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# Who works in a working region? Inclusive innovation in the new manufacturing economy

Nichola J. Lowe<sup>a</sup> and Laura Wolf-Powers<sup>b</sup>

## ABSTRACT

Who works in a working region? Inclusive innovation in the new manufacturing economy. *Regional Studies*. Scholars have documented economic gains for regions that promote manufacturing through co-location of innovation and production activities. But it is unclear whether the production jobs created in this new context remain inclusive of workers with limited formal education. This paper compares US states that specialize in biopharmaceuticals to understand who participates in a so-called working region. While some state policy-makers have privileged scientific and design occupations at the expense of the production workforce, regional actors in North Carolina have increased employment in design and development while growing their biopharmaceutical production base, aligning innovation and equity goals in the process.

## KEYWORDS

manufacturing policy; United States; innovation; social equity; workforce development; biotechnology

## 摘要

谁在就业的区域中工作？在新兴制造业经济中的包容性创新。 *Regional Studies*。学者已纪录了透过创新和生产活动的共同区位促进制造业的区域经济之益处。但有关在此一新兴脉络中所创造的生产性就业，对于正式教育程度有限的工人是否仍具包容性，则不甚清楚。本文比较强调生计医药的美国各州，以理解谁参与了所谓的就业区域。当若干州的政策制定者偏好科学与设计工作，因而忽略了生产方面的生产力时，北卡罗来纳的区域行动者，却逐渐增加设计与发展的就业，同时在过程中扩大了生计医药生产基础，相应的创新和平等的目标。

## 关键词

制造业政策；美国；创新；社会平等；劳动力发展；生物技术

## RÉSUMÉ

Qui travaille dans une région au travail? L'innovation inclusive dans la nouvelle économie manufacturière. *Regional Studies*. Les érudits ont fourni des preuves des atouts économiques des régions qui encouragent la fabrication par voie de la colocalisation de l'innovation et de la production. Cependant, il n'est pas tout à fait évident si, oui ou non, la création d'emplois liés à la production dans ce nouveau contexte comprend des travailleurs ayant une éducation formelle limitée. Cet article compare les états aux É-U qui se spécialisent dans la biopharmaceutique afin de comprendre qui participe dans une région appelée région au travail. Tandis que certains décideurs étatiques occupent des postes privilégiés dans les domaines de la science et du design au dépens des effectifs de production, les acteurs régionaux situés dans la Caroline du Nord ont augmenté l'emploi dans le design et le développement tout en assurant la croissance de la base de production de produits pharmaceutiques, alignant ainsi les objectifs d'innovation et d'équité.


## MOTS-CLÉS

politique industrielle; États-Unis; innovation; équité sociale; développement de la main-d'oeuvre; biotechnologie

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**ZUSAMMENFASSUNG**

Wer arbeitet in einer Arbeitsregion? Inklusive Innovation in der neuen produzierenden Wirtschaft. *Regional Studies*. Seitens der Wissenschaft wurden wirtschaftliche Gewinne für Regionen dokumentiert, die die produzierende Industrie durch gemeinsame Standorte für Innovations- und Produktionsaktivitäten fördern. Hierbei ist jedoch unklar, ob die in diesem neuen Kontext geschaffenen Arbeitsplätze in der produzierenden Industrie auch Arbeitnehmern mit begrenzter formeller Bildung offenstehen. In diesem Beitrag vergleichen wir verschiedene auf die biopharmazeutische Industrie spezialisierte Bundesstaaten der USA, um herauszufinden, wer an einer sogenannten Arbeitsregion teilhat. Während einige staatliche politische Stellen die Berufe in Wissenschaft und Konstruktion auf Kosten der Arbeitnehmer in der produzierenden Industrie privilegiert haben, haben regionale Akteure in North Carolina das Beschäftigungsniveau in den Bereichen Konstruktion und Entwicklung erhöht und zugleich ihre Produktionsbasis im biopharmazeutischen Bereich ausgebaut, wobei die Ziele für Innovation und Gerechtigkeit aufeinander abgestimmt wurden.

**SCHLÜSSELWÖRTER**

Politik für produzierende Industrie; USA; Innovation; soziale Gerechtigkeit; Weiterbildung von Arbeitnehmern; Biotechnologie

**RESUMEN**

¿Quién trabaja en una región de trabajo? Innovación inclusiva en la nueva economía productiva. *Regional Studies*. Los académicos han documentado los beneficios económicos en las regiones que fomentan la industria de producción mediante la ubicación conjunta de actividades de innovación y producción. Sin embargo, no queda claro si los puestos de trabajo en la producción creados en este nuevo contexto incluyen también a los trabajadores con educación formal limitada. En este artículo comparamos los Estados de los EE.UU. que se especializan en empresas biofarmacéuticas para entender quién participa en la llamada región de trabajo. Mientras que algunos políticos estatales han privilegiado a las ocupaciones científicas y de diseño a expensas de la mano de obra de producción, los protagonistas regionales en Carolina del Norte han aumentado el empleo en diseño y desarrollo logrando a la vez un crecimiento de su base de producción biofarmacéutica y adaptando sus metas de innovación e igualdad en este proceso.

**PALABRAS CLAVES**

política manufacturera; Estados Unidos; innovación; igualdad social; formación de empleados; biotecnología

JEL D63, J48, J62, L65

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**INTRODUCTION**

After decades of passive tolerance for deindustrialization, manufacturing is enjoying a policy renaissance in the United States. Driving this policy shift is a growing recognition that production activities within the manufacturing sector are essential to national and regional economic growth and resilience. Not only is manufacturing the largest contributor to research and development (R&D) spending in the United States, but also recent analysis captures the importance of complementary production activities to the successful commercialization of scientific discoveries and the advancement of technological innovation. Recent studies of America's new production economy maintain that manufacturing – and specifically the production process itself – plays a large role in stimulating, accelerating and sustaining the economic innovation that builds national competitive advantage (Berger, 2013; Christopherson, 2009; Clark, 2014; Pisano & Shih, 2012). Furthermore, production jobs are now touted as drivers of innovation in their own right, and production workers are increasingly portrayed as 'knowledge workers' (Jemielniak, 2012).

Scholars have noted the economic gains for US regions that actively promote co-location of innovation and production activities and occupations, resulting in the *in situ* integration that Clark (2013) defines as a *working region*.

But the question remains open as to whether the production jobs created in this new context will be vehicles of economic stability and mobility for workers who begin with limited formal education. This paper explores the issue of what type of workers make employment gains in a so-called working region, recognizing that gains in employment resulting from the co-location of innovation and production do not inherently or automatically include blue collar workers. It focuses on US biopharmaceuticals, an industry characterized by geographical clustering in a few major states and subject to varied state-level policy approaches for guiding and motivating innovation (Bagchi-Sen, Lawton Smith, & Hall, 2004).

Using primary and secondary data on employment, occupational composition, job openings, and workers' educational attainment within the pharmaceutical and medicine manufacturing sector (NAICS 3254) in US states, the paper draws out three distinct labour market trajectories.<sup>1</sup> First, in states that historically dominated pharmaceutical research and production, namely New York, New Jersey and Pennsylvania, there have been significant employment declines in production occupations in the sector in recent decades, and slow or stagnant growth in non-production occupations. Second, states where pharmaceuticals emerged as a key industry in the mid-1980s with the shift from chemical-based drug manufacturing

to biotechnology – California and Massachusetts – have seen strong job gains in both research and design and production. Employment in these states, however, heavily favours workers with college degrees. The third trajectory is evident in an important hybrid case, the state of North Carolina. In recent decades, North Carolina has seen sizeable job growth in its biopharmaceutical sector, growing its base of production employment while also increasing employment in design and development. Unlike other states characterized by accelerated growth, however, it has also added jobs for workers at the lower end of the educational attainment spectrum. This paper shows how a network of intermediaries anchored by the North Carolina Biotechnology Center has successfully encouraged biotechnology and pharmaceutical firms to locate or initiate both production and design activities in the state and created a workforce development infrastructure that positions the state's existing manufacturing workforce for resulting production jobs.

Based on in-depth observation of this institutional assemblage, it is argued that North Carolina policy-makers have created a unique policy platform (Asheim, Boschma, & Cooke, 2011) that extends the traditional triple helix model of regional innovation (Etzkowitz & Leydesdorff, 1998, 2000). First, they have formulated an industrial recruitment strategy for the state in biopharmaceuticals that embraces manufacturing on a par with research and recognizes that knowledge creation inheres in the production process as well in the laboratory. As a result of incentive policies favouring the co-location of research and manufacturing activities, companies have been persuaded of the logic of locating both functions in the state. Second, policy-makers have incorporated workforce intermediaries, particularly community colleges, into the state's innovation system with the result that highly trained production workers make contributions to the innovation process from the shop floor. The institutional platform through which North Carolina policy-makers have accomplished balanced and interconnected growth between research and production jobs in a changing manufacturing economy is unusual in the US biotechnology sector, and embodies a strategy termed here *inclusive innovation*.

The paper is structured as follows. After a literature review summarizing major questions about jobs and work in the new innovation economy, it characterizes trends in the geography and occupational composition of firms in the focus industry: pharmaceutical and medicine manufacturing. The paper then presents the North Carolina case, and highlights the arguments about the state's exceptional approach to biotechnology innovation by presenting a more detailed comparison with the state of Pennsylvania, whose policy reorientation as it has moved from synthetic drugs into biotechnology privileges research over production. The paper ends by concluding that policy deliberately organized around promoting linkages between research and production can support a strategy aimed at making the benefits of manufacturing-driven regional growth more equitable and inclusive, providing well-paid employment to workers with a variety of educational pedigrees. It is

asserted that a strategy of inclusive innovation depends on the incorporation of workforce intermediaries into the mix of mediating agencies and institutions geared toward constructing place-based advantage in a particular industry sector.

## MAKING MANUFACTURING INNOVATION MORE INCLUSIVE

Renewed interest in and attention to manufacturing policy in the United States – whether manifested in President Barack Obama's announcement of a manufacturing revitalization strategy or in local governments' embrace of the 'maker' movement – is premised in part on the presumed role of the sector in creating opportunity for blue-collar workers (Helper, Krueger, & Wial, 2012; White House Office of the Press Secretary, 2013). Implicit in much of the contemporary discourse on manufacturing policy is the idea that, unlike sectors such as retail, hospitality and business services, manufacturing offers workers who do not possess bachelors' degrees a chance to earn middle-class wages. In announcing an assemblage of manufacturing-related policies in an appearance at a mining equipment plant in Asheville, North Carolina, in 2013 (held the day after the State of the Union Address in which he had unveiled his administration's manufacturing strategy), President Obama stressed the possibilities of new domestic manufacturing investment, combined with investments in workforce training, to produce secure, high-earning employment opportunities in US metropolitan regions. A White House fact sheet touts the administration's advanced manufacturing policy as a plan to 'make America a magnet for jobs'. In both the United States and Europe, academic and professional research has examined the potential for the re-shoring of previously internationalized production, as fluctuations in transportation and input costs prompt firms to re-evaluate their choices about which functions and processes to internalize and which to obtain at arm's length in the market (Bailey & De Propris, 2014; Kinkel, 2012).

Despite this optimism, evidence on the shifting technological dynamics affecting goods-producing enterprises (and on the strategic choices of their executives in the current political economy) suggests that in North America and Europe employment in engineering, research and product design *within* the manufacturing sector increasingly outstrips employment in production occupations (Bryson & Rusten, 2010; Van Winden, Van den Berg, Carvalho, & Van Tuijl, 2011). Doussard and Schrock (2015), analyzing the occupational composition of 29 US manufacturing industries between 1980 and 2010, find that each of them demonstrated a higher ratio of design to production workers in the United States in 2010 than 30 years earlier. Given automation, corporate consolidation and the offshoring of production work in the classic profit cycle dynamic identified by Markusen (1985), this stands to reason (see also Coe, Hess, Yeung, Dicken, & Henderson, 2004; Kemeny & Rigby, 2012). Design intensification also appears to have a regional dimension – in Doussard and

Schrock's (2015) analysis, regions with stable or growing employment in manufacturing had high design-production quotients, meaning that by a standardized measure, more successful regions had grown more design-intensive over time. In four of the top five regions by employment in the computer manufacturing sector, for example, design-production regional quotients increased between 1980 and 2010. The healthiest regions for manufacturing, in other words, specialize not only in growing or stable industries, but also in design or research (also known as 'innovation') functions within those industries. Thus, even within the manufacturing sector, traditionally a source of middle-class jobs, there is a growing risk that knowledge-intensity will widen income and wealth gaps.

This poses a challenge for policy-makers, if actions taken to increase the innovative capacity of manufacturing industries come at the expense of occupational access for job seekers with fewer economic and educational advantages. This policy tension ultimately suggests an opening for institutional interventions to support manufacturing growth in ways that reconcile gains in innovation with equity concerns around job access. The triple helix model of regional innovation specifies a mechanism of constructed regional advantage by which university research capacity, organized industry, and supportive government combine and overlap to generate surplus value (Cooke & Leydesdorff, 2006). Building from this, it is suggested that just as state and third-sector policy-makers are integrally involved in creating innovation systems that construct regional advantage through innovation, so too can they build systems that simultaneously promote inclusion within innovative industries.

As many scholars have pointed out, local and state actors and institutions influence firm choices – with respect to technology adoption, market strategy and employment practices – that affect industries' trajectories in particular places (Martin & Sunley, 2006; Schoenberger, 1987). Adding job access and inclusion to the list of regional development objectives has implications for the level and intensity of institutional intervention, as well as the nature of institutional coordination that might be necessary to influence firm and industry decisions in ways that integrate multiple, often conflicting, development objectives (Asheim et al., 2011). Studies of European efforts to promote sustainable economic development through 'smart specialization' have anticipated this policy challenge, noting that strategies in support of inclusive (and also sustainable) development require participation of institutional actors beyond those associated with the more standard triple helix approach to innovation (Carayannis & Rakhmatullin, 2014).

Scholarship on America's new production economy adds further institutional insight, noting which additional institutional actors and supports facilitate stronger connections between manufacturing and process innovation in key industrial sectors (Berger, 2013; Clark, 2014; Pisano & Shih, 2012). Still, we are at the early stages of understanding what this mediating institutional role might look like in shaping job access in the new production economy and in

particular how institutions may act with diverse workforce needs and educational profiles in mind. Clark (2014) argues that to participate effectively in current debates about the future of US manufacturing, scholars and policy-makers must take into account a 'regionally varied and industrial system organizing labour markets, supply chains *and* innovation' (p. 2; added emphasis). As this suggests, it is not enough only to focus on regional intermediaries that support innovation and supply chain integration. Instead, one needs to understand when and whether labour market intermediaries achieve equal status and influence to research hubs and supply chain aggregators as agents of the US manufacturing resurgence. This opens space for enquiry and especially for learning more from cases in which states and regions promote innovation as a core strategy for sustaining or reinvigorating production activities as they keep open a broad range of production-related employment opportunities.

The case of biopharmaceutical manufacturing in North Carolina represents a model under which institutions have coordinated their roles and activities to pursue strategies of inclusive innovation. To situate that case, the paper first presents an overview of employment, occupational and geographical trends in the US biopharmaceutical industry.

## US PHARMACEUTICAL AND MEDICINE MANUFACTURING: TRENDS IN INDUSTRY, GEOGRAPHY AND OCCUPATIONAL COMPOSITION

Although biopharmaceuticals is one of the most heavily studied industries in the regional policy field, few scholars have examined manufacturing activities within this industry, choosing instead to focus on the research-intensive activities that have accompanied the shift from chemistry to genetic engineering as the basis for product development. Scholars' emphasis on the laboratory over the shop floor is understandable; biopharmaceuticals is fundamentally and increasingly science driven, and the translation of knowledge from basic research through the development and commercialization of drugs and therapeutics is of great interest to those who study the innovation process. Much of the research dealing with life science innovation has not focused on pharmaceutical and medicine manufacturing (NAICS 3254) at all, but rather on firms occupying a newly added sector dedicated to scientific research in biotechnology, NAICS 541711. Contained in NAICS 541711 are R&D applications that take place in laboratories and specialized facilities that offer research services in recombinant DNA (rDNA), cloning, protein engineering or nano-biotechnology.

The near absence of pharmaceutical and medicine manufacturing from innovation scholarship is unfortunate as this industry segment continues to be a bright spot on the US manufacturing landscape in terms of employment. Between 1990 and 2006, while most manufacturing sectors shed jobs, employment in pharmaceutical and medicine manufacturing grew by 33% nationwide, from just over 217,000 to about 290,000 according to the quarterly census



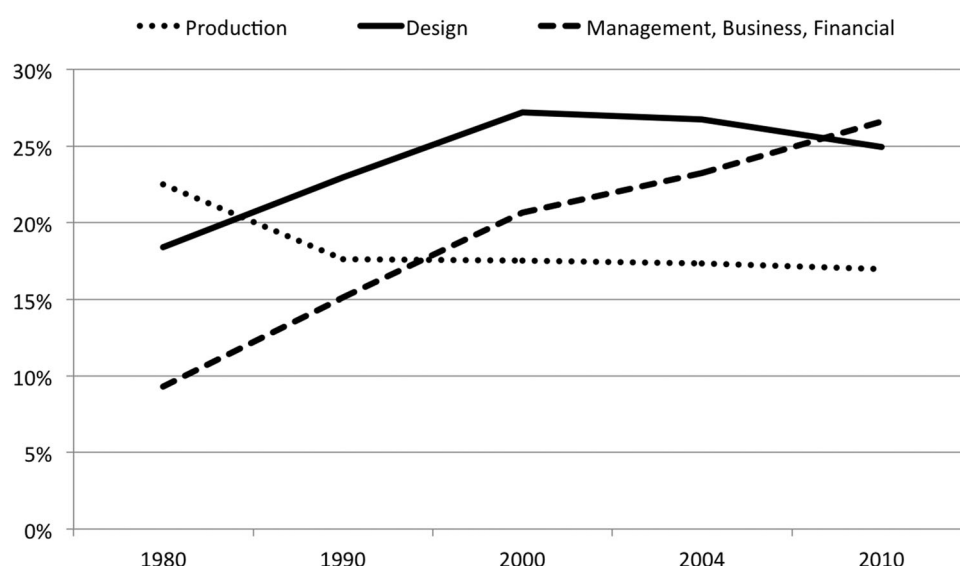
of employment and wages. While dropping slightly during the subsequent recession, employment in the sector exhibits strong growth since 1990.

Nevertheless, within the manufacturing industry classification of NAICS 3254, employment in production occupations is increasingly overshadowed by employment in other occupational classifications, whether research related, sales related or managerial (Figure 1). In other words, even within manufacturing facilities, employment is trending towards non-production occupations, with recent gains concentrated in management, business and finance.

Nationally, science and management occupations have come to predominate over direct production employment within NAICS 3254. But at a sub-national level there is more variation. An assessment of the biotechnology sector by Cortwright and Mayer (2002) identified nine dominant states containing regional concentrations in pharmaceutical and medicine manufacturing. This included traditional pharmaceutical manufacturing hub regions in New York, New Jersey and Pennsylvania, which benefited from first-

mover advantages, but also metropolitan areas in California and Massachusetts, whose specialization in pharmaceuticals owed much more to top-notch research capacity in molecular biology. Since the turn of the 21st century, venture capital investment, firm formation and employment growth have continued to favour these newcomer biotech states. Over time, the states in which the pharmaceutical industry first developed have shed production capacity and jobs, while newcomers possessing both active research institutions and a critical mass of small start-up biotechnology firms have consolidated growth.

Recent data from Battelle, a leading business analytics organization that specializes in bioscience industry analysis, illuminates this trend (Table 1). States with historic strengths in pharmaceuticals, namely New Jersey and Pennsylvania, have lost considerable ground over the past decade, experiencing absolute employment losses in biosciences driven by large employment declines in manufacturing. Between 2001 and 2012, Pennsylvania lost a full quarter of its jobs in the pharmaceutical and medicine



**Figure 1.** Changes in occupational composition, 1980–2010, NAICS 3254, United States.

Sources: US Census Bureau, American Community Survey; IPUMS-CPS, University of Minnesota. Retrieved from [www.ipums.org/](http://www.ipums.org/).

**Table 1.** Bioscience industry employment trends, 2001–12.

	Drug and pharmaceutical manufacturing (%)	Research, testing and medical laboratories (%)	Total bioscience industry (%)
<i>Growing or stable states</i>			
North Carolina	11 <sup>a</sup>	96	24
Massachusetts	15	52 <sup>a</sup>	15
California	13 <sup>a</sup>	43 <sup>a</sup>	13
<i>Declining/transitioning states</i>			
Pennsylvania	-25 <sup>a</sup>	19 <sup>a</sup>	-9
New Jersey	-30 <sup>a</sup>	2 <sup>a</sup>	-13
New York	-4	21	1

Note: <sup>a</sup>The state is ranked in the top four states for employment in 2010.

Sources: Battelle and BIO (2012, 2014). Reports retrieved October 16, 2015, from [www.bio.org/](http://www.bio.org/).

manufacturing sector, with New Jersey experiencing even higher employment declines, dropping by one-third. New York, another early leader in drug and pharmaceutical manufacturing, saw a slight (1%) jump in overall bioscience employment during the same period, but like its north-eastern neighbours, it experienced a decline in drug and medicine manufacturing, one that became even more pronounced between 2007 and 2012.

In comparison, California and Massachusetts – states that first entered the industry in the mid-1980s by building on research strengths in rDNA or biotechnology – experienced sizeable and sustained employment growth. The two newcomer states not only reported high growth in overall bioscience employment but also saw a significant uptick in pharmaceutical and medicine manufacturing jobs during the same period.

There is similar cross-state variation when it comes to job growth in bioscience research and testing (NAICS 541711) and medical laboratories (NAICS 62151). Historic pharmaceutical regions in the Northeast experienced slow employment growth in this area of the biosciences in the early 21st century; New Jersey saw only a 2% increase from 2001 to 2012, though New York and Pennsylvania fared better. In contrast, California and Massachusetts experienced massive employment growth in bioscience research and testing during this period, with Massachusetts gaining 13,500 jobs between 2001 and 2012 and California nearly 24,000 jobs. These states expanded in drug and pharmaceutical manufacturing while strengthening and consolidating their early lead in biotechnology research.

This geographical divergence suggests that in the biosciences sector, states in which companies had pioneered the then-new field of biotechnology research during the final decades of the 20th century were well positioned for bioscience growth (in both research and manufacturing) in the 21st century. Whereas some scholars drew on early evidence to predict a sustained spatial disconnect between biotechnology research and biomanufacturing (Bagchi-Sen et al., 2004; Gray, 2002), others argued that the collocation of biopharmaceutical R&D with production would encourage cross-pollination between the two and fuel rapid regional growth in places where design/production integration occurred successfully (Feldman & Ronzio, 2001). Employment trends in California and Massachusetts bear out the latter prediction. Reinforcing this point using more recent data, Pisano and Shih (2012) note that a subset of production jobs in biopharmaceuticals (especially those associated with biotechnology applications using cell and tissue culture, where California and Massachusetts continue to lead) are especially difficult to offshore. They and others argue that innovation in the manufacture of drugs and therapeutics (as well as other products with high innovation content) is strongly connected and symbiotic with the scientific research involved in originating those products.

A plausible interpretation of the pattern shown in Table 1 is that employment in the drug and medicine manufacturing sector has shifted geographically over time to concentrate in the regions exhibiting high growth in

biotechnology R&D. This interpretation is consistent with the argument that regional development strategies can only marginally affect firm location in the presence of market-driven locational forces (in this case, the pull of ‘new’ locations with roots in molecular biology over the cradles of chemical-based production), and with the argument that the forces of occupational change are similarly impermeable to policy intervention: while the pharmaceutical and medicine manufacturing sector is healthy, policy actors can do little to keep production jobs in the United States or in any particular region (Gray, 2002). The case of North Carolina, however, complicates this assumption. As indicated in Table 1, it has maintained steady employment growth in biopharmaceutical manufacturing establishments since 2000, at the same time that it has seen 96% employment growth in related R&D establishments (increasing from 10,000 to 19,000 jobs). This is notable because North Carolina, unlike California and Massachusetts, specialized early on in chemical-based production rather than molecular biology. Beginning in the 1930s, when pharmaceutical complexes in the Northeastern states were already mature, North Carolina began to attract large branch-plant facilities in pharmaceutical and chemical-based production and medical devices. By the early 1990s, Glaxo, Burroughs-Wellcome, Wyeth, DSM, Abbott, Merck, Weck Closure and Baxter had active branch plants in the state. One might then expect that because of this ‘outpost’ status, capital-intensification and automation trends, along with increased offshoring of routine production, would exert a negative impact on North Carolina’s biopharmaceutical manufacturing industry as it has done on those of Pennsylvania, New Jersey and (to a lesser extent) New York. However, North Carolina has experienced overall job gains since 2000. Surveys of US biotechnology clusters in 2012 and 2014 by Jones Lang LaSalle ranked the greater Raleigh-Durham area (where a sizeable share of North Carolina’s biopharmaceutical establishments are concentrated) fourth behind Boston, San Francisco and San Diego in terms of jobs and earnings growth, scientific discoveries, and commercialization of new products. Philadelphia, in contrast, ranked fifth in the survey in 2012, dropping down to seventh in 2014, while New Jersey/New York City/Westchester ranked sixth in 2012 and fifth in 2014 (Jones Lang LaSalle, 2012, 2014). North Carolina, with its diversified and expanding bioscience portfolio, represents a case with significant and sustained job growth across two sets of activities (research related and manufacturing) and across distinct technology specializations (chemical based and biological).

## AN INSTITUTIONAL COMPARISON OF NORTH CAROLINA AND PENNSYLVANIA

What explains North Carolina’s balanced pattern of job growth? To explore this further, this section compares the experience of North Carolina with that of Pennsylvania. As discussed above, Pennsylvania is representative of states with historic strengths in traditional pharmaceuticals.

It is also a state in which the authors have conducted independent qualitative research on the development of the life sciences industry, which enables one to build on prior knowledge to draw out historical and contemporary differences. The two-state comparison draws on several publicly available or proprietary sources of quantitative data: the American Community Survey, which allows for the decomposition of employment by occupation over time; Wanted Analytics for real-time information on job openings, searchable by NAICS, region and company; and the Quarterly Workforce Indicators dataset for state-level data on level and mix of educational attainment for an industry's workforce. These data are complemented with archival materials, including transcripts and summaries of in-depth interviews conducted with economic development practitioners and bioscience industry experts in each state. Interview data helps one to contextualize policy decisions identified through media accounts and published histories.

Pennsylvania has a legacy of leadership and innovation in pharmaceuticals, historically centred in the Philadelphia metropolitan region, which was the first biosciences hub in the United States. Feldman and Schreuder (1996) argue that this stemmed from multiple conditions – early advances in medical research and practice, expertise in pharmaceutical marketing, wholesaling and distribution, and leadership in manufacturing process technology – that conferred initial advantage and repeatedly prompted drug firms to innovate and adapt. In the latter part of the 19th century, an industrial corridor developed in New Jersey that united industry complexes in Pennsylvania and New York, and this mid-Atlantic cluster remained resilient through the 20th century, persisting in the face of shifts from botanical products to alkaloids and biologicals and, finally, to synthetic drugs (Feldman & Schreuder, 1996).

Pennsylvania's historic dominance in pharmaceutical manufacturing began to dissipate during the 1980s and 1990s. This coincided with a shift away from the fine chemistry and trial-and-error drug development historically practised by researchers in large drug companies and toward molecular biology and genetics as the basis for drug development (Cooke, 2004a, 2004b). This trend disrupted vertically integrated 'Big Pharma' companies, which merged or consolidated, laying off employees and contracting out many functions. Focusing on research, university partnerships and alliances with dedicated biotechnology firms (DBFs), large firms shed manufacturing capacity and bought start-ups rather than growing talent in-house.

Economic development policy-makers, meanwhile, focused on the government sector's role in commercializing university-based research, and on attracting and providing venture funding for R&D. Workforce policy focused almost exclusively on the training of high-level scientists and laboratory technicians (Wolf-Powers, 2012). Industry leaders and policy-makers in Pennsylvania did not conceive of the state's traditional strengths in manufacturing as an asset to the retention, growth or attraction of bioscience enterprises; in interviews, leaders of state and regional bioscience organizations and intermediaries expressed little

interest in biomanufacturing as a growth opportunity. A publication marking the 30th anniversary of the Ben Franklin Technology Partnership of Southeastern Pennsylvania (which places early-stage investments in life sciences companies) asserted its contribution to the region's innovation ecosystem but emphasized that ecosystem as a departure from the state's historical manufacturing specialization (Ben Franklin Technology Partners of Southeastern Pennsylvania, n.d.).

Pennsylvania has had some biotechnology development successes. Early biotech pioneers Centocor and Cephalon were founded in Pennsylvania in 1979 and 1987 respectively, and the region's scientific talent continues to be a significant asset (Devol, Yeo, Chaterjee, Bedroussian, & Wong, 2009). In recent years, the state has added new firms in NAICS 541711 (scientific research in biotechnology), partly due to the efforts of intermediaries focused on capital access and advising, such as the Ben Franklin Technology Partnership and BioAdvance. High demand and low vacancy in the University City Science Center in Philadelphia, new construction on the Route 202 Corridor in Bucks and Montgomery counties, and an emerging cluster associated with university-based research facilities in Pittsburgh indicate the continued strength of the state in R&D for the life sciences. However, this has not made up for a steady decline in the state's traditional employment base in pharmaceutical and medicine manufacturing.

North Carolina, in contrast, has sustained balanced employment growth in biosciences subsectors over time. At the centre of the North Carolina story is the state's Biotechnology Center, a quasi-public, state-funded organization. From its inception in 1981, the Biotech Center has adopted a range of strategies in support of high-paying job growth for recent university graduates (Feldman & Lowe, 2011). Equally important, it has helped pull down the bioscience career ladder so that it now includes 'rungs' for those with modest technical training beyond secondary education, including workers displaced from North Carolina's traditional manufacturing industries, textiles, furniture and tobacco processing (Lowe, Goldstein, & Donegan, 2011).

The Biotech Center has adopted three main strategies in its pursuit of workforce equity. In all cases, it functions as a mediating institution, bringing together a wide array of institutional partners – including educational and research institutions – that can offer customized workforce and innovation solutions for the state's diverse biopharmaceutical industry.

First are efforts to replace traditional pharmaceuticals jobs lost in industry mergers and consolidation (a trend that affected North Carolina much as it did Pennsylvania) by working closely with 'home-grown' bioscience firms designing and prototyping new products. For this set of bioscience start-ups, the Biotech Center provides a mix of grants, loans and technical assistance to help them develop in-house manufacturing capabilities. They also create an integrated institutional platform, through which entrepreneurial firms can access support for prototyping new products and to ensure quality as production is



brought to scale. A key institutional partner is the Biomanufacturing Training and Education Center (BTEC), a pilot manufacturing facility housed at North Carolina State University. In addition to helping research-oriented firms develop biomanufacturing capabilities, BTEC offers specialized workforce training and an access point for recruiting new employees.

The Biotech Center also offers a range of supports to incumbent manufacturing firms that wish to develop or expand internal R&D capabilities. Today, over 40% of all production-oriented establishments in North Carolina also conduct some form of in-house R&D or contract research. In many cases, the Biotech Center has been instrumental in helping North Carolina's established biomanufacturers secure financing and state-backed incentives to facilitate the integration of research with production.

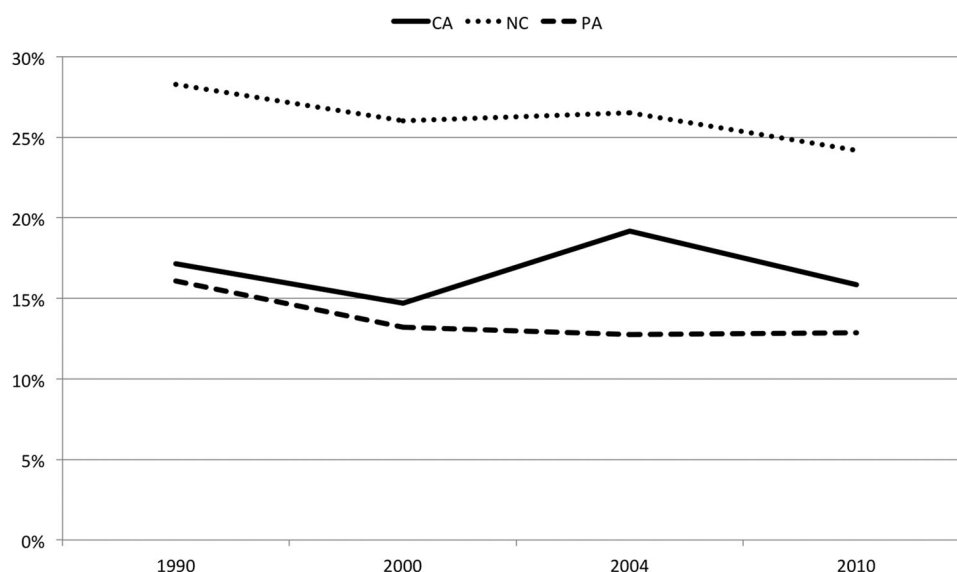
In addition to their focus on home-grown and incumbent firms, the Biotech Center also supports strategic industrial recruitment, targeting non-local firms building new manufacturing facilities (Lowe, 2014). Recent firm recruitments in biomanufacturing include large multinational biopharmaceutical firms, including Novartis and Merck; these two firms alone have created over 1000 new jobs in North Carolina since 2010. Biotech Center staff members have also successfully recruited smaller firms, like Canada-based Medicago, which sought a US location for vaccine manufacturing in order to secure government-sponsored contracts.

Outside firms are often drawn to North Carolina because of workforce quality, and not simply at the upper levels of higher education. The Biotech Center again is deeply involved, working in close partnership with the state's community college system to create a robust and flexible biomanufacturing workforce development infrastructure. The result is a customizable system that offers both classroom and job-site training. With this system in place, the Biotech Center and its partner institutions are

in a position to convince bioscience firms to relax standard hiring protocol and employ workers that have transferable manufacturing skills and experience but less than a four-year bachelor's degree (Lowe, 2007). In some cases, the Biotech Center and its community college partners have worked with traditional pharmaceutical firms that are shedding employees, helping support the transition of their incumbent production workforce to jobs in other high-growth facilities that depend on molecular-based production systems.

This workforce infrastructure has also facilitated process innovation in biomanufacturing, enabling firms to upgrade their production processes and keep their production workforce in step. Equally, the continued commitment of the Biotech Center and its institutional partners to support training and skill development across the employment and educational spectrum encourages biomanufacturers to tap production workers as partners in process innovation. As one example, Biogen used North Carolina as a global testing site for designing new biomanufacturing techniques involving disposable technologies and for implementing improvements in support of increased throughput and yield. Individuals overseeing this project at Biogen's manufacturing plant in Durham, North Carolina emphasized the essential contribution of shop-floor worker knowledge for identifying and solving production bottlenecks. In this regard, the Biotech Center is helping build an integrative institutional platform that expands job access as it promotes innovation practices that involve non-college-educated shop-floor workers.

This account of institutional divergence between North Carolina and Pennsylvania provides additional context for the interpretation of notable differences in occupational mix and growth rates in the two states (Figure 2). Nationwide, according to household data, 22% of the workers in the drug and medicine manufacturing sector (NAICS 3254) were employed in production occupations in 1980.



**Figure 2.** Change in production employment as a proportion of total employment, 1990–2010, NAICS 3254, selected US states. Sources: US Census Bureau, American Community Survey; IPUMS-CPS, University of Minnesota. Retrieved March 12, 2014, from [www.ipums.org/](http://www.ipums.org/).

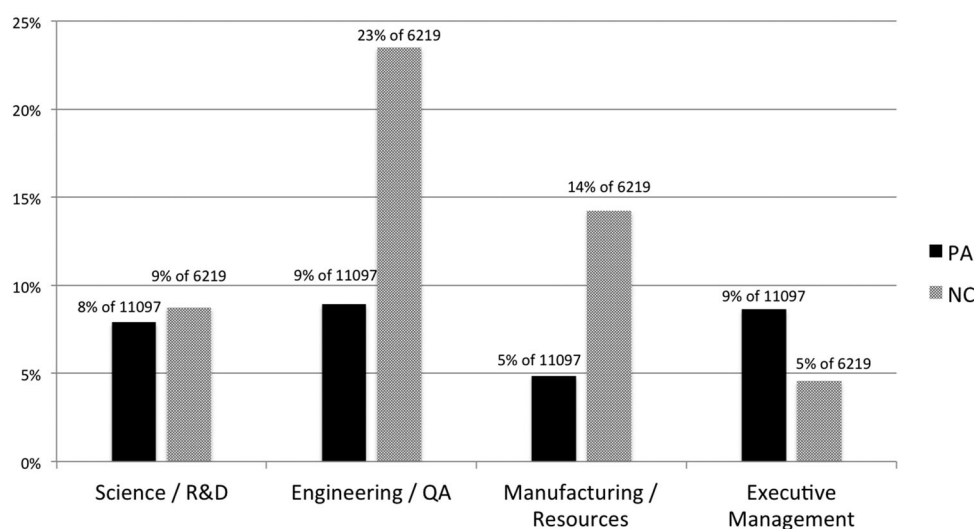
By 2010, this national production occupation ratio had dropped to 17%. Pennsylvania's production occupation ratio, at 22%, was equivalent to the nation's in 1980, but by 2010 this had declined to just 12.9%, well below the national figure. North Carolina was also heavily specialized in production occupations in 1980, and like other states, it too has seen a relative decrease over time in production employment as a proportion of total employment in biopharmaceutical manufacturing. However, absolute production employment in North Carolina has steadily increased over the decades, and production workers continue to account more than 30% of North Carolina's biopharmaceutical manufacturing workforce. Significantly, the total number of production-related jobs within North Carolina's drug manufacturing industry now surpasses Pennsylvania's, having grown from 6517 in 1990 almost 8700 in 2010. The industry's occupational composition in California, added for purposes of further comparison, is closer to that of Pennsylvania, although California, because the sector is larger there, has a higher absolute number of production workers.

Data from Wanted Analytics, a proprietary source of real-time information on job openings, also underscores the relative importance of production occupations in North Carolina. Figure 3 shows the top 20 companies within NAICS 3254 by number of jobs posted between May 2011 and June 2015. While Pennsylvania's top firms posted more openings overall, North Carolina firms were more likely to post manufacturing positions. The 871 jobs in manufacturing production identified in North Carolina represented 14% of all postings, whereas the 555 production jobs advertised in Pennsylvania accounted for just 5% of total openings. North Carolina firms seeking workers also posted more science (traditional 'innovation work') and engineering jobs (a combination of traditional innovation and manufacturing support positions) than Pennsylvania companies who were hiring. Only in

management occupations did Pennsylvania firms advertise more openings. This implies that compared with Pennsylvania, a larger share of the hiring in North Carolina's biopharmaceutical cluster over the past several years has been centred on production, production-support and innovation occupations. This lends support to the claim that in North Carolina, production and innovation work are symbiotic and mutually constitutive.

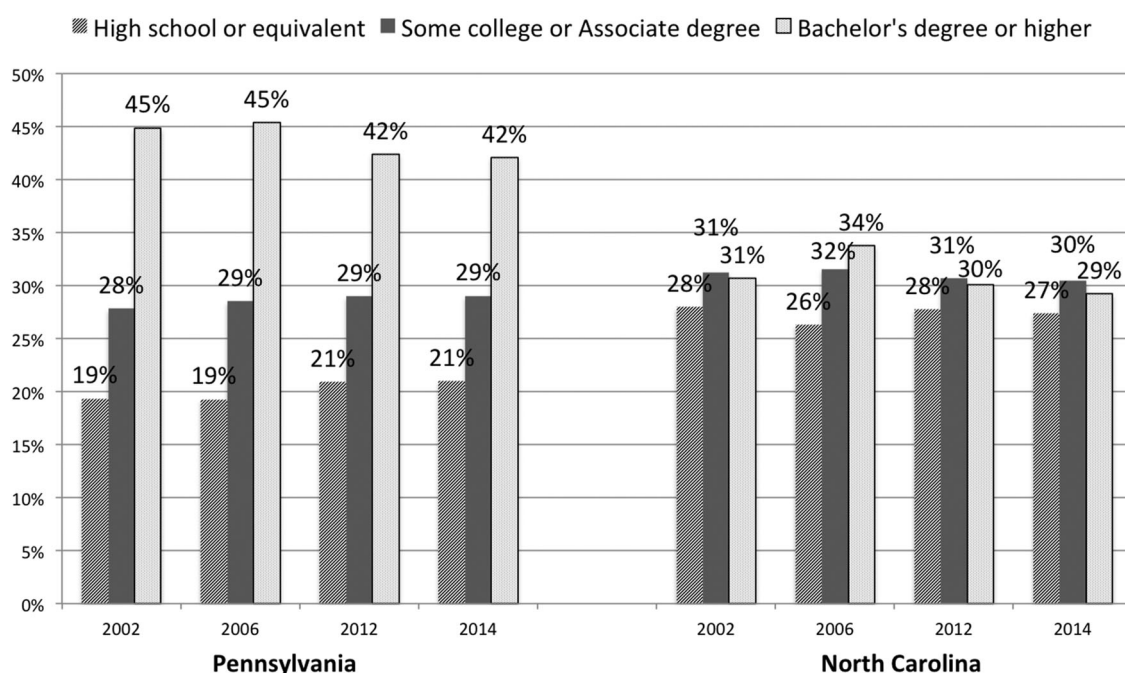
Finally, the equity dimension of this case comparison is demonstrated in Figure 4, which draws on Quarterly Workforce Indicators data from the Longitudinal Employer–Household Dynamics survey. Compared with Pennsylvania's, North Carolina's biopharmaceutical manufacturing industry employs significantly more moderately educated workers than its peers. In 2012, for example, more than 40% of Pennsylvania's workforce in the sector possessed a bachelor's degree or higher credential, while only 25% of the sector's workforce had a high-school degree or less. In contrast, about 30% of North Carolina's biopharmaceutical workers held college or graduate degrees, while 35% had high school equivalency or less, and another 30% had associates degrees or some college. This trend is consistent over the period (starting in 2000) for which data are available. North Carolina's workforce in bioscience occupations is also more diverse educationally than in any of the other comparison states examined.

There is little question that drug manufacturers were initially attracted to North Carolina by affordable green-field property (real estate), low-cost labour and low taxes – the classic elements of a 'branch plant' strategy (Markusen, 1985, 1987). However, as noted above, the institutional role of the Biotech Center, and particularly its support for cross-fertilization between research/design and production, is also an explanatory factor in the growth of both biomanufacturing and life science research in the state. As a quasi-public, state-funded organization, the Biotech Center convinced pharmaceutical companies to



**Figure 3.** Job openings advertised by the top 20 drug and medicine manufacturing companies in North Carolina, November 2011–July 2015.

Sources: Wanted Analytics. Historical Hiring Data for Pharmaceutical and Medicine Manufacturing in North Carolina (NAICS 3254). Retrieved November 11, 2015, from [www.wantedanalytics.com/](http://www.wantedanalytics.com/).



**Figure 4** . Education by percentage of workers, pharmaceutical medicine manufacturing, NAICS 3254.

Sources: US Census Bureau, Quarterly Workforce Indicators Data. Employment totals in private firms in NAICS 3254, Pharmaceutical & Medicine Manufacturing by firm size (all inclusive) and employee level of education (three distinct categories). Longitudinal Employer–Household Dynamics Program. Retrieved August 25, 2015, from <http://ledextract.ces.census.gov/>.

build both production and research capacity in the state, helped home-grown bioresearch establishments to move into production, connected production and R&D capabilities, and encouraged firms to harness the knowledge and expertise of the production workforce regardless of formal educational experience. This has certainly yielded high-paying jobs for recent university graduates, including those with advanced academic degrees in biological sciences and engineering, fulfilling the Biotech Center's mission. Equally important, it has helped extend quality employment opportunities to those with modest technical training beyond secondary education.

This research suggests that differences in motivation and especially institutional capacity and coordination help to explain a divergence in outcomes for Pennsylvania and North Carolina over the past decade. This divergence hints more broadly at opportunities for policy influence over activity location and intensification, suggesting that at least with respect to biotechnology it has been possible to construct policies that help achieve balanced employment growth in production and research/design while maintaining manufacturing production work as a pathway into the middle class for people without four-year college degrees – a policy stance that is called here 'inclusive innovation'.

## IMPLICATIONS FOR POLICY AND FURTHER RESEARCH

Regional studies scholars have documented the benefits to regional economies when innovation is embedded within the production space itself, and when production activities

are located in close proximity to product and process design (Christopherson, 2009; Clark, 2014). No longer dismissed as a less valuable second cousin to design/R&D work, production jobs are now touted as drivers of innovation in their own right. As noted above, however, depending upon a strengthened association between production and design as the basis for manufacturing employment growth presents an equity dilemma. Under the new paradigm, jobs may be out of reach for workers lacking college degrees, and this may be particularly true given the demise of internal training and career ladders that once tied skill development to ongoing exchanges and opportunities at the workplace (Applebaum & Batt, 1994; Osterman, 1999). Clearly, renewed focus on the complementarity of design and production activities not only impacts the geographic future of manufacturing work but also influences which sets of workers have access to it.

The case of North Carolina demonstrates the potential for regional institutions to prevent or mitigate labour market exclusion by encouraging the co-location of research and production activities in ways that prompt companies to create production jobs within the United States while positioning workers with technical credentials (but not necessarily advanced degrees) to obtain those jobs. By posting employment growth in biomanufacturing in addition to research, North Carolina has shown (along with California and Massachusetts) that bioscience-specialized regions can add jobs in manufacturing while staying on the cutting edge of innovation. North Carolina's case, however, shows that the creation and deployment of institutional resources can also drive favourable equity outcomes. Combined with investments in training, the North Carolina

Biotech Center's project of recruiting manufacturers and encouraging them to tightly couple research and production activities resulted in the growth of (and quick replacement of losses in) high-paying employment for moderately educated production workers.

This analysis of the North Carolina case leads to two conclusions relevant to firm strategy and public policy. First, from a firm strategy perspective, it confirms that co-locating R&D with manufacturing and encouraging cross-pollination between them can enhance innovation and promote growth (Clark, 2013; Feldman & Ronzio, 2001). Second, it suggests that organizing a deliberate policy strategy around the linkage of research and production can also support an equity function. Most notably, we find clear evidence in North Carolina of a strategy of *inclusive innovation* aimed at sharing the benefits of regional growth in ways that ensure less educated workers are not displaced by innovation, but rather are given an opportunity to contribute to its development by securing access to productive spaces and occupations.

This empirical analysis of the North Carolina case offers insights for other regions that are seeking to advance social mobility through their support for innovative manufacturing. Firstly, it suggests that strategies of inclusive innovation may require institutional arrangements at the level of the state or region, where human capital interventions have been found to play important roles in promoting systems of innovation and reducing barriers to competitiveness (Bagchi-Sen et al., 2004; Lawton Smith & Waters, 2011). In biotechnology and other innovative industries, state policy actors, including educational organizations and systems, often exert influence on the nature and character of manufacturing growth, and the choices they make have significant implications for job access, especially for less educated workers. In this regard, involvement of educational institutions should not be limited to just those engaged in graduate training or cutting-edge research – institutions that in isolation might foreclose job access and thus exacerbate regional inequity. Rather, from an equity perspective, there is added value to involving a broader array of educational institutions, including technical and community colleges, that represent the interests of a wider segment of the regional population and workforce. These institutions can be especially helpful in shaping firm-level decision-making, by encouraging innovative manufacturing firms to be more inclusionary with respect to internal policies around hiring, training and career advancement. Evidence from this case and elsewhere suggests that, with such encouragement, decision-makers within firms come to recognize that more inclusive practices can also reinforce innovative and absorptive capacity (González, Miles-Touya, & Pazó, 2016).

This gets to a second, related implication: the need to think more critically about what is meant by valuable knowledge in the context of regional innovation. Studies of regional innovation systems often parse out of types of knowledge, using broad categories like analytical, scientific, synthetic or technical to denote differences in cognition and applied expertise (e.g., Asheim & Coenen, 2005).

But there is considerable risk that these categorizations can lead to normative assumptions about what types of knowledge may be more vital to processes of regional innovation, and that groups of workers associated with certain knowledge types might be cast aside and presumed inferior. As regional actors make advances on both the equity and innovation fronts, there may be value in relaxing some of these rigid categories, looking opportunistically for interventions that promote knowledge sharing and creative collaboration across portions of the workforce that are normally kept segmented and out of communication with one another. In this regard, regional innovation policies might draw insights from studies of organizational management and related research that looks at the institutional and organizational settings that facilitate innovation by bringing together groups of individuals who offer diverse perspectives, experiences and interpretative frameworks (Bechky, 2003; Lester & Piore, 2009; Stark, 2011).

This speaks as well to future research and especially the need to consider both institutional variation *and* coordination. Recent arguments in support of more inclusive approaches to regional economic development have noted the value of having a wide variety of institutional actors in the policy mix (Clark & Christopherson, 2009; Summers & Balls, 2015). But if policy-makers treat equity and innovation as concurrent yet separate development objectives, there is risk of further social stratification within the regional economy – with equity policies narrowly focused at the bottom of the labour market while innovation policies focus on the well-educated. For example, if they limit their equity objectives to increases in the minimum wage, policy-makers may be foregoing opportunities to initiate actions that promote social mobility through the reconceptualization of innovation.

In this regard, the North Carolina case suggests an opportunity for further research on the role mediating institutions play in intentionally forging and re-forging connections between policies in simultaneous support of innovation and inclusion. In North Carolina's Biotechnology Center, one finds an example of a workforce-centred institutional 'policy platform' – an integrating governance mechanism that brings together a variety of local institutional actors with the goal of 'joining-up' diverse interests and perspectives (Cooke, 2007; see also Boschma, 2014). In this and other regional contexts, the policy challenge in support of inclusive development, as Asheim et al. put it, 'involves transitioning from the waning into the waxing opportunity by "constructing advantage" through engaging "differentiated knowledge bases" – including incumbent worker knowledge bases – in the moulding of regional platforms' (Asheim et al., 2011, p. 901). Necessary components of and conditions for regional and state policy platforms that support inclusive innovation would seem to be a worthy object for future investigation.

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## DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

## NOTE

1. NAICS = North American Industry Classification System.

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