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Patterns of nanotechnology innovation and governance within a metropolitan area



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ABSTRACT

The present study employs a real-time, practice-oriented, and place-based approach to dissect the process of nanotechnology innovation in support of novel governance schemes. The research question is: What are actors specifically doing in the process of nanotechnology innovation in a metropolitan area, and what are enabling and constraining drivers that could be leveraged for novel governance approaches? The study presents results from 45 interviews and a synthesis workshop with actors from academia, industry, government, and the civil society in Phoenix. Results show that actors follow preconceived mental models of innovation with the primary objective to deploy profitable commercial or military products. The dominant network actors are academics, industry, and government funding agencies. The network is divided along product-based sectors with few cross-sector linkages. Considerable governmental support for entrepreneurs and for academic research via the National Nanotechnology Initiative enables nanotechnology innovation in the early stages. Market failures and corporate barriers, however, constrain the value proposition in later phases. There is novelty in the nanotechnology products; yet, little attention is paid to consumer input, adverse effects, or broader public value generation.

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1. Introduction

Cities across the United States currently face a diverse set of challenges from economic stagnation to aging populations and from increasing energy demands to environmental degradation. Technology is commonly used to address some or all of these challenges, including new and emerging technologies, such as nanotechnology [1]. City officials, university researchers, healthcare providers, economic development agencies, private investors and others shape how technologies emerge in the city through decisions taken in the course of their daily activities. Government agencies can regulate laboratory practices in

cities, university partnerships with local healthcare facilities offer an opportunity to explore novel technologies, and investors can lure entrepreneurs into moving in or away from a city.

Traditionally, innovation studies focus on specific technological sectors and innovation processes from a macro perspective. Abernathy & Townsend [2] followed innovations in railroad and computer technology with historical analysis. To better understand current activities, scholars have more recently shifted to contemporary studies that address the governance of emerging technologies. Scholars most often analyze national and international level decision-makers [3]. Those levels are often disconnected from places where practical decisions are taken on a daily basis in regional innovation systems [4]. Innovation studies connected to practice often focus on single regulations – e.g. Jaffe [5] explores the influence of the Bayh-Dole Act. Others have focused on isolated

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actors – e.g. Fisher's [6] work with laboratory scientists. Still others focus on transition points between phases – technology transfer from universities to the private sector [7].

However, this body of literature has not taken a holistic approach to couple these “real-world” perspectives including: addressing real-time innovation processes, focusing on the actual decision processes, connecting to the places where they happen and play out. New concepts such as real-time technology assessment [8], practice-oriented analytical approaches [9], place-based technology development [10], and whole product design [11] provide guidance for how to overcome the outlined deficits. A real-time perspective to technology assessment helps to overcome delays between technological innovation and governance efforts [12]. The practice-oriented analytical perspective is based on the obvious fact that innovation happens through people, their decisions and actions within their spheres of influence [9]. From here, we argue that if innovation ought to happen somewhat differently (with somewhat different decisions and actions), namely in more anticipatory and responsible ways, we first need to know *who is doing what (and why) within the innovation process*. The place-based perspective centers on places as ‘hubs’ where people interact and are ‘invested’ in life and work; where similar socio-cultural and socio-political forces reign; and where emerging technology arise and transform society. The holistic approach shifts attention away from specialization and segmentation of innovation to a model that accounts for all stages of innovation (c.f. chain-link model Kline & Rosenberg [13]) and thereby allows for more systemic analyses to avoid blind spots by understanding the previous and ensuing consequences of technological innovation.

This study addresses the following research question: What are actors specifically doing in the process of nanotechnology innovation in a metropolitan area, and what are enabling and constraining drivers that could be leveraged for novel governance approaches? This is an intermediate question, which creates the basis to explore how to co-construct governance arrangements and enable responsible innovation [10]. The study applies a simplified framework from institutional analysis [14,15]. The *who*-question identifies key actors, defined as stakeholders with critical roles in the innovation system, and their positions within the nanotechnology innovation process. The *what*-question draws out the activities (decisions, actions, or reactions) performed by the actors. The *why*-question teases out constraining and enabling forces that drive actors to take the actions they take. And all of these questions are addressed from a real-time, place-based, and holistic perspective as outlined above – with the ultimate goal to explore how constraining and enabling forces and actor collaboration could be changed and complemented in ways that would enhance innovation activities in anticipatory and responsible ways. We conducted and analyzed data from 45 interviews and an interactive review workshop with a sub-sample of the interviewees.

Cities have been the nexus of creativity, technical and non-technical innovation, as well as wealth generation for millennia [16]. Hundreds of cities are fostering cultures of innovation, drawing talent, economic opportunity, and

recognition to their place in the world as regional innovation centers [17]. Yet, a counter argument to our place-based study could be that emerging technologies are not emerging in *one* place and are, in fact, being shaped by national, international, and even global processes and networks [18,19]. Our approach is not blind to the broader forces operating at higher levels (from a multi-level perspective) than cities, and therefore allows for activities occurring outside this boundary to be captured. Despite a leaky boundary between cities and the broader world, cities continue to be proven leaders and catalysts for regional innovation clustering and economic success [20–22]. Florida [23] points out that a city's “creative economy” is a critical success factor for career options. This reinforces the point that social networks (while maintained in virtual spaces) are forged in real places of learning, recreating, and working – all of which happens in the city.

Nanotechnology, the chosen unit for this study, is an agglomeration of nanoscale science and engineering activities funded by the U.S. National Nanotechnology Initiative [24]. This has resulted in the U.S. Patent and Trademark Office (USPTO) creating a new classification for patents that leverage nanotechnology [25]. Additionally, the search terms that defined by Porter et al. [26] can describe a significant increase in peer-reviewed publications that draw together a diversity of disciplines that intersect with nanotechnology as a common denominator. Further, Youtie & Shapira [27] demonstrate the connection of nanotechnology patenting and publishing with urban innovation clusters.

Metropolitan Phoenix was selected as a case study for several reasons, substantive and pragmatic ones. The first was pragmatic as metropolitan Phoenix offered a unique opportunity for frequent engagement between local actors and researchers to enhance the collaboration, networking, and collective reflection process. Second, city leaders in metropolitan Phoenix are seeking to revitalize the economy by clustering high-technology companies as suggested by Felbinger & Rohey [21]. Third, Phoenix is one of the top thirty nanodistricts in the U.S. [27] and more recently was ranked 18th out of the 358 metropolitan regions surveyed for patents between 2007 and 2011 [28]. The survey results indicate that nanotechnology innovation activities, such as research and development (patents), are elevated in urban areas, which are hubs of knowledge sharing, corporate R&D, and academic research [28]. Fourth, metropolitan Phoenix is home to city, county, and state levels of government involved in technology funding and regulatory activities. Fifth, Arizona State University launched an effort to create a “New American University” with a strong commitment to generate use-inspired knowledge to help solving problems in metropolitan Phoenix [29]. Finally, there are several university partnerships that allow for in-depth analyses of nanotechnology innovation in metropolitan Phoenix, involving, for example those universities, healthcare facilities and private research laboratories fostering personalized genetic medicine. Additional partnerships are dedicated to the research, development and production of nano-enhanced solar energy. There are also collaborative activities that directly explore governance

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