, these programs have been designed to leverage new jobs created by maturing segments of these industries, from basic programming and customer services in information technology (Chapple & Zook, 2002; Melendez & Harrison, 1998) to drug manufacturing and packaging in life sciences (Fitzgerald, 2006). But in today's rapidly changing economic environment, where lower level manufacturing and service jobs in knowledge-intensive and technology fields are increasingly being off-shored or outsourced (Bardhan & Kroll, 2003; Dossani & Kenney, 2007; Peck & Theodore, 2007), workforce development agencies may need to adopt a more direct approach to regional employment generation by acting to influence key industry location and hiring decisions. In essence, this entails moving from a peripheral role

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of increasing the supply of entry-level workers in a region to a more central role as regional labor market developer.

This role is certainly not a new one for workforce development agencies in the United States. Project Quest in San Antonio, Jane Addams Resource Corporation in Chicago, the Wisconsin Regional Training Partnership in Milwaukee, and New York City's Garment Industry Development Corporation have all influenced the employment practices and growth strategies of regional employers by acting as workforce intermediaries, that is, agencies that expand local employment opportunities by simultaneously promoting regional industrial development and upgrading. In each of these cases, business establishments receive structured technical assistance from these agencies to make them more competitive in quality-demanding consumer markets. Vocational training supports play a crucial role in the upgrading process by enabling firms to enhance and expand worker skill, and thus sets to incorporate new technologies and production processes (Fitzgerald & Green Leigh, 2002; Harrison & Weiss, 1998). In most cases, these training supports are linked to local hiring goals and commitments, which enable these agencies to influence regional hiring and promotion decisions including those that involve disadvantaged populations (Lautsch & Osterman, 1998).

These workforce intermediaries have been especially helpful in stabilizing traditional manufacturing industries, including garments in New York City, metal working in Chicago and Milwaukee, specialty furniture in the San Francisco Bay area, and transportation equipment in central Texas (Bernhardt, Dresser, & Rogers, 2001; Conway & Loker, 1999; Fitzgerald & Green Leigh, 2002; Fung & Zdrzil, 2004; Hum, 2003; Lautsch & Osterman, 1998). By combining technical assistance and worker retraining, these intermediaries have not only helped firms cope with intensified global competition, but in the process, have created a powerful development tool for keeping open quality job opportunities for the region's less educated manufacturing workforce. In essence, their success in helping less educated workers and job seekers reflects their ability and willingness to combine and coordinate workforce and economic development activities and goals (Giloth, 1998).

Less information is known about related intermediation efforts involving knowledge-intensive industries. What has been documented is the role of a broader set of labor market intermediaries in reducing industry risk and uncertainty, especially in the wake of the recent "tech" crisis (Benner, 2002). In information technology, for example, temporary staffing agencies have enabled technology workers in rapidly changing and precarious labor markets to switch to new and better jobs and, when necessary, cobble together multiple freelance assignments. Newly created tech unions and member-based employee groups often provide important job networking, credentialing, and professional training supports. These supports not only enable technology workers to adjust to rapidly changing industry skill requirements, but they also provide technology firms with the "organizational infrastructure" and networking support needed to identify and combine regional skills to support ongoing processes of innovation (Benner, 2003).

As with programs that target traditional manufacturing industries, these tech-based supports jointly address employer and job seeker needs by featuring and enhancing the region's available skill sets and, at times, influencing employer skills expectations and preferences. Still, in contrast to their traditional industry counterparts, these supports mostly benefit elite workers and, in particular, professional degree holders with advanced degrees in scientific or engineering fields. Less clear is the role that these intermediaries can play if extending their workforce and economic development functions to also create viable employment opportunities in these same industries for less educated and less privileged job seekers. Yet it is here that coordinated actions can be crucial for making a region's transition to the knowledge economy more socially inclusive.

How can development agencies enhance regional growth opportunities in knowledge-intensive industries? Under what conditions can they position themselves as effective workforce development intermediaries? What are the broader socioeconomic impacts of these efforts, especially from a perspective of regional employment creation and retention?

This article explores these questions by examining recent efforts to promote the expansion of North Carolina's life science industry with the specific goal of enhancing employment opportunities

for displaced traditional industry workers in the state. North Carolina has already established itself as a major player in the U.S. life science industry, ranking third behind Massachusetts and California in number of establishments and industry employment (Cortright & Mayer, 2002; DeVol et al., 2004). For the purposes of this study, the more interesting feature of this development relates to the state's decision to actively promote life science manufacturing (i.e., pharmaceutical drug, vaccine, and medical device manufacturing), not just "upstream" research and development activities. Media coverage of this development tends to focus narrowly on state and local industry recruitment efforts. In the mid-1990s, Massachusetts-based Biogen (now Biogen-Idec) received state and local incentives to open a biomanufacturing facility in North Carolina's Research Triangle Park—this facility is one of Biogen's largest East Coast manufacturing operations and currently employs 500 workers. The city of High Point, North Carolina, provided New Jersey-based Banner Pharmacap with a \$1 million incentive package, including a 25-acre plot of land to open a gel cap manufacturing facility in 1994. KBI Pharma, a smaller sized biomanufacturing firm, was recruited last year to the state from Atlanta, Georgia—the company's incentive package included a \$1 million start-up loan from the North Carolina Biotechnology Center. In a recent case, Merck received \$40 million in state and local incentives to build a new vaccine manufacturing facility in Durham County. The facility will be completed in 2008 and will open with an initial 200 manufacturing employees.

Recruitment efforts are certainly an important contributor to job and establishment growth in the state. Still, other less publicized efforts are under way to help anchor newly recruited firms in the region and also guide the expansion and location decisions of a small but increasing number of homegrown manufacturing operations. The remaining sections of this article focus on three interrelated strategies. It starts by examining the central role of the state's workforce development system—and in particular a network of specialized community colleges—in identifying and addressing shared regional workforce development needs and challenges. By involving multiple firms in program design, workforce development officials have been able to encourage life science employers to respond to an initially tight local labor market by relaxing formal education requirements and using nested training supports to address resulting skills gaps and training needs. This, in turn, is helping to create viable employment opportunities for less educated workers in the state, particularly those displaced from declining industries such as textiles and tobacco processing, industries that have shed approximately 200,000 workers in the state since the mid-1990s. Building on this finding, the article then examines the use of this workforce partnership as a powerful development tool for promoting industry expansion, first by convincing existing manufacturing firms to assist the state with industrial recruitment efforts and second, by working with firms to identify new areas for coordinated institutional action. As one illustration, state agencies and educational institutions—including North Carolina's premier research universities—are working together to coordinate research, testing, and manufacturing activities with the goal of speeding up product and process innovation times. This, in turn, is encouraging life science manufacturers to deepen their North Carolinian roots. At the same time, it is creating an additional need for workforce intermediation.

Combined, these efforts are especially important in light of increased global competition from emerging life sciences manufacturing centers in places such as China, India, and Singapore (Kamarck, 2006; Thiel, 2004; Vollmer, 2004). By continuously working to anchor firms in the region, development agencies are enhancing the staying power of individual firms and, with it, the stickiness of well-paying manufacturing jobs. At the same time, these coordinated efforts increase agency bargaining power when advocating on behalf of less advantaged socioeconomic groups. This article concludes by reflecting on the broad lessons of this sectoral strategy for regional economic transition.

The findings presented in this article draw on a mix of methods, including 45 semistructured interviews conducted in 2005 and 2006. In-depth interviews were conducted with the continuing education directors, life science instructors, and job placement coordinators from 11 community colleges. These colleges participate in North Carolina's BioNetwork program and offer both customized and open enrollment training courses in life science manufacturing. Interview questions focused on the college's history and experience with life science training, their current life science

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TABLE 1
North Carolina's Life Science Manufacturers

<i>Type</i>	<i>Total Establishments</i>
Biomanufacturers	16
Pharmaceutical manufacturers	19
Contract manufacturing organizations	9
Medical device manufacturers	185 ^a

SOURCE: North Carolina Biotechnology Center (2005).

a. North Carolina Medical Device Organization, unpublished data provided to the author by the former director. It is based on the organization's own market research.

training provisions, their strategies for assisting trainees with job placement, and the nature of their relationship with regional life science employers. A survey was also conducted at 7 of these colleges to develop a general profile of life science manufacturing job seekers. This in-class survey was collected from students who were enrolled in BioWork, a 128-hr course that provides entry-level training for the life science manufacturing industry. Although additional life science manufacturing training programs and curriculum courses are available at these colleges, BioWork was selected because it has limited barriers to entry and is therefore available to job seekers with lower levels of education. In addition to collecting information at the community college level, in-depth interviews were also conducted with key workforce and economic development specialists from the North Carolina's Biotechnology Center and the Department of Commerce.

Finally, interviews were conducted with executives from 20 of the state's large-scale biopharmaceutical and medical device manufacturing firms. Establishments were selected primarily on the basis of their involvement in formulating workforce development strategy in the state. Interview questions focused on the company background, location decisions, workforce characteristics and training needs, and relationship with state and local development agencies. Information gathered through these interviews was supplemented by a review of two human resource surveys conducted by the North Carolina Biotechnology Center in 1997 and 2003 with 32 (or 72%) of the biopharmaceutical employers in the state. These surveys document changing educational requirements and hiring practices of industry employers during this period. Company-level information was also collected through an extensive search of newspaper articles and press releases dating back 10 years.

COMMUNITY COLLEGES AS INSTRUMENTS FOR REGIONAL INTEGRATION

North Carolina has more than 200 life science manufacturing establishments. These firms fall into the following broad manufacturing categories (see Table 1): (a) biomanufacturing and pharmaceutical manufacturing facilities that produce chemical and biological-based drug therapies, (b) contract manufacturing facilities that offer specialized manufacturing services to local and nonlocal biopharmaceutical establishments, and (c) medical device manufacturers that produce a range of surgical, diagnostic, assistive, and imaging technologies. Employment in biopharmaceuticals (i.e., biomanufacturing and pharmaceutical manufacturing categories combined) and contract manufacturing is approximately 16,000 (Kennedy, 2003). According to the 2002 U.S. Economic Census (U.S. Census Bureau, 2002), 105 medical device manufacturers employed approximately 7,500 workers in North Carolina; this figure, however, does not include employment at hybrid operations that manufacture FDA-approved specialty medical devices yet, fall within other industry classifications such as auto parts, information technology, or business services. This may account for the fact that FDA-generated lists include an additional 80 medical device establishments, raising the state's establishment total in device making to 185.

In the past decade, reported job growth has been fastest in the biomanufacturing subcategory, averaging 10% per annum since 1990 (North Carolina Biotechnology Center, 2004b). Pharmaceutical

TABLE 2
Biopharmaceutical Job Categories and Educational Requirements

<i>Job Category</i>	<i>Minimum Education Requirements</i>	<i>Share of Employment (%)^a</i>
Production		
Process technician	High school or GED plus relevant work experience or training	52
Manufacturing prep process technician	High school or GED plus relevant work experience or training	
Formulation or fill technician	High school or GED plus relevant work experience or training	
Packaging technician	High school or GED plus relevant work experience or training	
Quality control		
Quality control assistant	2-year associate's degree	19
Quality assurance assistant	2-year associate's degree	
Quality control associate	Bachelor of Science degree	
Process quality inspector	Bachelor of Science degree	
Manufacturing support		
Maintenance technician	High school or GED plus relevant trade certification	14
Instrumentation technician	2-year associate's degree	
Environmental technician	2-year associate's degree	
Maintenance engineer	Bachelor of Science degree	
Process control engineer	Bachelor of Science degree	
Environmental engineer	Bachelor of Science degree	
Research and development		
Process development associate	2-year associate's degree with industry experience	10
Process development scientist	MS degree with industry experience or PhD	

SOURCE: Kennedy (2003).

a. Standard breakdown for a large-sized bioprocessing or pharmaceutical manufacturing enterprise; 5% in other nonlisted areas.

manufacturing has also experienced steady job growth in recent years—from 2001 to 2002, employment in this sector increased by more than 8% (Kennedy, 2003). According to the U.S. Economic Census, employment in the medical device area has increased by more than 10% and inflation-adjusted annual payroll by almost 20% since 1997.

Innovations in drug therapies and medical devices typically require input from scientific and engineering specialists. It is not surprising, therefore, that research and development facilities tend to congregate around or spin out of reputable research universities and related public research centers (Cooke, 2004; Feldman, 2003; Lowe & Gertler, 2005). Manufacturing of approved drugs and devices—the visible result of successful upstream discovery work and research and development—does not imply a reduction in skill needs per se but rather a shift in required skill sets. Research and development staff remain on hand to make improvements and modifications to existing production processes and identify possibilities for extending production technologies and applications. In contrast to R & D facilities and laboratories, however, this group typically accounts for a small share of a manufacturing facility's total workforce. Instead, quality control and quality assurance experts play a more central role by ensuring products and production processes meet stringent federal manufacturing standards. Maintenance workers ensure the smooth and continuous functioning of highly complex machinery. Production workers combine technical knowledge with procedural accuracy in diverse areas from cell development (for biomanufacturing) to sterilization and chemical mixing (for traditional drug making) to plastic injection molding and metal stamping (for medical devices). They also focus on product finishing and packaging tasks. Each position has different skills requirements and builds on different levels of formal training and education—this diversity is illustrated in Table 2, which lists job categories and minimum educational requirements for a typical large-scale bioprocessing plant.

In North Carolina, life science manufacturing firms are increasingly outsourcing training needed for select production, manufacturing support, and quality control positions to the state's

community college system and more specifically to a subset of technical colleges that participate in the state's BioNetwork program. In the early 1990s, life science manufacturing firms, then much smaller in number, developed in-house training programs. In recent years, however, they have worked closely with community colleges to develop and test entry level programs for new hires and short courses for continuous upskilling of incumbent workers. Although community colleges were involved in life science manufacturing training a decade or so ago, their initial role was to broker deals between firms and freelance training experts within and outside the state. Today they are directly involved in curriculum design and development and course instruction and offer a range of industry training and educational supports, including prehire, entry-level courses such as BioWork (described below), firm-specific customized training, 2-year associate's degrees in applied biotechnology, and related feeder programs for students interested in pursuing advanced degrees in molecular biology and chemical engineering at 4-year colleges and universities.

At first glance, the increased role of North Carolina's community colleges in life science manufacturing training appears to reflect overlapping skills requirements by local employers and, thus, fits standard theories of human capital (Becker, 1964). Under this lens, the growth of firms demanding similar skill sets enhances opportunities for intraregional employee mobility. In essence, skilled employees, once trained at one manufacturing facility, can easily be lured away by another facility offering slightly higher wages or benefits. Employers, fearing a loss of their investment in employee training, reduce their contribution to regional upskilling. This forces employees to eventually invest in their own training. In turn, they demand greater involvement in skill formation from educational institutions in the region.

Closer inspection of firm-level training decisions in North Carolina's life science manufacturing sector reveals a more complex and interactive process of strategic partnering. It is true that establishment growth in recent years has resulted in overlapping skills requirements and, thus, has heightened opportunities for employee mobility. North Carolina's tightening labor market in the late 1990s and more recently with the state's rebounding economy has only helped to fuel intraregional competition for qualified workers. It is also true that technical colleges have taken on greater training responsibilities in the past decade and now offer a wide array of general enrollment courses to existing and prospective industry employees. Yet to attribute the increased role of local colleges in life science training to a simple change in specific skill ignores the fact that development practitioners and educators actively encourage manufacturing firms to outsource their training needs to technical colleges in an effort to further anchor these establishments in the region. Related to this, local colleges have expanded their role beyond worker training to offer a wide array of job placement and career development services. As such, they fall into an emerging category of labor market institutions described by others as "workforce intermediaries" (Fung & Zdrzil, 2004; Giloth, 1998; Osterman, 1999). The colleges' willingness to juggle the needs of multiple "clients" (i.e., local employers, displaced workers, recent high school graduates)—itself a reflection of an earlier mandate by the state legislature—puts these institutions in a unique position to negotiate for expanded employment opportunities for North Carolina's disadvantaged socioeconomic groups. Their ability to offer top-quality, state-of-the-art training and their long-standing role as community educators not only enable them to influence who gets access to well-paying jobs in North Carolina's fast-growing life science industry but how life science firms themselves come to value particular segments of the region's workforce. A few examples help to illustrate this dynamic.

COMPANY-COLLEGE TRAINING PARTNERSHIPS

Despite their increased reliance on community colleges, North Carolina-based firms continue to invest heavily in employee training. Development practitioners and college administrators help to direct some of this investment to general-use training infrastructure—that is, community infrastructure designed for the benefit of local residents and future employers. In Johnston County, for example, three life science manufacturers—Novo Nordisk, Talecris (formerly Bayer),

TABLE 3
North Carolina Community Colleges Offering BioWork

<i>County or Counties</i>	<i>Community College</i>	<i>Starting Year^a</i>
Granville, Franklin, Warren, Vance	Vance-Granville Community College	2001
Johnston	Johnston Community College	2001
Wake	Wake Technical Community College	2002
Durham	Durham Technical Community College	2002
Caswell, Person	Piedmont Community College	2002
Chatham, Lee, Harnett	Central Carolina Community College	2002
Pitt	Pitt Community College	2003
Wilson	Wilson Technical Community College	2003
Buncombe, Madison	Asheville-Buncombe Technical Community College	2004
Cumberland	Fayetteville Technical Community College	2004
Guilford	Guilford Technical Community College	2005
Lenoir, Greene, Jones	Lenoir Community College	2006

SOURCE: North Carolina BioNetwork.

a. Starting year for general courses. Customized versions of this course were available at some colleges at an earlier starting date.

and Hospira—recently agreed to contribute 8 cents per \$100 in property value to a training fund that helped to finance the construction of the county's Workforce Development Center. The center, opened in July 2005, provides local firms with off-site training space. As a satellite campus of the Johnston County Community College, the center is also designed to provide county residents with college-level courses in applied math, science, and engineering. County officials brokered this agreement by offering to create a special economic development zone and in the process, protect "companies from annexation and taxation by any town" (Schwind, 2005, p. B1). Still, participating firms, for their part, value this exchange as more than just a source of tax savings. Their affiliation with and proximity to the training site not only help to feature them as potential employers for graduating students but also enable them to reduce start-up training times by having access to a combination of customized and general courses. In recognition of this contribution, local firms have made sizeable donations in training equipment. They also regularly visit with students and college instructors at the center to make them aware of local employment opportunities.

Educators and development practitioners have also involved local firms in course and curriculum development. One example is BioWork, a 128-hr, semester-long certificate course that provides students with entry-level process technician skills for both biomanufacturing and chemical-based pharmaceutical manufacturing. Funding for the program comes from North Carolina's GoldenLeaf Foundation, a nonprofit organization created in 1999 to disperse tobacco settlement funds to social and economic programs in tobacco-dependent and distressed counties throughout the state. BioWork training modules focus on a range of topics from safety and quality control to process sterilization and growth of living cells. Today, 12 of North Carolina's 58 community colleges offer this course to the general public and to existing and newly recruited biomanufacturing firms in the form of customized vocational training support (see Table 3). The program is now required for most entry-level biopharmaceutical jobs in North Carolina. More than 900 students enrolled in BioWork in 2005,¹ an increase of 241% since its first open enrollment offering in 2001.

BioWork has limited enrollment requirements and is available to job seekers with low levels of education (i.e., a GED or higher). A 2006 survey of BioWork students provides us with a representative profile of the state's less educated life science job seeker.² For the surveyed group, median enrollee age is 38, with only one fifth under the age of 28. Of all BioWork students, 64% are female; 53% self-identify as African American, with nonHispanic whites representing less than 40% of trainees. Only 25% of enrollees have earned a 2-year associate's or 4-year undergraduate degree. Approximately 35% of BioWork trainees were unemployed at the time of the survey. Still, despite the fact that 65% were employed while enrolled in the course, 93% indicated a strong

desire to secure better paying work. This is understandable given that the majority of students are employed in low-paying industries such as retail sales, food service-hospitality, and health care support. As anticipated, a sizable share of BioWork enrollees have been displaced from traditional manufacturing industries, including textiles.

BioWork was first offered to the general public at Vance-Granville Community College, a state-funded technical college located to the north of the state's Research Triangle Park. The college continues to play a lead role in program development as a site for "train-the-trainer" courses for BioWork instructors from other colleges.³ The BioWork course was the outgrowth of a formal partnership established between the North Carolina Biotechnology Center and the state's community college system in 1998 (North Carolina Biotechnology Center, 1999). This partnership encouraged involvement by larger pharmaceutical and biomanufacturing firms from the state. The Biotechnology Center had already solicited input from these companies in the mid-1990s when it conducted a firm-level survey through which it was able to identify growing demand for process technician skills in the state. Curriculum development for BioWork helped to deepen this public-private exchange. Human resource managers at Novozymes, for example, worked closely with community college instructors at Vance-Granville to design the original BioWork program—in fact, one of these HR managers, Joanne Steiner, had originally proposed the idea of developing a certificate course at the college in the mid-1990s to reduce worker turnover and jump start the process of "on-the-job learning" (Fitzgerald, 2006, p. 122). Novozymes not only agreed to pretest a pilot version of BioWork on its incumbent employees but also reviewed job applications from trainees who completed the first semester of the program at Vance-Granville in 2001. This resulted in another round of revisions to the original course design, including the addition of job placement modules on resume writing and interview preparation.

Novozymes support for BioWork extends well beyond curriculum design and modification. In 2001, they also made a donation of \$250,000 to finance a training laboratory at Vance-Granville Community College (Lancaster, 2001). Similar industry-institution exchanges have occurred in other counties. Biogen-Idec, for example, has worked closely with college instructors in Durham County to make additional improvements to BioWork's training modules. In Wilson County, Merck Manufacturing, Leiner Health Products, Eon Labs, and Purdue Pharmaceuticals have also been involved to various degrees in program design and testing. In Wilson's case, the result is a slightly modified version of BioWork that more closely reflects the skills needs of regional employers. In contrast to other counties, Wilson's life science manufacturing relies heavily on chemical-based production processes. As a result, training modules at Wilson Tech Community College have been modified so that trainees develop skills in chemical mixing, solid dose tableting, and coating rather than cell growth and culturing.⁴ In exchange for modifying the program, existing life science manufacturers in the region have agreed to reserve interviews with BioWork graduates from Wilson Tech for all relevant job openings. Although this does not guarantee employment at the interviewing company, it does provide local trainees with a leg up, insofar as they advance to Stage 2 in the application screening process. Furthermore, it creates opportunities for Wilson Tech instructors and career counselors to request company and student feedback on the interview process and use this information to improve future rounds of training and job placement support. Wilson Tech's modified version of BioWork is currently under review at community colleges in other regions of the state that host large numbers of chemical-based manufacturers.

The blurring of boundaries between industry and publicly funded colleges might lead some to raise concerns about strategy formation and, more specifically, the ability of educators to effectively balance the needs of workers and students (both present and future) with those of current employers in the state. Interestingly, however, the deepening of ties with life science manufacturers seems to have opened up opportunities for state officials and educators to push firms to modify hiring practices and preferences in ways that are more socially inclusive. Wilson Tech's ability to negotiate on behalf of local BioWork trainees is one illustration of this. The college's willingness to customize programs to reflect the needs of local manufacturers essentially gave it greater bargaining power when making demands for more inclusionary employment review processes. In this case, Wilson Tech has essentially created its own version of a first-source hiring agreement,

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whereby public sector organizations act as de facto employment agencies.⁵ Whereas traditional incentives-for-jobs type arrangements influence only the number of new hires at a subsidized firm, Wilson Tech and other first-source brokers are shaping who from the regions gains access to high-paying manufacturing jobs.

Similar efforts have helped keep open employment opportunities in life sciences for high school diploma holders from the state. As Table 2 indicates, roughly 60% of jobs at an average life science manufacturing establishment in the state are available to high school diploma and GED certificate holders. This is somewhat surprising given ongoing industry changes that elsewhere have resulted in hiring practices that favor workers with bachelor's degrees. Other North American life science manufacturing centers, such as Massachusetts and California (Fitzgerald, 2006), have experienced a ratcheting up of formal educational requirements in recent years. In drug making, this is likely because of an increase in biomanufacturing establishments and the growing use of biomanufacturing processes by traditional, chemical-based manufacturers. Similarly, in medical devices, demand for higher educational credentials likely coincides with a shift from stable, mass production-oriented markets to highly innovative systems that seek to shorten product life cycles to 7 years or less.

How then have high school diploma holders in North Carolina managed to maintain a foothold in life science manufacturing? To answer this question, it is important to consider the actions of training specialists from organizations such as the North Carolina Biotechnology Center and Community College System. Through their frequent interaction with local firms, training specialists from the state have developed a sophisticated understanding of the specific skill requirements of and training needs for each job category in life science manufacturing. By organizing industry focus groups and conducting regular surveys with human resources managers, training specialists from the state have also been able to track changes in skills requirements over time and assess future industry skill needs. This, in turn, has resulted in the design and redesign of specialized courses and interlocking training modules. Rather than addressing potential skills shortages by bumping up the formal degree requirements of potential job applicants, firms in North Carolina have built on their relationships with local community colleges to respond to skills gaps by codeveloping and piecing together customized training modules. Under this system, firms are assured follow-up training support for workers who enter with lower levels of formal schooling. BioWork is but one piece of this customized training chain. Although BioWork provides only basic, entry-level skills, companies view participation in the program, especially by GED and high school diploma holders, as a sign of an applicant's openness toward and willingness to complete additional rounds of firm-specific training.

This incremental approach to upskilling has a second, related benefit for local manufacturing. It has provided manufacturing firms with a solution to a growing industry challenge—high worker turnover or “churning” among bachelor's degree holders. According to industry executives, bachelor's degree holders often apply for biomanufacturing positions to first gain entry into the industry. It is rare for these workers to remain in these positions for more than a few months. Opportunities for internal promotion, poaching by other life science manufacturing operations, and the lure of cutting-edge work at research-oriented establishments result in high turnover rates among this subset of highly qualified job candidates. In contrast, manufacturing firms find that high school diploma holders remain loyal to their jobs and employers. By relaxing formal educational requirements and using incremental training to address skills shortages, larger employers in the state have been able to lower turnover rates and, thus, stabilize their workforce. At the same time, they have been able to expand the pool of eligible job candidates and, in the process, address some of the challenges associated with a tightening local labor market in life sciences.

Training experts from the state recognize that industry pressures for continued upskilling, including the adoption of biomanufacturing processes and techniques by an ever-growing number of traditional drug makers in the state, may eventually limit employment opportunities in life sciences for high school diploma holders. Recent surveys of human resource managers now indicate a growing preference for 2-year associate's degrees across all levels of manufacturing (Kennedy, 2003). According to industry experts, workers with associate's degrees are more easily moved from

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one type of job category to another and therefore enable firms to respond quickly to unanticipated shifts in demand or production-related regulatory decisions. Ironically perhaps, community colleges in the state are helping to fuel this demand for increased educational standards through the formation of new 2-year associate's degree programs in biopharmaceuticals. Still, until these programs produce large numbers of potential employees, training experts and intermediaries from the state still have an opportunity to shape local hiring practices in ways that continue to favor traditionally disadvantaged groups with low levels of formal education. This is particularly important given North Carolina's low college completion rates, especially in nonmetro counties.⁶ At the same time, this provides college educators with an opportunity to test out and garner state support for innovative strategies that encourage high school graduates to enroll in 2-year college curriculum programs with the goal of stabilizing job prospects in life sciences.

PARTNERS IN INDUSTRIAL RECRUITMENT

Industrial recruitment efforts are also under way to expand the number of life science establishments in North Carolina and with it, employment opportunities in manufacturing. Here, too, development practitioners have solicited the support of firms in promoting the region to other nonlocal life science manufacturers. This is initially surprising, given that executives of North Carolina-based firms admit to facing a tight local labor market, which has not only resulted in interfirm competition for and, thus, "poaching" of workers, but has increased wage premiums for both entry-level and higher skilled positions. Yet rather than considering a move to alternative, labor-abundant locations in the United States (or for that matter, globally), life science manufacturers in North Carolina are actively helping to recruit other manufacturing facilities to the region. They do so by meeting with representatives from prospective firms and in some cases, providing guided tours of their manufacturing facilities. Although local firms acknowledge they are potentially contributing to increased interfirm competition in the short run, they justify their participation in these recruitment efforts as a means to ensure additional state support for training and workforce development. To paraphrase the operations manager of a Durham-based life science manufacturing facility, efforts to expand the state's manufacturing base help to justify additional requests for training investments and resources from local foundations and policy makers and also enables life science executives to recognize and praise the hard work of development practitioners by featuring this as a distinct, regional asset.

Practitioners use a variety of strategies to encourage existing firms to look beyond their immediate employment challenges by considering their role in promoting long-term regional growth.

Practitioners use a variety of strategies to encourage existing firms to look beyond their immediate employment challenges by considering their role in promoting long-term regional growth. Firms are invited to participate in strategic planning events, industry surveys, and targeted focus groups organized by both the North Carolina Biotechnology Center (a state-sponsored agency) and the North Carolina Community College System. As one example, representatives from Biogen-Idex, Novozymes, and AlphaVax were involved in the Workforce Training Work Group that contributed to the state's 2004 Biotechnology Strategic Plan (North Carolina Biotechnology Center, 2004b).⁷ Executives and human resource managers from these same firms continue to play an advisory role for state agencies in the area of workforce development. Industry representatives have also been recruited for key systems management roles. Wake Technical Community College, for example, recently appointed Dr. Linxian Wu as dean of the college's BioNetwork Capstone Center. Prior to joining Wake Tech, Dr. Wu was the president and chief operating officer at Fresenius Kabi, a contract manufacturing and pharmaceutical development operation in Clayton, North Carolina, that was acquired by Hospira in 2004.⁸ His involvement not only symbolizes a deepening relationship between community colleges and industry but reflects current efforts to better bridge 4-year and 2-year institutions; the Capstone Center (to open in 2007) will be a shared community college-university training site at North Carolina State University's Centennial Campus. Forsyth Technical Community College has also successfully recruited life science entrepreneurs to play a lead role in workforce development programs. Russ Read, former president and CEO of Kucera Pharmaceutical Company in Durham and founder of Hope Pharma Consulting, is currently the executive director of the National Center for the Biotechnology Workforce at Forsyth Tech.

As the examples presented in this section and the previous one illustrate, development practitioners and educators from the state are using workforce development as a unifying theme for bringing together diverse groups of life science manufacturers. Firms also organize around other shared challenges; for smaller life science manufacturers, particularly those that started out as homegrown biotechnology firms, this includes the pressing issue of midstage financing. For larger firms, there are longstanding concerns about patent protection and federal-level regulatory approval processes. Here, too, institutional actors from North Carolina play an important coordinating role. For now, however, workforce development concerns affect all categories of life science firms, not only in North Carolina but in other manufacturing centers in North America (Fitzgerald, 2006). North Carolina's existing strength in workforce development and especially its well-coordinated system of publicly funded and managed vocational training centers and colleges (Osterman & Batt, 1993) give it an added regional advantage in responding to this industry-wide challenge. At the same time, the quality of the state's training supports has enabled practitioners to encourage firms to cast a wide employment net and, in the process, to consider hiring individuals from more vulnerable socioeconomic groups in the state. Their ability to influence the local hiring practices of high-tech, high-growth employers has broader implications when thinking about recent transformations in the U.S. labor market and more specifically, declining real wages and rising job instability of the noncollege-educated cohort (Fligstein & Shin, 2004; Howell, 1994; Osterman, 1999). In essence, practitioners in the state have not only developed a system for managing the upskilling process but more important, have devised an effective bargaining tool for addressing growing regional concerns about social and economic exclusion.

Development practitioners and educators from the state are using workforce development as a unifying theme for bringing together diverse groups of life science manufacturers.

CONNECTING RESEARCH AND MANUFACTURING CAPABILITIES

As mentioned earlier in this article, manufacturing operations represent a subset of North Carolina's life science establishments. The state is also home to a large (and growing) number of early and midstage "core" biotechnology firms, and a sizeable group of "big pharma" research divisions, the largest of which is GlaxoSmithKline's facility in the Research Triangle Park.⁹ Combined, there are approximately 180 research-oriented life science establishments in North Carolina. Contract research organizations (CROs) are another, fast-growing, category of life science firms—80 firms on last count. Quintiles, for example, was established in North Carolina in 1982 by a University of North Carolina–Chapel Hill professor to provide statistical and data management consulting services to pharmaceutical (and eventually biotechnology) clients. Today, it is one of the largest CROs in the country, with a global workforce of more than 16,000 workers. Other North Carolina-based CROs include PPD Development of Wilmington, Parexel International Corp., and Lineberry Research. In total, it is estimated that 18,000 workers are currently employed in biotechnology and biopharmaceutical research establishments in North Carolina. An additional 16,000 work for North Carolina-based CROs (Kennedy, 2003).

For this group of establishments, the main institutional anchors in the state are research universities and teaching hospitals, such as Duke University, University of North Carolina–Chapel Hill, and North Carolina State University. Not only do these institutions provide firms with highly educated talent in the form of undergraduate and graduate researchers, but they also provide access to emerging technologies through formal licensing and related technology transfer agreements and consulting contracts with eminent scholars and research faculty. As with manufacturing firms, research establishments receive state support (via North Carolina's Biotechnology Center), including research grants and a variety of loan options, from small business innovation awards that bridge federal funding gaps to proof-of-principle loans that help firms move closer to technology commercialization.

For the most part, research and manufacturing establishments in life sciences operate in isolation and draw on distinct innovation systems for their growth and development.¹⁰ In recent years, however, a handful of life science manufacturers are starting to take steps to deepen their North Carolina roots by connecting to the state's existing scientific research infrastructure. Some firms, namely mid- and late-stage biotech establishments that have expanded their activities to include

biomanufacturing, already have strong connections to the state's institutions of higher education. Examples include AlphaVax, Biolex, and Embrex, three university spin-offs from the late 1980s and early 1990s that have recently developed in-house manufacturing capabilities. The more interesting finding are those cases where established (and initially stand-alone) manufacturers are developing applied research capabilities in the state. Not only are these efforts helping to further anchor firms to the region, but they are resulting in organizational changes that appear to offer greater opportunities for internal career advancement for entry-level manufacturing workers.

Although a complete review of these cases is beyond the scope of this article, it is useful to highlight a few examples and their implications for future rounds of policy support. One case involves a medical device firm that I call PR Therapeutics.¹¹ This firm has both research and manufacturing divisions in North Carolina. Interestingly, however, these divisions function separately, sharing only basic administrative responsibilities such as professional training and hiring. In recent months, executives have proposed a new model that would better integrate the region's product conception and execution tasks. In essence, this would involve localizing the company's value chain. Under the company's existing organizational model, new product ideas generated by North Carolina-based research staff are first shared with prototype developers and regulatory specialists at the company's Northeast headquarters. Once product development and testing procedures are complete (a 4-to 7-year process), the final product is sent back to North Carolina for manufacturing. The proposed change is an attempt to better capitalize on proximity by drawing on the region's existing knowledge of complex manufacturing processes to help researchers and prototype developers design higher quality and more cost-effective medical devices. At the same time, local integration of tasks will help to shorten the product development life cycle and, thus, enable the firm to introduce new products more quickly to market.

As executives move toward implementing this strategy, they recognize the need to draw on local training supports to upskill their current manufacturing workforce. Additional training will be used to provide manufacturing workers with a deeper understanding of existing medical technologies and, thus, a common language around which to engage with medical researchers and design specialists. To quote the company's operations manager,

Right now there is a chasm between some of the entry-level roles and maybe some of the higher skilled roles. Meaning if you come into our plant and you are looking for an entry-level position, running a machine for instance, . . . and then you want to move to the next position—that is typically someone of a technical nature or with quality skills and there is a \$3-to-\$4 an hour difference—well, there is no real easy path for how to get from A to B. We are trying to revamp our compensation and training systems to make this a smaller step function. People can come in and learn a few things and get recognized for that, contribute to that. Then, when the next big thing comes up, there will not be such a big gap. And it gives people internal opportunities for advancement within the different job needs and also gives us a better pool of people for those higher skilled needs down the road. (personal communication, 2005)¹²

PR Therapeutics is attempting to create linkages between established yet historically independent research and manufacturing divisions, both of which were established in North Carolina before 1985. In contrast, Wyeth and Contact Medical are integrating backwards into research from a starting base in manufacturing. Wyeth opened its first North Carolina-based research laboratory in February 2004; the company established a vaccine manufacturing plant in Sanford, North Carolina, in 1987. Durham was chosen as a research location "because of its proximity [40 miles] to the company's vaccine manufacturing plant . . . but also because of the area's scientific resources" ("Wyeth Opens New Lab," 2004). The \$7 million laboratory currently employs approximately 70 researchers from the Research Triangle Park area. Contact Medical has embraced a different strategy for integration, which entails the development of formal working relationships with the state's premier research universities and teaching hospitals.¹³ The company is currently

in negotiations with Duke-based faculty and medical researchers to develop formal partnerships. Initial exchanges will focus on prototype testing; eventually, the partners will involve applied research that will result in new product design and development. As with PR Therapeutics, Contact Medical, also a medical device manufacturer with out-of-state headquarters, plans to use vocational training as a mechanism for better integrating regional manufacturing and research capabilities.

Efforts by manufacturing establishments to build on the region's research infrastructure have been initially company led. Still, development practitioners are starting to take note of this crossover into research and, in the process, are considering different channels for supporting and diffusing this growth strategy. Interestingly, training infrastructure projects seem to offer immediate possibilities for bridging the state's research and manufacturing communities. One example is BTEC, a shared university-community college training facility currently under construction at North Carolina State University; the earlier mentioned Capstone Center is one part of this facility. The \$34 million training center, the largest of its kind in the United States, simulates a pilot biomanufacturing facility to provide both university and community college students with hands-on experience in bioprocessing, quality control, and plant maintenance. During interviews, manufacturing firms have also identified BTEC as a potential research site, insofar as it provides university engineers and research faculty with access to large-scale equipment for designing new and improved manufacturing processes and techniques. The challenge for development practitioners is to effectively promote BTEC's secondary use (along with other regional research supports) so as to help life science manufacturers embrace innovation strategies as a way to better cope with emerging competitive pressures.

EXPANDING THE ROLE FOR WORKFORCE INTERMEDIATION

"North Carolina's economy is in transition. As manufacturing jobs in traditional industries decline, new opportunities for job creation must be identified and aggressively pursued" (North Carolina Biotechnology Center, 2004b, p. 9). This passage from the opening lines of North Carolina's 2004 Strategic Biotechnology Plan underscores the central development objectives motivating the workforce development strategies outlined in this article. In contrast to many other U.S. regions that simply give lip service to inclusionary job expansion efforts in knowledge-intensive sectors, North Carolina has taken concrete steps to coordinate knowledge-deepening and job-creation activities to influence who participates in and benefits from regional economic transformation. Through their efforts, state development agencies have established a model of workforce intermediation for guiding industry expansion; they have done so with the goal of creating quality job opportunities for displaced and less educated workers.

It is not surprising, therefore, that North Carolina has caught the attention of policy makers and practitioners throughout the United States. Observers are especially interested in the transferability of this program to their own region and more specifically, the degree to which North Carolina's dual economic and workforce development strategy offers a viable channel for helping displaced workers elsewhere transition to the knowledge economy. At the same time, observers are looking for guidance on how to manage this transition in the face of growing global competition from emerging life science manufacturing centers in Asia including Taiwan, Singapore, and India. The rapid expansion and increased visibility of these centers and their low relative wages and competitive incentive packages make it increasingly difficult for U.S. regions to compete on cost savings alone. Rather, a region's ability to retain life science manufacturers will require a deepening of locational advantages other than low taxes, abundant land, and cheap labor. The North Carolina case provides us with some insights into how this process might look.

As we have seen, state agencies in North Carolina have played a central role in defining life science manufacturing as a target growth sector. Their use of incentives to influence firm location and expansion decisions has certainly been an important factor in explaining increased growth and diversification of North Carolina's life science industry in recent years. The more interesting

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development, however, is the state's ability to create strong linkages and interdependencies among manufacturers, technical colleges, and research institutions. This has been achieved by blurring the boundaries between companies and educational institutions, by encouraging firms to entrust colleges with greater training responsibilities, by incorporating industry executives into industry expansion efforts, and by using vocational training needs as a shared challenge around which to build industry consensus and, in turn, for identifying new targets for coordinated institutional support.

Higher skilled positions in life sciences, namely those requiring advanced undergraduate and graduate degrees, have also been promoted through parallel initiatives that encourage the expansion of research-intensive laboratories and start-up enterprises. These efforts have helped to anchor manufacturing firms to the region by creating opportunities for greater coordination of research and production activities. At the same time, they are expanding opportunities for career advancement for lower skilled, entry-level workers and, thus, are helping to trigger the next wave of workforce intermediation.

NOTES

1. This figure includes enrollment rates for all BioWork sessions offered during a calendar year, which includes the spring, summer, and fall semesters of each reported year.

2. This survey was conducted by the author and was administered to students for all spring 2006 BioWork sessions that had enrollments of 10 or more students. Surveys were collected from approximately 250 students, a response rate of close to 85% of the total enrollment in these surveyed sections. This survey provides a baseline for an ongoing longitudinal study of enrollees.

3. See <http://www.vgcc.cc.nc.us/evangran/2003/bi-0803c.htm>.

4. See http://www.wilsontech.cc.nc.us/coned/pharm_mfg.htm.

5. Similar initiatives are in place in Berkeley, California, Portland, Oregon, and Minneapolis–St. Paul, Minnesota. In the case of Portland, the city government uses first-source hiring agreements for most firms that receive state support, in the form of either tax incentives or government procurement contracts. The program, with links to the city's Comprehensive Employment Training Act, was started in the mid-1980s (Schweke, 1999, 2004).

6. According to North Carolina's Rural Economic Development Center, 29% of the state's adult population has a 2-year college degree or higher. In urban counties of the state, this number is closer to 40%; for rural counties, this number drops to 20%.

7. Firms were also involved in other working groups assembled for the Strategic Plan, including the Building Entrepreneurial Companies Group, Recruiting Life Sciences Companies Group, and the University Research and Infrastructure Group.

8. See http://www.waketech.edu/newsandpub/nr_WuBio04.htm.

9. GlaxoSmithKline also has a large manufacturing facility in Zebulon, North Carolina.

10. Parallel systems have been identified in other life science megacenters in North America. For American examples, see Cooke (2004). And for Canadian examples, see Niosi and Bas (2003) and Lowe and Gertler (2005).

11. The company name has been changed to honor confidentiality agreements.

12. The name of the manager is not referenced to honor a confidentiality agreement.

13. The company name has been changed to honor confidentiality agreements.

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