



FROM THEORY TO PRACTICE: What Policies Can Prepare Regions for the Challenges and Opportunities Associated Disruptive Technologies?



Broadening innovation policy: New insights for cities and regions

**From Theory to Practice:
What Policies Can Prepare Regions for
the Challenges and Opportunities
Associated with Disruptive Technologies?**

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Background information

This paper was prepared as a background document for an OECD/EC high-level expert workshop on “Developing strategies for industrial transition” held on 15 October 2018 at the OECD Headquarters in Paris, France. It sets a basis for reflection and discussion. The opinions expressed and arguments employed herein do not necessarily reflect the official views of the OECD or of its member countries, or of the European Union. The opinions expressed and arguments employed are those of the authors.

Broadening innovation policy: New insights for regions and cities

The workshop is part of a five-part workshop series in the context of an OECD/EC project on “Broadening innovation policy: New insights for regions and cities”. The remaining workshops cover “Fostering innovation in less-developed/low-institutional capacity regions”, “Building, embedding and reshaping global value chains”, “Managing disruptive technologies”, and “Experimental governance”. The outcome of the workshops supports the work of the OECD Regional Development Policy Committee and its mandate to promote the design and implementation of policies that are adapted to the relevant territorial scales or geographies, and that focus on the main factors that sustain the competitive advantages of regions and cities. The seminars also support the Directorate-General for Regional and Urban Policy (DG REGIO) of the European Commission in their work in extending the tool of Research and Innovation Strategies for Smart Specialisation and innovation policy work for the post-2020 period, as well as to support broader discussion with stakeholders on the future direction of innovation policy in regions and cities.

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Executive summary

1. The prospects for designing and implementing effective innovation policies capable of managing the rate of technological change anticipated are perhaps better than many analysts suggest. Since the 1990s, the gradual transition away from the historical post-war model of national-scale science and technology policies in most OECD countries has led to policy innovations beyond the traditional investments in basic research capacity largely irrespective of geography, scale, and regional variation in industrial and technological capacities. Instead, there has been a growing recognition of regional and local innovation *systems* involving firm networks, local institutions, and embedded assets and capacities (Morgan 2004). This focus has prioritized empirical analysis of the processes of knowledge diffusion and the subsequent design of policies to support those processes.

2. Policy responses to the rapid diffusion of technological change generally work towards two goals: mitigating the negative impacts of the resulting industrial transitions on places and people (job loss, deindustrialization) and facilitating the absorption of the new technologies through skill development, entrepreneurship programs, incubator and accelerator programs, and technology transfer activities. Disruptive technologies promise to produce new industries by developing new products and reaching new markets. However, disruptive technologies are also “enabling” or “process” innovations like additive manufacturing, artificial intelligence, machine learning, robotics, internet of things, and nanotechnology that affect multiple sectors and markets. Further, the revenue models for these technologies are additionally disruptive often relying on innovations in advanced business services including consumer and industry financing, marketing, advertising, and connectivity. All of these factors lead to uncertainties about which industries and firms (and places) will benefit from the proliferation of these technologies and which will need to 1) invest substantially in managing technological transitions, and 2) redesign appropriate governance strategies.

3. This paper reviews the two dominant policy paths that have emerged to manage the diffusion of enabling technologies at the regional scale in recent decades. The first is an administratively centralized approach, which relies on the model of research centers that developed in national innovation systems during the post-war period to implement regional innovation strategies. The second approach focuses on the regional-scale implementation of specific policies understood to facilitate the absorption of new technologies (entrepreneurship, education and training, shared services, technology transfer, infrastructure investments). The paper then identifies two challenges that these models face as disruptive technologies take shape: first, the role of “use cases” like autonomous vehicles, in framing the economic and social impacts of new technologies (and defining the scope of public investment) and second, the growing importance of governance of platform technologies (notably data and connectivity) in shaping the trajectory of disruptive technologies.

4. The scope of the actual and potential impact of disruptive technologies is remains quite broad. Disruptive technologies are arguably different because these technological innovations are diffusing into a global economic system in which the financialization of innovation is more developed and less managed than in previous periods. And, further, the implications for disruptive impact are amplified by the extent of the variation between

places in terms of the characteristics of both varieties of regional innovation systems and regional variations in underlying and existing industrial systems (regional specializations, labor skills, global value chains, etc.). Therefore, ascertaining the impacts of disruptive technologies on particular places is an imprecise task. However, what is clear is that managing disruptive technologies is likely to require a dynamic policy response tailored to local conditions and capable of adapting to the introduction of technologies that simultaneously disrupt the systems that govern and support innovation policies and practices and the industries that apply, integrate, and emerge from technological innovations.

1. Background: Policy Transitions and Disruptive Technologies

5. Much of the discussion of disruptive technologies and their impacts and implications has focused on the technologies themselves (Woetzel et al. 2018; Manyika et al. 2013). The emphasis on these technical specificities has often obscured *the need for* and *the details of* a corollary conversation about the management of these disruptive technologies (and their impacts and implications) across multiple sectors and a variety of places. Among the missing factors in these conversations about the implications or technologies like artificial intelligence, cloud computing, the Internet of Things, and others is a recognition that technological development --- research and development through commercialization --- is currently a *managed* process. There are now, and have been for the better part of the post-war period, both national and regional systems of governance and management of the innovation processes facilitating research, development, and discovery across the private and public sectors. And further, these systems are dynamic (McCann and Ortega-Argilés 2015). The policies, institutions, and relationships that govern and support technological development are under constant revision --- adjusting for scale and scope and in response to shifting public sector priorities and private sector practices.

6. In the context of a new set of disruptive technologies, the question then is what is particularly distinct or novel about these technologies and how that difference affects the existing policies and practices facilitating and supporting innovation. And further, what the difference means to the design of effective innovation policies in a technological, social, and economic environment that is distinct from the previous period.

7. The challenge for innovation policies then is to consider the ramifications of disruptive technologies within the context of a set of existing economic and social conditions. In the absence of this conversation about disruptive technologies, there is already an extant debate about whether the current system of national and regional innovation policies is effectively integrating sustainability and equity goals or adequately contributing to productivity gains or labor market upgrading. In other words, before the conversation about the technical specificity of disruptive technologies even begins, there are substantial gaps in the ability of the incumbent innovation system to address the economic and social goals articulated by organizations such as the OECD as necessary for sustainable and equitable economic growth.

8. In discussions about disruptive technologies, the emphasis is often placed on their potential economic value. Determining that value, of course, is a complicated proposition for many reasons not the least of which is the recent evolution of new instruments for speculative investment. To no small extent, a substantial tier of the value of disruptive technologies lies in their *perceived potential value* separate and apart from their ultimate applications (OECD 2013). That speculative value, as well as the ultimate applied value, has spatial implications and differential impacts for cities and regions.

9. The scope of the actual and potential impact of disruptive technologies is consequently quite broad. Disruptive technologies are arguably different because these technological innovations are diffusing into a global economic system in which the financialization of innovation is more developed and less managed than in previous periods. And, further, the implications for disruptive impact are amplified by the extent of the variation between places in terms of the characteristics of both varieties of regional

innovation systems and regional variations in underlying and existing industrial systems (regional specializations, labor skills, global value chains, etc.). Therefore, ascertaining the impacts of disruptive technologies on particular places is an imprecise task. However, what is clear is that managing disruptive technologies is likely to require a dynamic policy response tailored to local conditions and capable of adapting to the introduction of technologies that simultaneously disrupt the systems that govern and support innovation policies and practices and the industries that apply, integrate, and emerge from technological innovations.

2. Recent Progress in the Design and Practice of Innovation Policy

10. The prospects for designing and implementing effective innovation policies capable of managing the rate of technological change anticipated are perhaps better than many analysts suggest. Since the 1990s, the gradual transition away from the historical post-war model of national-scale science and technology policies in most OECD countries has led to policy innovations beyond the traditional investments in basic research capacity largely irrespective of geography, scale, and regional variation in industrial and technological capacities. Instead, there has been a growing recognition of regional and local innovation *systems* involving firm networks, local institutions, and embedded assets and capacities. This focus has prioritized empirical analysis of the processes of knowledge diffusion and the subsequent design of policies to support those processes.

11. Policy responses to the rapid diffusion of technological change generally work towards two goals: mitigating the negative impacts of the resulting industrial transitions on places and people (job loss, deindustrialization) and facilitating the absorption of the new technologies through skill development, entrepreneurship programs, incubator and accelerator programs, and technology transfer activities. Disruptive technologies promise to produce new industries by developing new products and reaching new markets. However, disruptive technologies are also “enabling” or “process” innovations like additive manufacturing, artificial intelligence, machine learning, robotics, internet of things, and nanotechnology that affect multiple sectors and markets. Further, the revenue models for these technologies are additionally disruptive often relying on innovations in advanced business services including consumer and industry financing, marketing, advertising, and connectivity. The revenue models are particularly complex due to the interlinked valuations of the necessary data and services, which enable the products, platforms, and systems produced by the disruptive technologies. All of these factors lead to uncertainties about which industries and firms (and places) will benefit from the proliferation of these technologies and which will need to 1) invest substantially in managing technological transitions, and 2) redesign appropriate governance strategies.

2.1. Understanding Enabling Technologies

12. In addition to a shift towards understanding innovation as a process and a system (or set of systems) involving multiple actors and varying across sub-national contexts --- by economic and institutional contexts not simply as a result of national governance --- there has been a shift towards thinking across and beyond sectoral boundaries. Perhaps most evident in the evolving policy treatment of software development since the 1980s, innovation policy has progressively adapted to the role of *enabling technologies* in seeding new industries and expanding and enhancing capacities within incumbent industries (Markusen, Hall, and Glasmeier 1986).

13. Initial analyses of the software industry positioned software as just that --- and industry. Using industry studies analytical techniques honed on traditional industries such as autos and steel, researchers and policy makers first viewed software through a lens they understood. It was only later that the complexity of software as a series of emerging and enabling technologies that would --- and indeed has --- transformed sectors was widely recognized. Although the analysis of emerging and enabling technologies in terms of implications and impacts is not routinized, it is now far better understood. As enabling

technologies have garnered increasing attention because of their value to incumbent industries as well as their ability to initiate new markets and new products, analysts and policymakers have also expanded the scope of innovation policies to think beyond product innovation to better understand and support process and materials innovations.

14. In addition to software, photonics is another example of the progressive engagement and growing focus of innovation policies on enabling technologies (Christopherson and Clark 2007b; Clark 2013; “Photonics in Europe: Economic Impact (2007) European Technology Platform Photonics 21 (EU)” 2007; “The Leverage Effect of Photonics Technologies: The European Perspective” 2010). In the 1980s and 1990s, as the optics and imaging industries were experiencing significant transformations across consumer and industrial markets as well as in the industry’s global production network, few policymakers identified photonics as an enabling technology capable of disrupting the industry and shifting its spatial organization. The attention of policy makers was focused on international competition affecting the large, incumbent firms in the existing industry (Sternberg 1992). It took decades for policymakers intent on salvaging a high-tech, high-wage, technologically-intensive, advanced manufacturing industry to shift from an industry-specific economic development strategy to a targeted-technology innovation policy (“Towards a Bright Future for Europe: Strategic Research Agenda in Photonics” 2006; Photonics21 2017).

15. If we take this one technology/industry category as an example, we can illustrate the relationship between scientific research and regional policy and the challenge established national innovation systems face in integrating the two. The optics and photonics industry serves as an example of the broader point about regional innovation systems and the role of urban research centers. The photonics industry is a merger of a high-tech enabling technology, photonics, and the continuing evolution of a traditional manufacturing industry, optics and imaging. Photonics technologies are broadly understood as the science and engineering of generating and transmitting light (photons). The industry involves products and components associated with this science. While the current photonics industry does not include all optics manufacturing, it is inclusive of a wide range of end products and intermediate components including optoelectronics. Although the industry is research and development intensive, it also has an established manufacturing capacity.

16. Both in the US and internationally, the photonics industry tends to be highly agglomerated in city-regions with pre-existing optics and/or imaging production specializations as well as photonics research capacity (Christopherson and Clark 2007b; Clark 2013; Maryann Feldman and Lendel 2010; Hendry and Brown 2006; Hendry, Brown, and Defillippi 2000; Miao and Hall 2012). These regions include Ottawa, Montreal, and Quebec City in Canada; Jena in Germany; and Rochester, New York and Tucson, Arizona in the United States. This tendency to co-locate in particular regional economies makes photonics an emblematic case of the industrial cluster model as it pertains to technology-intensive enabling industries (Karlsson 2008). Evidence from this industry also provides indicators of the concentration of scientific research in areas with universities and established high-tech regional labor markets (Chapple et al. 2004; Etzkowitz and Leydesdorff 1997; M. Feldman, Francis, and Bercovitz 2005; M. S. Gertler and Levitte 2005; Glasmeier 1986). In addition, the photonics industry provides employment-level evidence of the co-location of basic and applied research activities in those cities and regions with existing and related industrial specializations --- a process increasingly supported by research on relatedness and innovation (R. Boschma, Heimeriks, and Balland 2014; Rigby and Essletzbichler 2006; Turok et al. 2017).

17. What the software and photonics cases illustrate about the development of innovation policy is an ability of policymakers to adapt at the policy level as well as the technological level. And, that adaption has included the growing recognition that first, place matters in innovation. National innovation strategies are not sufficiently tailored to localized industrial and technological specializations and regional labor market conditions to be efficient policy tools. Second, innovation policies are more effective when they are targeted towards technologies rather than industries. In other words, regional innovation strategies are more effective when they *look forward* from an emerging technology rather than *look backward* from an incumbent industry. And finally, these regional innovation systems which integrate and involve actors across institutional boundaries --- public, private, academic, and third-sector --- are better able to manage the diffusion of enabling technologies which requires specific policy innovation across categories: skill and training, entrepreneurship, intellectual property, financing, certification and standards, subsidies and incentives, and infrastructure investments.

18. Although there is some evidence that cities and regions are beginning to manage this new model for managing enabling technologies, there is a distinction to be made. First, technologies like photonics and software initially had clear markets – obvious use cases. These initial applications secure significant markets for the technologies and established firms and networks of firms. These markets also allowed firms to develop supply chains. In both the photonics and software cases, the initial markets were largely composed of consumer and defense applications. It was later the industrial applications of both technologies expanded and embedded in production processes across sectors.

19. In the case of many of the disruptive technologies recently identified the initial markets are less clear. This is particularly true for consumer markets. Hence, the technology sector and investors in it have highlighted the development of use cases for disruptive technologies in an effort to scope and define those initial markets. The challenge here, of course, is that although the potential for the technologies is disruptive, the adoption of them remains necessarily incremental – limited by time, resources, and risk. The question is whether policymakers have learned the lessons from earlier experiences with disruptive technologies and can apply those lessons to what is a faster and broader rate of technological change affecting a greater number of sectors and places.

2.2. Prioritizing Regional Innovation Policy

20. As the emphasis in innovation policy expanded beyond product innovation and established sectors, so did the focus on the national scale for scientific investment. The result has been a shift in innovation policy design and implementation away from national science and technology strategies emphasizing pre-commercial research and development and towards policies supporting regional innovation systems and associated theoretical and policy models (such as innovation districts, learning regions). The result is the multilevel governance of innovation policies and practices broadening the innovation conversation to the scale of cities and regions and sub-national policy design (McCann and Ortega-Argilés 2015; Clark, Huang, and Walsh 2010; Lowe and Wolf-Powers 2018; Moulart and Sekia 2003; Asheim and Isaksen 2002).

21. However, this shift has been uneven across national and regional contexts and the devolution of innovation policies towards the regional scale has been partial and incomplete. Further, in North America where economic development policies are determined at the state or provincial and local level, the devolution of innovation policies has brought them closer to the traditional patterns and practices of local and regional

economic development – long dominated by established rather than emerging industries and technologies. The selection of targeted technologies in both regional and national innovation strategies often reflects anticipated applications of incumbent industry actors (Christopherson and Clark 2007a).

22. The result is a push and pull situation in which regional innovation policy struggles to establish a pattern of practices distinct from both national science and technology policy and local and regional economic development strategies by emphasizing technologies rather than industries and networks and systems rather than firms. The extent to which regional innovation policies are successful in this regard determines to a significant degree the effectiveness of the policies themselves.

23. In the dynamic process of “putting innovation in place,” there are two key points that emerge from the analysis of regional innovation systems produced by economic geographers. First, research and development institutions appear to function better when they function as nodes within both a regional and a national innovation system. In other words, they are multi-scalar institutional forms. And second, innovation centers appear to function best when they serve an intermediary function in addition to their central scientific functions. Location plays a key role in both arguments. And, as the optics and photonics evidence indicates, basic and applied research is already co-locating in cities and so is the labor market that supports both innovation and production. Further, if this analysis is representative and proximity and centrality matter to the successful development and deployment of scientific research, it becomes increasingly difficult to visualize a future for US science.

24. In addition, the rise of regional innovation policies as a response to the advocates of industry clusters and related typologies depends upon a recognition of regional variation and the necessity of understanding the nuances of local economic capacities and conditions. Policy analysis thus requires a shift in emphasis towards how proximities (geographic, technological, organizational, etc....) facilitate technology diffusion and how distance restricts and limits diffusion and then efforts to shorten those distances (R. A. Boschma 2005; Crevoisier 2004; Morgan 2004). For cities, regions, and firms already “distant” from the technological frontier (spatial and industrial proximities) this is especially critical as these distances affect both lagging regions and incumbent industries (e.g. older industrial regions and/or established sectors like energy and manufacturing) differentially depending on their existing connectivities.

2.3. Connecting the Public and the Private through Systems and Networks

25. Connectivity is a particularly influential factor in managing disruptive technologies. It perhaps more than simply ironic that most of the disruptive technologies identified by industry analysts and policy makers require a substantial level of technical connectivity simply to operate. In parallel, the management of these disruptive technologies increasingly requires institutional connectivity. The model of innovation policies or firm subsidies in which a government invests in a specific technical project of a specific firm is largely over. Although these practices continue, their efficacy, beyond their basic function as firm-level subsidies, has been widely critiqued (Bristow 2005; Christopherson and Clark 2007a). The combined processes of deindustrialization and globalization challenged the viability of that historical model.

26. Instead, academics and analysts have pointed policy makers towards network approaches and a rethinking of the institutional infrastructure required to develop systems

to promote and support technology diffusion over time and across sectors for broader purposes than product innovation alone. In other words, embedded in the innovation systems approaches is a recognition that productivity increases from process and materials innovations are also important to sustainable and equitable economic growth (Montanari, Sgaragli, and Teloni 2017; Lowe and Wolf-Powers 2018). And further, the absence of simultaneous investments in labor market upgrading leads to growing challenges in term of income distribution and well-being.

27. Disruptive technologies create substantial and usual economic opportunities with large economic value. Incremental innovations provide for systematic and gradual adaptations in the underlying institutions and networks. The shift in towards regional innovation systems has, in part, been an effort to design a policy model to support incremental innovation as a platform for the development of disruptive technologies while recognizing the contributions of incremental innovations to consistent gains in productivity. That being said, there remain open debates about how to design regional innovation polices and particularly how to balance public and private investments in research and development. These debates pre-date the recent proliferation of disruptive technologies.

28. The policy models emerging in North America (and to a lesser degree in the United Kingdom and the European Union) increasingly require public and private partners at multiple stages in regional innovation systems moving both forward and backwards across the technology readiness scale. As a result, it is much more difficult to separate investments in basic research (private and public) from investments in applied research (commercial or commercializable technologies). This is a distinction from past approaches to public investment in research and development which separated early stage technologies from later stage commercialization tied to a specific industry or set of firms.

29. In this respect, disruptive technologies may, in fact, be most immediately disruptive to traditional policy approaches to public investments in research and development and commercialization. Because disruptive innovations obscure the boundary between pre-commercial and commercial research, these innovations also destabilize what was once a common firewall in the design and implementation of national science and technology policies: the public sector invests in pre-commercial research and the private sector picks up the process when the industry applications become clear.

30. Disruptive technologies destabilize this system pf public investment in basic research for several reasons. First, disruptive technologies are frequently enabling technologies with multiple applications across a wide array of incumbent and emerging industries. It is therefore not obvious which industries or firms are likely to benefit directly (or the most directly) from moving pre-commercial innovations across “the valley of death” to commercial applications. The valley of death corresponds to the technology readiness levels (TRL) 4-7 in the research and development process (Bryson, Clark, and Vanchan 2015).

31. Take for example the disruptive technologies identified in the oft-cited 2013 McKinsey Report on disruptive technologies (Manyika et al. 2013). The report highlighted the top twelve technologies that the authors associated with increased economic growth: mobile internet, automation of knowledge work (inclusive of artificial intelligence), the Internet of Things (IoT), cloud technology, advanced robotics, autonomous vehicles (and more autonomous vehicles), next generation genomics, energy storage, 3-D printing (or additive manufacturing), advanced materials, advanced oil and gas explorations, and renewable energy.

32. Looking back on this list five years later, among the notable issues are the varying implications of each technology identified when considering the underlying industrial mix of different regions and the characteristics of incumbent industries --- firm and occupational structure, skill, capital requirements, connectivities, and a host of other variables and factors. Further, the disruptive technologies identified are, to no small degree, mutually interdependent. In effect, these are nested technologies without clear distinctions between them in term of sequencing of implementation and the required, antecedent platforms. That is to say, *Is the Internet of Things dependent on the widespread deployment of cloud technologies and the mobile internet? How far does artificial intelligence need to advance before autonomous vehicles become viable? Do advanced robotics and autonomous vehicles require new forms of energy storage?*

33. This is not only an issue of sequencing for private investment. It is also a question of which technologies are platforms *required for* regional development – and thus appropriate targets of public investment as distinct from which are industry-specific and thus appropriate targets of private investment.

34. In other words, disruptive technologies have destabilized the patterns and practices of public research and development investment or economic development (and the *rationale for* and *application of* public subsidies) at both the national and regional scales. That disruption reveals the need for a substantial rethinking of regional economic development policies --- and particularly as they pertain to the positioning of cities and regions in an interconnected and competitive global economy. Although disruptive technologies did not alone create the cracks in this system, they do underscore the widening gaps between the stated goals of economic development polices and their effects (Pike, Rodríguez-Pose, and Tomaney 2006; Fitzgerald and Leigh 2002; Leigh and Blakely 2010)

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3. Regional Policy Strategies in a Disrupted Innovation System

35. For the academics and policy makers immersed in the regional innovation systems literature and the details of regional economic development policy, a discussion about sub-national science and technology strategies seems ordinary and accepted. And, to a much greater degree, this is the case in the European Union. In North America, however, regional economic development policy remains experimental and to some extent provisional and regional innovation policies even more so. If indeed, managing disruptive technologies is most effectively tackled through policies design for and implemented at the regional scale, then there are two concurrent challenges emerging: first, the existing unevenness of the transition from national innovation policies to multi-scalar (regional) innovation policies and second, the equally uneven shift towards a multi-sectoral technology diffusion model incorporating the public and private sectors.

3.1. Track 1: Innovation Centers: Supporting the diffusion of disruptive technologies at the regional scale

36. In spite of these challenges, it is possible to identify some common characteristics of effective policy responses to disruptive technologies based on existing innovation policies in practice. These policies tend to fall into two tracks. The first track coordinates and consolidates a wide range of innovation-related policies under one administrative structure: a research center. Through the structure of the research center these policies **support the adoption of disruptive technologies at the regional scale through** continuing investments in regional innovation systems: specialized labor markets, local firm networks (especially small and medium sized firms), and connecting basic research in universities and national labs to existing industry and firms. The following sections describe Canadian and US examples of the top-down (national to regional) approach to distributed research centers supporting regional innovation systems.

37. Within this track, there are also examples of a bottom-approach to innovation centers. These centers develop within regions for the purposes of supporting existing and evolving industrial specializations. In some cases, these centers are deeply engaged in the ongoing integration of incremental innovations into a regional production network generally associated with an innovation district.

38. The second track, in contrast, organizes an array of individual policies targeting the diffusion and absorption of enabling technologies at the regional scale through not through a research or innovation center as a coordinating administrative unit. In these cases, cities or regions design and implement policies and services targeting entrepreneurship, SME start-up and scale-up, immigration and migration, workforce development and certification, and other innovation-related policies. These policies place a continuing focus on entrepreneurship and innovation and production in place with scale up strategies as an essential component.

Evolving Models:

- Network of Centers of Excellence (NCE) – Canada
- National Network for Manufacturing Innovation Institutes (NNMI) – United States
- Regional Innovation Centers

39. Regional development policy has historically focused both on specific geographies as well as on specific sectors or industries. This tendency emerges from the emphasis in economic geography and later in economic development practice on the role of agglomeration economies in regional development. In other words, the analytical lens has been trained on not only the development path of specific places but the specific industries that contribute to the path. This tendency to emphasize industrial specialization has led to a retrospective approach to analyzing regional industrial and technological specializations. The focus is on the needs and capacities of incumbent industries, often with an emphasis on individual firms or networks of firms rather than the “institutional infrastructure” embedded within regions and underpinning the growth (and innovation) trajectories of these firms and firm networks.

40. The regional policy challenge then is how to effectively invest in local and regional capacities – including the ability of regional institutions to absorb new technologies and pass those innovations through to existing and emerging networks of firms at various stages in the development process (start-up, scale-up, established, and transforming). This section describes policy efforts in the US and Canada to use a distributed network approach to managing technology diffusion across and within cities and regions. In the Canadian case, the model began in 1989 and has adapted to political, economic, and technological transitions over time while simultaneously managing the multi-scalar coordination of investments and administration. The US case is more recent, initiated in 2015 and represents a first step towards an approach to innovation policy that is intentionally and consciously multi-scalar.

41. In both countries, previous strategic iterations of national scientific investment often used sectors as the organizing framework. For example, energy and defense investments dominate the scientific investments in the United States (as well as in several other industrialized countries). Apart from energy and defense, policies and strategies intended to support innovation were broken down by their proximity to commercialization. Administratively, the policies aimed at existing industries tend to sit in the Department of Commerce in the US or Industry Canada in the Canada. Investments in basic research – pre-commercial medical and scientific investigation – sit in research-focused agencies such as the National Science Foundation (US), the National Institutes of Health (US), and Canadian Institutes of Health Research (CIHR). These organizational firewalls were intentionally constructed as part of the post-war national research and development system to keep basic research separate from applied development.

42. In the case of Defense and Energy applications a network of national research centers developed tasked with integrating basic and applied research in these domains for the purposes of national security (inclusive of energy security). This was not the case for technologies and domains that fell outside of these designated national priorities. For industries and technologies without a direct claim to defense and energy applications the path from research to commercialization was delinked with public investments in the first stages (Technology Readiness Levels 1-4) and the expectation that firm specific supports would be available – as appropriate for the commercialization process (TRL 5-9).

43. Among the notable characteristics of disruptive technologies is their broad potential applications to multiple products, processes, and markets. As a consequence, as the number of potentially disruptive innovations has increased, this siloed, domain-specific approach to national science and technology investment has proved too narrow and too rigid. And as those siloes have broken down, the potential for viewing innovation systems through a

geographic rather than industry-specific lens has expanded. Effectively what regional innovation systems seek to do is break down these domain barriers both across scale and across domain to better understand and manage the diffusion of disruptive technologies into incumbent and emerging industries.

44. Economic and urban geographers are well acquainted with the extensive literature on territorial innovation systems and the emphasis on links between regional economies and embedded innovation capacities (Asheim and Isaksen 2002). This literature developed from a series of discussions--notably industry clusters and learning regions--highlighting the role of human and social capital and institutional infrastructure in producing and retaining territorially-embedded capacities in enabling and emerging technologies in a complex and competitive global economy (Meric S. Gertler and Wolfe 2002). Although a series of policy frameworks followed from this extensive literature, the vast majority of science and technology policies have been slow to recognize geography as a critical variable in the analysis of innovation and technology transfer. As a consequence, US science and technology policy has rarely considered regional industrial specializations – even urban economies – in its locational criteria. In fact, the importance of spatial proximity to generating and sustaining innovative economic activity remains a subject of debate among leading economists with policy influence in the US. In an editorial in *The New York Times*, Christina Romer, former Chair of President Obama’s Council of Economic Advisors, expressed skepticism about the benefits of economic clustering at all (Romer 2012).

45. In spite of this lack of *consensus on* and *recognition of* the operational connection between innovation and regional economies, regional and national governments continue to focus on an expanding for research centers to serve as market intermediaries tasked with technology diffusion as well as development. Thus, research centers increasingly bridge the gap between basic research financed and supported by public sector actors and the commercialization of innovations facilitated by private sector actors. However, the transition from basic to applied work and the hand-off from public and academic researchers to private market actors has remained messy and somewhat muddled. While “muddling through” has worked as a site-by-site policy approach in the past, the global recession highlighted the need for a more efficient and generalizable approach to moving publicly funded research into private market commercialization.

46. There are three identifiable models for the regional research centers approach to combining research with technology diffusion. The first distinct model is a *Firm Networks Approach*: an explicit regional policy oriented towards an industry or technology cluster present in the region. This model is built on industrial districts and industry clusters frameworks. The rationale for this targeting is to support and sustain agglomeration economies. As such, the model is explicitly linked to the regional economy and the actors and firms present in the region. The Canadian model of regional development is a variation of this model (Bramwell, Nelles, and Wolfe 2008; Doloreux 2004; Salazar and Holbrook 2007). Italian industrial districts follow this structure as well. Although the firm networks approach was popularized and adapted to the regional context in the mid-1990s by Michael Porter’s work on industry clusters, the model is significantly older (Krugman 1995; Marshall 1920; Porter 1990). The industrial districts research in Italy in the 1970s lead to the development of regional-scale industry approaches to providing resources and coordinating development and innovation efforts, particularly for small and medium-sized firms (Cainelli and Liso 2005).

47. The second distinct model is a *Technology Infrastructure Approach* that is a loosely organized innovation policy implemented through infrastructure investments or capacity building investments in research universities and/or cooperative research centers (Boardman, Gray, & Rivers, 2012). The selection of sites of investment is typically determined through a competitive proposal process that determines the location of investment. Although these selection processes are not immune from political considerations, merit criteria play a central role. As a consequence, places with existing infrastructure and capacity tend to do better than those building it. Similarly, places with existing political power tend to do better than those developing it. The current US system of innovation investment looks very much like this model with an emphasis on basic rather than applied research.

48. Although the technology infrastructure approach is necessarily competitive and thus reinforces a mode of inter-jurisdictional competition that has been sharply criticized in recent years, it can be constructed to mitigate negative effects of that competition (Malecki 2004; Bristow 2005). For example, the Fraunhofer Institutes model in Germany allows for many sites of investment, with varied and specific portfolios based upon the embedded capacities of firms and institutions in an existing region. The role for firms in the Fraunhofer model is significant both in terms of engagement and funding. In many ways, the Fraunhofers function as innovation intermediaries linking universities, government, and industry in an effort to move research into commercialization.

49. The third model is an *Industrial Policy Approach* organized as a targeted national industrial policy that incorporates an innovation strategy. This approximates a traditional industrial policy coordinated with a national science and technology strategy. In this model, priorities are defined at the national scale and locations for investment are selected in the course developing the industrial policy.

50. Although these policy models remain underspecified, disruptive technologies present the opportunity to confront a siloed post-war system and develop a new one focused on technologies rather than industries and the specific assets and capabilities of regions. In both the US and Canada, attempts to coordinate the national and regional innovation systems in order to manage disruptive technologies have required partnerships across established federal agencies and have largely taken the form of special initiatives championed by a given administration (and often dismantled by subsequent administrations).

3.1.1. Network of Centers of Excellence (NCE) – Canada

51. In the mid-1990s the US and Canada undertook two different strategies aimed at supporting identified industry clusters and developing a research centers model compatible with innovative, small firm networks. The US took a decentralized state and local approach consistent with the devolution common for the period. Canada took a different approach. Instead of simply devolving science and technology policy, Canada attempted to coordinate federal, provincial, and local policies and resources. At the same time, Canadian policymakers crossed policy and scale boundaries between economic development and science, technology, and innovation policy to pursue a broader innovation project. The result was a “distributed network approach” to innovation, commercialization, and production with research and development resources as a centerpiece (OECD 2017).

52. Canada’s National Centers of Excellence (NCE) program began as a partnership of Industry Canada and three other federal agencies: the Natural Sciences and Engineering Research Council (NSERC), the Canadian Institutes of Health Research (CIHR), and the

Social Sciences and Humanities Research Council (SSHRC).¹ The centers are primarily based in universities but also in research hospitals and similar institutions.² This network approach pairs a national network of researchers and research centers with a locally embedded network of firms and industry actors. Thus, the Centers of Excellence are both *embedded* in existing regional industrial clusters and *connected* across Canada to a national scientific network (Globerman 2006). In general, scientific priorities (articulated through funding of targeted technologies) have been identified by the federal government and implemented through the university networks and regional institutions (Salazar and Holbrook 2007).

53. This is the case with photonics – a key enabling technology. The Canadian Institute for Photonics Innovation (CIPI), located in Quebec City at Laval University, was part of the NCE system from 1999 to March 2012.³ CIPI coordinated a networked research program across 20 Canadian universities with over 300 graduate students and 90 researchers with an annual budget in excess of CDN\$4 million. In April 2012, CIPI joined with the Canadian Photonics Consortium (CPC) to form PhotonsCanada or Le Consortium Photonique de l'Industrie Canadienne (CPIC). Also headquartered in Quebec City, PhotonsCanada is an industry-led network of research centers, firms, and agencies focused on the Canadian photonics industry as a whole from a base in Quebec.

54. This model of multi-scalar innovation policy prioritizes horizontal linkages to other institutions as well as vertical linkages to local, regional, provincial, and federal actors (Atkinson-Grosjean 2002). In other words, the distributed network model matches the multi-scalar and multi-locational strategies of firms oriented towards global markets and distributed supply chains. At the same time, the NCE model recognizes the role of proximity, what Meric Gertler called “being there” in the development, commercialization, and ultimately production in technology-intensive industries (R. A. Boschma 2005; M. Gertler 2003). Identifying regional specializations has proved to be a crucial step towards designing an innovation system capable of absorbing enabling technologies and commercializing them in place.

3.1.2. National Network for Manufacturing Innovation Institutes (NNMI) – United States

55. In the United States, the most recent national policy effort to seed and sustain regional innovation systems is the National Network of Manufacturing Institutes (NNMI). The design and implementation of the Manufacturing Innovation Institutes (MII) provides an example of the convergence of national innovation policy and regional economic development policy through a technology infrastructure-based approach. However, in the case of the NNMI, their design attempted to incorporate elements of regional industrial specializations and create incentives for a networked approach reflecting a regional innovation systems approach. In other words, the NNMI are an example of an attempt to integrate across categories through an elaborated (and multi-site) research, design, and

¹ See also for details: (“Network of Centers of Excellence Program Guide” 2011)

² See also for details: (“Networks of Centres of Excellence: Research-Driven Partnerships” 2012) “The Networks of Centres of Excellence (NCE) fosters multi-disciplinary, multi-sectoral partnerships between academia, industry, government and not-for-profit organizations. It supports academic research, the commercialization of products and ideas, and the development of significant Canadian business advantages.” For reports on program impacts please see: (Rank 2002; Goss Gilroy Inc. 2015). In 2018 *The Global and Mail* reported that the NCE program, begun in 1989, was expected to be discontinued (Semeniuk 2018).

³ See (“Canadian Institute for Photonic Innovation” 2012)

commercialization center model focused on targeted technologies rather than existing industrial sectors.

56. For the United States, this nationally coordinated response to the 2007-2009 recession represented a break from the pattern of avoiding deliberate and explicit industrial (or innovation) policy. With the national unemployment rate over ten percent and the potential bankruptcy of Detroit automakers threatening to send an enormous shock through the auto supply chain, plans for a national strategy to sustain technological development and to connect that development to existing industries and agglomerations, briefly enjoyed legitimacy (Helper 2009; Clark and Doussard 2018). Beginning in 2010, the Obama Administration initiated the Advanced Manufacturing Partnership (AMP), which entailed rounds of private sector and university-led policy development charged with diagnosing, analyzing and acting to support industrial development and specifically address the gap between innovation and commercialization in the US economy (Clark 2013). Coordinated by the President's Council of Science and Technology Advisers which spanned across departments like Energy, Defense, Commerce, and Transportation, the resulting policy prescriptions primarily addressed the economic crisis by initiating an architecture for a national innovation system that connected local and regional production systems to emerging and enabling technologies (PCAST 2016, 2014, 2012).

57. The Advanced Manufacturing Partnerships 1.0 (AMP 1.0) and the Advanced Manufacturing Partnerships 2.0 (AMP 2.0), which operated from 2011 to 2014, resulted in two policy strategy reports (PCAST 2012). Both iterations of the AMP had goals that resembled those of conventional industrial policy. Writ large, they authorized national investments in technology, and made provisions for linking technological development to extant industrial capacity. Both reports recommended a National Network of Manufacturing Institutes (NNMI). The NNMI initiative created large-scale research centers (individually, Manufacturing Innovation Institutes, or MIIs) connected to industry, universities, and to the broader set of institutions constituting both regional and national innovation ecosystems defined by targeted technologies (PCAST 2014). This policy model explicitly acknowledged that national innovation investments diffuse more effectively when they are co-located with regional production capacities, as they are in the European Union, Germany, Canada (Clark 2014, 2010).

58. The original Advanced Manufacturing Partnership proposal for the NNMI suggested 50 or more MIIs, each focused on a technology relevant to the future of advanced manufacturing in the US. The new policy targeted federal investment in technologies rather than industries (i.e., steel) or sectors (i.e., energy) which were more frequently the focus of trade policy or basic research investments.

59. By 2018, the National Network of Manufacturing Institutes (NNMI), evolved into a federal program that 1) invests in basic technology, 2) sites those investments within newly formed regional technology institutes (MIIs), and 3) works to link technological development to industrial capacity and, ultimately, job growth. For the United States, this initiative represents a rare alignment with the multi-scalar innovation policies seen more frequently in the European Union, United Kingdom, and Canada. Fourteen individual MIIs were designated between 2012 and 2015 (see Table 1). In addition to disrupting previous innovation policy approaches by focusing on regional innovation systems, the MIIs were all initiated around technologies rather than industries. Among the targeted technologies are several often identified as "disruptive" including: additive manufacturing, digital design in manufacturing, flexible electronics, and biopharmaceuticals.

Table 1. US Manufacturing Innovation Institutes (2012-2017)

Manufacturing Innovation Institute (MII)	MII Name	Targeted Technology	Primary City	STATE	YEAR
National Additive Manufacturing Innovation Institute	America Makes	Additive manufacturing (3D printing)	Youngstown	OH	2012
Digital Manufacturing and Design Innovation Institute	DMDII	Digital design and manufacturing	Chicago	IL	2014
Lightweight Innovations for Tomorrow	LIFT	Lightweight metals	Detroit	MI	2014
American Institute for Manufacturing Integrated Photonics	AIM Photonics	Integrated photonic circuits	Albany	NY	2015
America's Flexible Hybrid Electronics Manufacturing Institute	NextFlex	Flexible electronics	San Jose	CA	2015
The Next Generation Power Electronics Manufacturing Innovation Institute	PowerAmerica	Wide bandgap semiconductors	Raleigh	NC	2014
Institute for Advanced Composites Manufacturing Innovation	IACMI	Advanced polymer composites and recycling	Knoxville	TN	2015
Advanced Functional Fabrics of America	AFFOA	Novel fibers and textiles	Cambridge	MA	2016
Advanced Tissue Biofabrication Manufacturing Innovation Institute	ATB-MII	Human tissue and tissue-related products	Manchester	NH	2016
Clean Energy Smart Manufacturing Innovation Institute	CESMII	Smart sensors and digital process controls	Los Angeles	CA	2016
National Institute for Innovation in Manufacturing Biopharmaceuticals	NIMBL	Biopharmaceuticals	Newark	DE	2016
Advanced Robotic Manufacturing	ARM	Collaborative robotic technologies	Pittsburgh	PA	2017
Rapid Advancement in Process Intensification Deployment	RAPID	Energy efficiency of manufacturing processes in industries such as oil, paper, and chemical	New York	NY	2017
Reducing Embodied Energy and Decreasing Emissions	REMADE	Reuse, recycling, and remanufacturing of materials	Rochester	NY	2017

3.1.3. Regional Innovation Centers

60. These two examples from Canada and the US of nationally-initiated efforts stand in contrast to the model illustrated by the industrial district centers in Italy (Potter, Marchese, and Proto 2010). These centers, primarily administrated and supported by regional governments, sit very close to the firm networks in their jurisdiction. As a consequence, they tailor their services to the needs of those firms. Those services increasingly involve facilitating the absorption of incremental innovations in incumbent firms by providing process (as well as product) prototyping services, connecting firms to supply chains both regionally and internationally, providing certification services to qualify firms for the standards required to join global supply chains (particularly but not exclusive for materials and processes established for quality control as well as various types of international standards including environmental/sustainability, consumer and worker safety, and labor standards. In addition, these industrial/innovation districts centers provide and/or connect firms with expertise in advanced business services including specializations in the intellectual property management, finance, service contracts required to adopt and absorb disruptive innovations and benefit from the ensuing productivity gains.

61. The growth of makerspaces and other membership-based models of shared spaces and services mirror the benefits of collocating innovation and production and proximity to front-line producers that has characterizes the Italian industrial district centers. Another benefit of these models is their ability to identify and isolate skill gaps – especially those associated with the introduction of new technologies – and subsequently identify labor market intermediaries with the ability to offer training and instruction. With disruptive

technologies the identification of specific skill gaps and strategies for the delivery of tailored training is a growing challenge. Makerspaces are often collocated with labor market intermediaries offering certifications and “badges” for discrete technical instruction. In other words, these regional innovation centers are able to manage incremental innovation because of their proximity to the local labor market, local firm network, and local institutions. Efforts to replicate these capacities from the top-down rather than the bottom-up have been – as both the Canadian and US cases demonstrate – challenging.

3.2. Track 2: Innovative Governance and Regional Policy: Strategies to facilitate productive and innovative SMEs (incumbent and emerging)

62. Research center strategies as regional innovation policy – whether bottom-up or top-down – take a comprehensive approach to managing disruptive technologies. By centralizing regional innovation policy under one administrative roof, they attempt to coordinate and align actors and activities. An alternative approach to managing disruptive technologies is to identify and engage distinct elements of the innovation project one at a time. For example, to identify infrastructure investments – like 5G connectivity – and invest in that platform.

63. And again, rather than following the research centers approach pioneered through science and technology policy, cities and regions can (and do) follow a pattern of practices more akin to economic development. For example, through a combination of development incentives (or facilitated permitting and certifications) for private enterprise and strategic investments in public sector deployments, regions can push the implementation of the enabling platforms and systems required for the diffusion of disruptive technologies. Further, cities and regions can tailor how that diffusion happens by minimizing the extraction-oriented revenue models that compromise privacy, safety, or security of citizens/civil society through the targeted regulations of data and connectivity (discussed in details in the next section).

64. These strategies require a certain level of capacity in the public sector, at the city and/or regional scale, to manage technology deployments and disruptive innovations. In some cases, like that of Boston, the city has strategically made those investments through the Office of New Urban Mechanics. Many large cities like New York, London, Chicago, Paris, and in this case, Boston, have identified the need for increased internal expertise in disruptive technologies and the analytical ability to understand how they might affect the management and administration of city services and operations. However, many local governments did not have the resources to invest in the expertise required in the wake of the public sector downsizing exacerbated by the 2008 recession. Instead, the private sector has designed a mechanism for seeding capacity within cities through “innovation delivery teams” and resilience officers (Clark 2019).

65. Since 2010, a wave of philanthropic investments has targeted increasing capacity building in urban and regional governments to address the application of disruptive technologies in cities and by cities. In the private sector the promise of disruptive technologies relates to productivity and growth. In the public sector, the promise of productivity is also alluring. Further, the potential to provides city services more sustainability, more efficiently, and more equitably is particularly promising. Concerns about city scale responses to climate change have increased interest in developing and diffusing urban policies for resilience planning. Many of these urban innovations attempt to leverage the same disruptive technologies that animate the conversation in the private

sector: municipal wireless, small cell deployments, environmental sensor arrays (array of things), electric charging stations, smart cities testbeds, 5G, and autonomous vehicles (buses, cars – private and ride hailing, trucks). And, these deployments require many of the same interventions and platforms that the private sector requires in terms of data and connectivity. However, in the public sector context, these deployments and priorities are interwoven with interests in civic participation and engagement and open data and data use policies.

66. Capacity building also requires a rethinking of the expectations for urban and regional planners and policymakers. Universities are beginning to redesign graduate and professional curricula to integrate innovation management and technology policy into public administration. Among the first programs to deliberately tackle training for professionals in urban innovation are University of Toronto's Urban Innovation master's degree and the Massachusetts Institute of Technology's Urban Science program.

4. Beyond Enabling Technologies: Key Challenges in Managing Disruptive Technologies

67. The previous section highlighted the ways in which regional innovation policies already recognize and engage the challenges posed by disruptive technologies. The purposes of presenting these models and initiatives is to demonstrate that the challenges posed by enabling technologies are not wholly new. Indeed, debates about how to manage the diffusion of enabling technologies are a characteristic of regional innovation policy design and implementation. Further, the question of how to manage disruptive technologies touches on all these underlying debates about the appropriate scale of innovation policy, the relative efficacy of top-down approaches versus bottom-up initiatives, the balance between public and private sector investment in the various stages of research and development, providing supports for small firm development while managing applications in existing industries, and finally, how to move from an industry-focused approach to a technology-focused approach when the latter presents so much uncertainty in terms of the magnitude and direction of a return on investment.

68. Managing disruptive technologies, however, also adds to this debate. In part that is due to the rapid adoption of disruptive technologies by the private sector. Some of this adoption is purely speculative and aligns with existing trends towards the financialization of intellectual property that animates much of the technology sector. However, some of this technology diffusion into the private sector has broader significance, especially the platform technologies (cloud computing, connectivity, energy) that enable the development of use cases like autonomous vehicles and robotics.

69. As mentioned previously, disruptive technologies do not just disrupt the logic of the industry practices, they disrupt the public sector policies intended to facilitate and support (and regulate) them across land, labor, and capital markets. The next sections illustrate how one popular use case, autonomous vehicles, disrupts policy frameworks. The following section then describes how the rethinking of data governance has the potential to manage the development path of disruptive technologies. The data governance example provides a potential model for managing the more economic and socially problematic implications of disruptive technologies for places and for people.

4.1. The Importance of “Use Cases” in Prototyping Applications of Disruptive Technologies

70. In the conversation about disruptive technologies there is an emphasis on “use cases” (autonomous vehicles, smart cities). Use cases increasingly the organizing logic for firms and for governments to understand the applications of disruptive technologies in practice. This logic substitutes for the sectoral and industrial boundaries which previously helped to scope the impact of new enabling technologies thus providing a method for identifying research agendas, stakeholders, policy changes, and affected geographies. The impacts of disruptive technologies are, by definition, not aligned with our current understanding everything from global production networks to infrastructure requirements. Thus, “use cases” become a substitute framework for understanding whether a disruptive technology is developing for a consumer or industrial market.

71. Despite the challenges in determining their impacts on existing industries and markets, disruptive technologies refer to a set of new technologies that necessarily graft on top of an incumbent infrastructure. That infrastructure serves as the platform for the development and application of these enabling technologies. The technical infrastructure required as the platform for the broad diffusion of the disruptive technologies is potentially requires some very large capital expenditures. A key challenge for disruptive technologies lies in resolving the question of how this infrastructure platform becomes more than what it currently is --- an antecedent condition, an antiquated backdrop behind the uneven implementation of technologically sophisticated objects and systems innovations. Who then upgrades the platform upon which technologically-enhanced systems and objects operate and upon which and about which data about the characteristics and behaviors of citizens is collected becomes a significant policy question. The issue here then is how the costs of the technology platforms are distributed between individuals, local and national governments, and the private sector.

72. Perhaps the most familiar example of a use case that illustrates how this challenge has developed is *autonomous vehicles*. The idea of “upgrading” from fleets of traditional operator-driven cars to fleets of autonomous vehicles has been embraced by both the public and the private sector. The promise of autonomous vehicles was even highlighted in the 2016 US Department of Transportation Smart Cities Challenge (“Smart City Challenge: Lessons for Building Cities of the Future” 2017). Autonomous vehicles present as a disruptive technology --- a change in the way life is lived, the way cities are designed, and the way firms develop their business strategies in sectors from automobiles to software. However, as is typical with this sort of technological transition, the change is more incremental than it is disruptive.

73. The entire typology of smart cities deployments: data, object, system, platform, is implicated in the autonomous vehicle project. Unlike some smart cities objects like device-charging solar park benches or traffic-monitoring systems, autonomous vehicles require investments in a smart cities platform to create the market for the smart cities object --- the autonomous vehicle. And so, the autonomous vehicle case provides a key example highlighting the complexity of how disruptive technologies play out in practice.

74. What is actually happening with autonomous vehicles is that an existing product is getting an upgrade. In this case, the individual vehicle remains the fundamental product platform. However, it becomes extensively interconnected through the addition of information and communication technologies (ICT) that take driving out of the hands of individual drivers. In other words, the car is completing an incremental transition from a discrete manufactured object to a service-embedded good (Bryson, Clark, and Vanchan 2015). Autonomous vehicles are vehicles with embedded connectivity services. The resulting product thus requires additional services in order to operate – vehicle owners (whether individual or institutional) will not just have to buy gas (or some alternative energy) but they will also have to purchase connectivity.

75. Notably, automobiles are already one of the most “service” embedded consumer goods. The car already connects to array of ongoing financial services including warranties, leases, and loans. The car already has information and communication services available including real time customer service calling, streaming radio, and navigation and traffic information systems. In fact, it was this recognition of the incremental innovation behind the autonomous vehicle that informed the US National Transportation Highway Safety Administration’s (NHTSA) guidelines for autonomous vehicle testing and deployment

describing the process in stages not in one giant, disruptive leap from operator-driven to autonomous.

76. The autonomous vehicle use case has gained prominence because it both affects and appeals to a very large constituency: people who drive cars, people who ride in cars, and the people who make cars and the information and communication technologies linked to them. The appeal of autonomous vehicles to consumers is largely because they may demonstrably save commuting time or potentially improve safety. Although, there is some evidence that neither is true in the short run.

77. Autonomous vehicles appeal to the private sector for a wide variety of reasons. The primary reason is perhaps counter-intuitive: fundamentally, AVs do not disrupt the automobile industry or the information and communications industry in a significant way. Instead, this use case allows both sectors to simultaneously pursue business retention and market expansion strategies focused on existing customers. Data-driven technological innovations – like autonomous vehicles – within incumbent industries allow for three types of new revenue generation: 1) through optimization of existing products or services (conserving revenues), 2) through the development of new services and products for existing customers (sustaining revenues), 3) through the development of new services or products for new customers (expanding revenues). Among those revenue opportunities created by autonomous vehicles is the one that automakers and connectivity companies can both monetize: a customer base captured in a specific location with embedded connectivity — people riding in their cars. People on a commute or errand with reliable connectivity and without the distraction of driving are a new target market. This is a whole new, undistracted audience to view ads, use software, and consume media content during a part of the day largely lost to the information and communications technologies industry under current conditions. It is also a whole new community of users from which to extract data on individual characteristics and behaviors.

78. Autonomous vehicles allow the auto industry and the information and communications technologies industry to both conserve and sustain revenues while creating a platform for expanding revenues. This is instead of the alternative path presented by the combined effects of increasing urban density and public investments in public transportation networks. That path points to a declining market for individual cars. Self-driving cars present a different alternative. Autonomous cars may also influence the urban form going forward. There may be decreasing demand for convenient parking places and increasing demand for waiting places for cars on curbs rather than parking garages. Cities can manage these shifts in demand by altering the number of parking spaces required for residential and commercial businesses in zoning regulations and designing new curb cuts and lane lines. These interventions all fall within current practices and programs. These are modifications to the current transportation platform not a disruptive transformation of it.

79. However, what autonomous vehicles actually require to move past the demonstration phase is a full-scale redeployment of transportation and connectivity platforms in cities. Curb cuts are not enough. Indeed, efforts to create testbeds for autonomous vehicles have demonstrated that it is their interactions with the existing environment that limit their successful implementation. It is not the level of the vehicle's autonomy that matters; it is the character of the built environment in which it is deployed – the clarity of the lane lines, the speed of the information it acquires (and sends and processes), the behavior of other actors in the external environment.

80. Because autonomous vehicles are designed as upgraded products for an existing market they reflect specificities (and histories) of that market. Autonomous vehicles are designed to be attractive to current consumers and to clients. And, that market is not currently asked to consider (or significantly share) the cost of the character of the urban environment in which the car operates. Those costs and characteristics are borne and determined by the cities and jurisdictions that provide the transportation platforms on which the city and its citizens conduct myriad individual and collective activities every day. Autonomous vehicles are effectively incompatible with the city *as is* because they were designed assuming the smart cities platform – the data, connectivity, and infrastructure enhancement required – would be provided for them, just as the antecedent urban transportation platform was developed to accommodate the driver-operated cars.

81. Of course, from an innovation policy position this is an untenable situation under current conditions. The diffusion of a promising enabling technology with the potential to increase productivity across sectors is limited by an absence of investment in the infrastructure platform required. The reason is that, although the private sector can provide technologically enhanced systems and objects to both cities and consumers, they cannot provide the platforms upon which the smart city operates: the energy grid, the networked connectivity, the transportation network, the roads, bridges, and highways. This is a role for the public sector. Or, more precisely, the private sector does not, for the most part, provide those infrastructure platforms now. In some cases, private utilities provide energy systems but they do so in a highly regulated environment, especially within municipalities. All this is to say that the private provisioning of enabling infrastructure – particularly at the platform scale rather than the project scale – represents a new phase and new form of privatization.

4.2. Disruptive Technologies: Regulation, Data, and Connectivity

82. In June 2018 in response to employee concerns about the firm's engagement with military applications of artificial intelligence, Google's CEO released seven corporate Objectives for Artificial Intelligence Applications. These objectives were: 1) Be socially beneficial, 2) Avoid creating and reinforcing unfair bias, 3) Be built and tested for safety, 4) Be accountable to people, 5) Incorporate privacy design principles, 6) Uphold high standards of scientific excellence, 7) Be made available for uses in accord with these principles (Google 2018).

83. Many experts on technology ethics described the articulation of these principles as a necessary, though likely not sufficient, first step in the management of artificial intelligence. From a policy perspective, the question is not only whether these objectives are appropriate but whether self-regulation by technology firms of the design and deployment of disruptive technologies is desirable at all. This debate – about industry self-regulation of the technologies and firm practices used to develop and implement them – culminated in the 2018 implementation of the EU's General Data Protection Legislation (GDPR).

84. The European Union's General Data Protection Legislation and new Data Protection Act known as GDPR have changed the situation for firms and organizations gathering data on individuals and developing revenue models from it. The GDPR reflects a new regulatory regime that indicates a shift from the governance of data controllers and processors through voluntary industry best practices of data extraction, collection, and use

to governmental regulations applied directly to firms engaged in the collection and use of data on individuals.⁴

85. Economic geographers have argued that firm strategies reflect the specificities of the national regulatory regimes in which they are founded (Christopherson 1993; Kristensen and Zeitlin 2005). In the US in particular, where many marquee technology companies like Facebook and Google were founded and scaled-up, the practices and standards around the collection of personal data – that is data about the characteristics and behaviors of individuals – have followed an extractive model grounded in business marketing strategies developed in the technology sector. The question has never been an issue of ownership in this context but one of use. Whoever collects the data can use the data. They can sell it as well. There is no real acknowledgement that individual consumers may own the data derived about their characteristics and activities or control or influence the terms of its use.

86. Instead there have been episodic and conditional admissions in some industries and pertaining to some kinds of data that in particular circumstances, privacy and security concerns affect specific uses of individual consumer data. For example, limitations to the use of individual data have emerged as a consideration in the financial services and health information context. Although people may not own the data collected on and about them, they are entitled to some level of protection from some potential uses (and abuses) of that data. Further, there is increasingly a role for government in defining those potential uses and acceptable level of protection. In 2018, the EU produced a direct regulatory challenge to the idea that those who collect the data on individuals are solely entitled to determine the terms and conditions of its use.

87. For disruptive technologies, a shift from voluntary industry governance of individual data to mandatory government regulation of firms presents an opportunity to reflect and reconsider about how cities and regions should best govern the data they hold on their citizens and the data they collect on them. As noted before, disruptive technologies depend on platforms providing both data and connectivity. The guiding assumption in the development of the disruptive technologies is that monetizing consumer and user data going forward can follow the same practices and standards as the firms have used in the past (pre-GDPR). And, if that is perhaps too broad an assumption, then at least the practices and standards in the health care and financial services industries could be applied – recognizing some more robust privacy and security protections but still holding to business models predicated on the assumption that a firm can use and process the data collected on users and consumers irrespective of that distinction for sale to third parties, product development, or marketing purposes. The assumption is that blanket opt-in rather than opt-out customer and user agreements provides sufficient consent.

88. The GDPR does not establish an individual property right to the data collected on an individual. It does, however, establish clear rights of access and of use by third parties: “controllers and processors”. And, it further establishes penalties for misuse and

⁴ See (“Guide to the General Data Protection Regulation (GDPR)” 2018) “The GDPR applies to ‘controllers’ and ‘processors’. A controller determines the purposes and means of processing personal data. A processor is responsible for processing personal data on behalf of a controller.”

unsanctioned access. Among the unsanctioned uses is the use of individual data without affirmative consent.⁵ The GDPR goes right to the heart of one of the two platforms essential to the design and deployment of disruptive technologies and which determine its geographic distribution: data acquisition and use. The second essential platform is connectivity. Regional variations in the regulation of data and the deployment of connectivity will likely influence the locational choices for firms engaged in the design and development of disruptive technologies – where they do business and with whom. If the firms and industries engaged in disruptive technologies follow a “race to the bottom” approach and pursue jurisdiction shopping as a means to elude more regulations then those locational factors will likely influence the ways in which local and regional governments move forward on regulation of both data and connectivity.

89. Although the GDPR functions at the supra-national scale, affecting the EU member states, similar data regulations are also emerging at the sub-national scale in states and provinces. California’s Consumer Right to Privacy Act is on the ballot in November 2018 as a citizen referendum. This law would establish similar regulations to the GDPR including an individual’s right to know what data has been and is being collected on them and a right to opt out of that data collection and commodification process (State of California 2018). The California data protection legislation highlights the challenges for managing disruptive technologies in a highly variegated regulatory environment – one that is increasingly varied at the national and the sub-national scales.

90. Although the privacy and security issues around the collection and use of data on individuals and their behaviors and characteristics has caught the attention of policymakers, the broader ethical implications of many disruptive technologies have yet to do so. As the Google case of artificial intelligence objectives demonstrates, firms are in a reactionary mode rather than a proactive one. For the regional innovation policy, the question becomes how to see data governance as an opportunity to direct the private sector towards more equitable applications of the disruptive technologies they develop.

⁵ Affirmative consent for specific uses of data collected on individuals is a long-standing requirement in social science research and governs the data collection on individual characteristics in most in not all formal research settings (like universities) under a formal structure called institutional review boards or IRBs.

5. Conclusions: Managing Uneven Impacts: Sustainability, Equity, Productivity

91. Public policymakers hold the tools to manage technological change and facilitate both economic development and improvements in equity, sustainability, and quality of life – particularly at the local and regional scale. Although the ability of cities and regions to design and implement technology policies (both incentives and restrictions), varies across national contexts, local governments are developing an array of policies and strategies to facilitate technology diffusion. In some cases, these policies are coordinated with national governments and in others they largely operate independent of national policy priorities.

92. To the extent that many disruptive technologies are targeted at consumer markets rather than industrial markets, cities and regions hold a significant amount of policy leverage as the primary sites of innovation, design, production, and consumption of disruptive technologies. In some cases, this is greater leverage than the limited position cities and regions held under previous conditions. There are now a number of examples of innovative governance strategies targeting the revenue models or the organizational practices of technology firms perceived to be more extractive than productive to the locality (Frug 2013; Lodato, French, and Clark 2018; Dalton, Taylor, and Thatcher 2016).

93. The implications of disruptive technologies for work and skill development are significant as well (Nedelkoska and Quintini 2018). Research findings indicate that industrial applications are likely to result in the continuing substitution of automation for labor depending on the availability of capital and both local characteristics and firm strategies (OECD 2018b; Clark and Bailey 2018; Bailey and De Propriis 2014). What is perhaps more uncertain is how disruptive technologies are changing the employment relationship itself leading to new forms of flexibility, contingency, and increasingly precarious work arrangements (Ticona, Mateescu, and Rosenblat 2018). The uneven distribution of broadband as well as 5G deployments will likely lead to the incremental and episodic changes to employment practices. Cities and regions are increasingly finding themselves at the center at the regulatory debates affecting employment practices in the sharing economy (Badger 2018; Burns 2018). The challenge becomes one of not only regulating industry activities in cities to manage transportation and commerce but to consider policy actions in the context of their implications for contingency and the future of work and inclusive growth (OECD 2018a, 2018b).

94. At present, the innovation policies pursued by cities and regions are both episodic and uneven. However, as new policies (programs and projects) are designed, adopted, implemented, and evaluated a series of models are emerging to manage the production and implementation of disruptive technologies in cities and regions and better assess both the opportunities and externalities generated. Among these models are efforts to design regional policy responses to the platforms required for the diffusion of disruptive technology, namely data and connectivity.

95. The uneven impacts of disruptive technologies are increasingly well understood. The OECD's recent study of the impacts of automation in the manufacturing sector demonstrated that countries, and subsequently regions, will experience these industrial transitions differently as a consequence of their current conditions (industry mix, labor market composition). What is distinctive about disruptive technologies is that they promise to produce new patterns rather than amplify old ones. In other words, while enabling

technologies can be expected to exacerbate past inequalities, disruptive technologies should – if they are indeed disruptive – produce new opportunities. The challenge for regional policy is to recognize how policy tools can facilitate those new opportunities. The smart governance of data acquisition and use and the strategic deployment of intelligent (connected) infrastructure present two potential starting points in that project (Mynatt et al. 2017).

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