Beyond Spatial Proximity: The Impact of Enhanced Spatial Connectedness from New Bridges on Entrepreneurship

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Abstract

Various strands of work have explored how spatial proximity helps (metaphorically) bridge barriers to resource mobilization and foster knowledge transfer. However, much of that work takes spatial connectedness as a given. We argue that spatial connectedness is a distinct construct that affects the extent to which spaces are not just proximate but are actually able to link people, ideas, resources and knowledge together. We explore one such source of connectedness—physical (not metaphorical) bridges. We find that the opening of newly-built bridges enhance startup founding in the local geographic community. Beyond its impact on startup founding, newly-built bridges also influence the organizing process for such ventures. This includes a positive impact on the entry of prospective founders into entrepreneurship and an increase in the number of early-stage investors. The subsequently founded ventures are also more likely to engage in recombination and to cross industry boundaries. We explore scope conditions around industry and connective heterogeneity. We also test for robustness to various modeling approaches. The discussion highlights contributions of these findings to the study of entrepreneurship, as well as of organizations and the institutional fields in which they operate.

INTRODUCTION

The bridge is simultaneously a utilitarian fact and a symbol for connectedness or transition from one place to the next, from one world to another. Pons is the common Latin root for bridge and priest. (Tuan 1990, p. 199)

A growing body of work in organization theory has begun paying attention to how entrepreneurship rates are influenced by social features of geographic communities (Cruz, Beck and Wezel 2018; Jennings et al. 2013; Klepper 2011; Lippmann and Aldrich 2016; Ruef 2010; Saxenian 1996; Thornton and Flynn 2003). Location influences both the formation of opportunities and the ability to exploit them (Alvarez, Barney and Anderson 2013). For example, geographic communities undergird networks of institutional, private, and individual actors, apart from access to local human capital (Feldman and Desrochers 2003; Saxenian 1996). They are settings where prospective founders draw social support from family, neighborhoods, and voluntary associations (Cruz et al. 2018; Ruef 2010). They provide collective knowledge and lenses for making sense of the environment and imagining recombinative possibilities (Jennings et al. 2013; Lippmann and Aldrich 2016; Dutta 2017). They are knowledge hubs through formal and informal interaction (Armanios and Eesley 2021; Audretsch and Feldman 1996). Geographic communities and their informal networks also circumscribe the investment targets for all but the most central investors (Sorenson and Stuart 2001), and influence their performance outcomes (Chen et al. 2010).

Such social features of communities that influence entrepreneurial activity often rely on the presence of (largely unobserved) physical connectivity. For example, much of entrepreneurship is a local phenomenon driven by local stocks of knowledge and problems (Aldrich and Ruef 2018). From an ecological standpoint, local patterns of interaction and expectation formation have an outsized influence over the emergence of groups of organizations than more aspatial sectoral characteristics (Lomi, Larsen and van Ackere 2003; Wezel and Lomi 2003). Even in the age of internet and mass media, physical proximity that affords the potential for contact remain critically important (Haas and Hansen 2007; Lee 2019). Schoonhoven and Eisenhardt (1992) noted how spatial proximity is crucial in collaborative ties between potential founders and employees, in part because of the transmission of tacit knowledge not necessarily codified or communicated formally (e.g., Brown and Eisenhardt 1995; Hansen 1999).

Conversely, the lack of community contact and connection often present barriers to entry for entrepreneurs (Cruz et al. 2018). Similarly, resource mobilization for building ventures to capture oft-uncertain opportunities requires face-to-face contact, both for recruiting cofounders and early employees (Ruef 2010), as well as for attracting financing from angel investors and venture capitalists (Bernstein, Giroud and Townsend 2016; Wiltbank and Boeker 2007). In short, entrepreneurs are not just standalone individuals with great ideas, but are socialized into their roles via face-to-face contact with others who have complementary skills, experience, and capital (Malecki 1997; Sorenson and Stuart 2001).

However, much of this literature treats geography as a stylized unit. Little attention is paid in this rich line of theorizing on the underlying levels of physical connectivity in places that enable or disrupt these social processes. This gap is particularly potent because often geographic features—both man-made and natural—influence the baseline levels of connectivity in places. On the one hand, even the most mundane physical structures, such as sidewalks, can help safely facilitate novel interaction and insights that can generate subsequent economic activity (Jacobs 1961). On the other hand, barriers such as railway lines or highways cutting across communities effectively separate and segregate them into distinct sub-communities, both in the spatial and social sense (e.g., Ananat 2011; Rothstein 2017; Samila and Sorenson 2017). Water bodies, such as rivers and bays, split statistically aggregated communities, often into distinct social worlds with different sociodemographic and economic features (e.g., San Francisco and Oakland as in Nemoto et al. 2015; also see Star 1999). Just as physical connections provide new sources of interaction that may inspire novel economic activity, so too do physical divides stunt that very potential for such activity. The lack of broader attention to physical connectedness in communities partly arises because the built environment is often seen as a relatively static and a taken-for-granted backstory, in spite of being the wellspring, and perhaps even the fora, of human experience and socialization (Halbwachs 1992, ch. 4).

In short, for all the prior organizational literature that focuses on bridging, it tends to think of bridges as social or cultural metaphors (Burt 1992; Granovetter 1973; Pachucki and Breiger 2010), and so we actually know very little as to how real, literal, *physical* bridges affect entrepreneurial activity. In particular, this paper argues that physical bridges play a distinct and important role in fostering entrepreneurial activity through developing new arteries of connectedness within geographic communities. Given physical infrastructure can both connect and divide in non-trivial ways (e.g., Ananat 2011; Jacobs 1961; Rothstein 2017; Samila and Sorenson 2017), we cannot continue to treat physical infrastructure such as bridges as accepted, unproblematic "givens" of connectivity in the organizational literature.

In making these assertions, we advocate for greater attention to the built environment by showing how the construction of new bridges drives greater rates of business founding in U.S. Core-based Statistical Areas (CBSAs).[1] We argue that the driving force behind such effects is the greater recombinative possibilities fostered from physical connectedness between people, resources, and ideas. We focus on the effects of greater connectedness in the founding of high-growth startups that typically receive venture capital (VC) funding. Further, we elaborate on the underlying mechanisms by showing how greater spatial connectedness fostered by bridges also leads to qualitative differences in organizational characteristics of the founded startups. We find that enhanced spatial connectedness from the opening of newly built bridges enhances the average number of early-stage investors in ventures, as well as increases the rate at which new founders enter entrepreneurship locally. We also find that such enhanced spatial connectedness is associated with the creation of ventures that span more industry categories. We further investigate the qualitative textual descriptions of such ventures, finding them to be more recombinative in their stated activities.

To illustrate these underlying mechanisms, we conduct additional analyses that explore variation in founding between industries that possibly require more or less social contact for innovation. We also leverage bridge heterogeneity—such as bridging natural versus manmade divides or adding sidewalks versus just roadways—to understand additional scope conditions under which these mechanisms operate. In these additional analyses, we find that the impact of such connectedness cannot be explained away by simple reduction in detour distances alone. We also conducted various robustness checks to further identify the proposed effects. These include testing for identification through instrumental variable methods,

[1] We look at CBSAs with population >50,000 per the 2010 US Census (called MSAs in earlier censuses). Excluded are Puerto Rico, DC, military bases, and other territories of the US. This left us with 366 CBSAs out of the 382 meeting the population cutoff (https://web.archive.org/web/20161110102915/https://www.whitehouse.gov/sites/default/files/omb/bulletins/2015/15-01.pdf)

alternative functional forms of the dependent variable, running models with and without potentially confounding controls, using autoregressive specifications, and assessing alternative outcomes such as the founding of non-startup organizations. In the Appendix, we also provide qualitative vignettes around the origination and siting of these bridges, as well as their economic impact on cross fertilization of ideas in geographic areas. We also discuss implications for the literatures around not just entrepreneurship, but also sociomateriality, organizational ecology, imprinting, and institutional theory. These insights stem from our study's core finding that spatial connectedness impacts not just the founding but also the qualitative characteristics of high-growth startups. In conclusion, Van de Ven (1993) famously argued for the consideration of three elements as the infrastructure of entrepreneurship: regulatory institutions, public resource endowments, and private firm capabilities. Our paper argues that perhaps what is critically remiss in the literature is the consideration of physical connective infrastructure as a fourth element of this framework.

THEORY AND HYPOTHESES

Works in geography, civil engineering, and urban planning have paid attention to how physical spaces and connectedness affect health, quality of life, and the distribution of resources (Fischer and Amekudzi 2011; Hitchner 2012; Jacobs 1961; Tzoulas et al. 2007). However, this literature largely aims to provide planning advice around infrastructure, rather than study implications on novel organizing. Such implications are the preoccupation of organizational theory, especially as applied to the phenomenon of entrepreneurship. More specifically, debates in this literature often center on what is good and worth doing. Some propose economic impact as a litmus test (Moser 1998), while others argue for quality of social life as the right infrastructural planning metric (Jacobs 1961). As far as we are aware, none of the extant work in this literature looks at entrepreneurship, apart from peripheral discussions of entrepreneurship in the smart cities literature (Kumar et al. 2020). This seems a glaring omission, given new business creation is seen as a key engine of innovation and dynamism, indicative of economic impact (Decker et al. 2014; Haltiwanger 2009), and also an intrinsically valuable process of self-actualization and 'emancipation', indicative of quality of life (Gimeno et al. 1997; Rindova, Barry and Ketchen 2009)

On the other side of the aisle, the literature in economics has variously explored the role of infrastructure as spending shocks (Bachmann and Sims 2012; Munnell 1992), albeit with externalities of economic development (Banerjee, Duflo and Qian 2020; Czernich et al. 2011; Esfahani and Ramirez 2003; Ostrom, Schroeder and Wynne 1993). For example, Munnell and Cook (1990) find such spillovers from infrastructure to have a public-to-private sequence, rather than the reverse. Démurger (2001) found transportation infrastructure to be the catalyst for economic growth when comparing regions with similar infrastructure spending, and suggested that geographic isolation presents negative externalities that can be mitigated to some extent by telecommunication linkages. Similar work has explored the role of digital communication infrastructure from the standpoint of externalities of economic growth (Czernich et al. 2011), although Roller and Waverman (2001) suggest that the critical mass for such effects is near-universal service. Audretsch et al (2015) similarly suggest that infrastructure has implications for entrepreneurship, and found comparatively higher impact of broadband compared to existing physical infrastructure.

Yet, physical infrastructure is often built with a desire for longevity, so the impact of older existing infrastructure on spurring new entrepreneurship is understandably muted. Existing bridges reflect the social values and resource distributions of the past (Suchman 2000; Winner 1980). Because these structures are often built to last for extensive periods of time, these structures often remain even as the communities around them change. This has led some to speak of existing public infrastructure, such as bridges, as "institutional relics" that persist as snapshots of social and institutional forces from the time in which they were built. Even if technologically adequate, these relics might become socially obsolete as sources for new kinds of social connectedness (Desai and Armanios 2018). In short, existing connective infrastructure becomes part of the collective memory of the past, rendering it a marker more of preservation than disruption. Similarly, repaired or expanded bridges might improve the flow of people and ideas. Yet, their impact is likely less significant, as the human ecology and distributions of human capital around such structures has likely ossified, and may even no longer reflect current population distribution and clustering (e.g., Banerjee et al. 2020). Therefore, for the generation of new opportunities, there needs to be new constructions that better reflect present-day norms and geographic space as opposed to entrenching outdated norms and notions of space (Dalgaard et al. 2018; Leonardi and Barley 2010; Star and Ruhleder 1996). Simply put, we cannot presume that past physical infrastructure can adequately support future entrepreneurial activity.

Despite this vibrant discussion of physical infrastructure in these other research streams, such discussion has largely been absent in the organizational literature. In fact, much of the organizational literature takes the issue of physical connectedness as a given, even when exploring the impact of spatial boundaries on organizational processes of legitimation, competition and founding. For example, computational and observational studies in organizational ecology have explored how local interaction and expectation formation drives local population ecology processes, which aggregate up to broader patterns of industry evolution (Lomi 1995, 2000; Lomi and Larsen 1996; Lomi et al. 2003). From a different perspective, shared social and normative characteristics influence the ecology of industries in different geographic areas (Wezel and Lomi 2003). Similarly, local associative activity and the distribution of resources and opportunities across space have been found to influence the founding of organizations (Dutta 2017, 2019; Kwon, Heflin and Ruef 2013). Interestingly in these studies, much of the built environment is largely perceived as a static background feature, particularly outside of emerging economy contexts (e.g., Glückler 2013; Marquis and Raynard 2015). As a result, studies of organizations and entrepreneurship start with an assumption of some persistent baseline level of physical connectedness in geographic communities.

However, when looking at the entrepreneurial process from idea generation to founding, physical connectedness is a critical driver. Drawing on seminal research traditions in organizational ecology (Hannan and Freeman 1989), institutionalism (Tolbert and Zucker 1996), and entrepreneurship (Reynolds and White 1997), Ruef (2005) described a model of entrepreneurship comprising initiation, resource mobilization, incorporation, social organization, and, finally, becoming operational. This involves iterative steps, such as beginning conversations and cross-fertilizing ideas to a point where they start to appear viable; mobilizing resources—people and financial—to explore pursuing said ideas; getting advice on incorporation; building the founding team and early employee group; and finally bringing the product and service to market. In each stage of the entrepreneurial process, physical infrastructure clearly matters. It influences frictions to contact, and it influences what resources you have at the ready.

Yet again, in these studies that focus on entrepreneurial processes, physical infrastructure is still predominantly seen as a given. Knowledge transfer and cross-fertilization between medical firms were influenced by face-to-face contact and cooperation (Schoonhoven and Eisenhardt 1992). Similarly, tacit knowledge—such as information and nuances missing in formal blueprints of procedures—was vital to entrepreneurial behavior (Brown and Eisenhardt 1995). However, such transmission in most studies assumes a baseline level of (unchanging) infrastructural connectivity, which can affect the degree to which there are frictions around these interactions. Geographic communities also underlie overlaps between potential entrepreneurs' associational activity, driving variation in rates of entrepreneurship in such communities (Kwon et al. 2013), while again their physical connectedness is largely assumed to be held constant. Even studies of bridging and bricolage talk about such processes as being primarily socially and cognitively constrained. For example, a seminal study on bricolage defines the process as "making do with 'whatever is at hand'" (Baker and Nelson 2005, p. 330). Yet, this study and others do not consider how something comes to be "at hand", in essence treating spatial connectedness – which conditions the flow of people, resources and ideas – as an unproblematic given. In short, the built environment is largely static or assumed so in the organizational literature. In fact, when terms such as bridging are used, they are all too often used as metaphors for, rather than as literal instantiations of, the physical connectivity within the built environment.

Bridges and Spatial Connectedness.

Access to nonredundant skills, complementary knowledge, and recombinative possibilities face not just a problem of spatial proximity, but also one of spatial connectedness. The literature on knowledge transfer has keenly focused on spatial proximity as a key driver of knowledge transfer (Argote and Ingram 2000; Argote, McEvily and Reagans 2003). Yet, proximity alone doesn't equate with connectedness, especially considering the reality that much of the geographic space in the United States is often segregated along sociodemographic lines and dimensions such as race, income, education, and human capital (Massey 2007; Massey and Denton 1988), that even divide along neighboring streets (Grannis 1998; Grannis 2009).

These divides often follow along the lines of natural and man-made barriers. Many American communities are 'tales of two cities' not just metaphorically, but also literally, as they are delineated by large water bodies such as rivers and river valleys, or bays and earthquake faults (Rothstein 2017; Star 1999). For example, describing the Ohio River that flows through the US Midwest, planners noted how *"For many, the Ohio River functions as a physical and psychological barrier that separates Southern Indiana from the rest of the Louisville region* (SIRDP 2015, p. 53)*."* Others have remarked how man-made features such as big highways can cut across communities, while large railway line systems present largely impassable barriers and segregate communities around social, economic, and human capital (Ananat 2011; Rothstein 2017; Samila and Sorenson 2017). While much of the multidisciplinary work on knowledge transfer conflates spatial proximity with spatial connectedness, they are analytically and empirically distinct (Grannis 1998; Grannis 2009). Without connectedness for example, Jacobian externalities (i.e., likelihood of knowledge spillovers due to proximity of firms across different industries and demographics) might remain unrealized (e.g., Fujita, Krugman and Venables 2001; Glaeser et al. 1992; Henderson 1997; Jacobs 1969). Similarly, agglomeration economies, both in terms of concentration and scale of impact (e.g., Shaver and Flyer 2000), might also be limited in the presence of frictions to contact.

Emerging work is only beginning to focus on spatial connectedness as a key unexplored variable in entrepreneurship. For example, Bernstein, Giroud and Townsend (2016) study the impact of introducing new airline routes, finding that firms with VC investment generate greater performance for their investors when a new airline route reduces travel time between the VC's offices and portfolio company locations. Through post-hoc surveys, they find that even a seemingly small change in air transport—such as going from indirect flights to direct flights—increases these VC-company interactions. While spatial proximity remained constant in their study, the increase in spatial connectedness had additional impacts on the fortunes of portfolio ventures. While studying a different context than ours, the paper highlights how increases in spatial connectedness has impact beyond proximity.

But spatial connectedness alone is not enough. To drive enhanced entrepreneurial outcomes such connectedness has to go beyond preexisting patterns of interaction (e.g., Hasan and Koning 2019). Existing spatial connections, such as existing bridges across natural and man-made geographic divides, are often relics of past institutional arrangements, social patterns, and political contentions (Desai and Armanios 2018; Suchman 2000; Winner 1980), so their import for generating new ventures is limited. New bridges, on the other hand, provide positive shocks to spatial connectedness in communities, and we argue that such enhanced spatial connectedness should subsequently increase the founding of new organizations.

Hypothesis 1 (H1): The opening of newly-built bridges in a geographic community increases startup founding rates in the subsequent year.

Given H1, it is worth reemphasizing three points. First, we emphasize *new* bridges rather than modifying or repairing *existing* bridges because bridges reflect the social values and resource distributions of their time (Suchman 2000; Winner 1980). Therefore as prior literature notes (Desai and Armanios 2018), existing bridges may reflect outdated norms and so for the generation of new opportunities, there needs to be new constructions that better reflect present-day norms and geographic space. This also operationally means that repairing or expanding existing bridges is likely to have less significant impact, even when the bridge traverses a major thoroughfare, as such bridges likely reflect population distribution and clustering from the time of their original construction as opposed to the present-day. Second, our theory does not presuppose *who* benefits from enhanced entrepreneurial activity, although studies in emerging economies have found the impact of new bridges do tend be unequal (e.g., Faoziyah 2016).

Third, we expect the hypothesized processes of spatial connectedness aiding recombination are more likely for industries where such activity requires greater physical ("offline") rather than virtual ("online") contact. For example, access to knowledge in biotechnology has been argued as a key concern for innovation (Powell, Koput and Smith-Doerr 1996). Such industries often involve not only documented technical knowledge but also tacit knowledge about a range of activities such as failed trials, uncommercialized basic discoveries, and experience in bringing formalized knowledge into rapid, changing contexts. As such, and in light of other studies (Whittington, Owen-Smith and Powell 2009), we expect industries such as biotech to see greater responsiveness to changes in spatial connectedness compared to other knowledge intensive startup areas such as computer science and engineering, although we expect both to show baseline responsiveness to enhanced physical connectedness from opening of newly built bridges.

Founder Entry Rate

Apart from the impact on startup founding, once we delve deeper into the organizational processes of founding, the importance of such enhanced connectedness stands out. Interpersonal contact and cooperation is important in finding cofounders and discovering relevant tacit knowledge residing among individuals (Brown and Eisenhardt 1995; Schoonhoven and Eisenhardt 1992). Similarly, serendipitous contact between individuals through interpersonal association often underlies the extent to which entrepreneurs can adequately contact others with the relevant skills and resources necessary for entrepreneurship (Kwon et al. 2013). Other studies found that frictions to contact are key barriers to creating the ideal founding team (e.g., Zellmer-Bruhn et al. 2021).

The extant work on spatial information spillovers has largely paid attention to the transfer of knowledge and human capital based on spatial proximity, and we argue that spatial connectedness is an unidentified, distinct, and critical pathway through which such processes happen. On the founders' side of the equation, one would therefore expect finding and developing relationships that allow for entrepreneurial teams to emerge and to involve fewer frictions in the presence of spatial connectedness. That is, we expect such spatial connectedness to not only foster greater founding rates but also draw more founders into entrepreneurship in the local community, net of the increase in founding rates itself. In other words, we expect not just new venture founding, but also more entry into entrepreneurship by potential (co)founders.

Hypothesis 2a (H2a): The opening of newly-built bridges in a geographic community increases the entry rate of founders into entrepreneurship in the subsequent year.

Early-Stage Investors

For the founding of startup firms, the local community also matters as a source of early-stage financing, apart from spillovers of tacit knowledge and connections between potential founders. Enhanced spatial connectedness (or connectedness with fewer frictions) is important not only among people with potential ideas and knowledge, but also between people with ideas and those with resources who can fund the commercialization of such ideas. Beyond the triumvirate of friends, family, and acquaintances, which are the mainstay of early financing and help (Ruef 2010), startups in the early stages also rely on various small, local, investors such as angels (Sohl 2008), informal groups of accredited investors (called "angel networks"), or occasionally larger players such as VCs. Such investors are often hyper-local in their investing behavior, driven by the need for personal interaction with founders so as to better mentor and advise these early stage ventures (e.g., De Clercq et al. 2006). For example, even though a few very prominent VCs are less constrained by location, spatial proximity undergirds the investing activity of most other investors (Sorenson and Stuart 2001). Cumming and Dai (2012) similarly noted how investors make their investment decisions partly based on a "twenty-minute rule" of distance to the startup as evidence for local bias in VC investments (for performance, also see Bernstein et al. 2016). Overlaying physical connectedness and proximity is likely to therefore allow greater connections between early-stage investors of various stripes and startups seeking financing.

Hypothesis 2b (H2b): The opening of newly-built bridges in a geographic community increases the number of early-stage investors in the average startup founded in the subsequent year.

Recombination and Industry Spanning

While Hypotheses 2a and 2b discuss flow of personnel, we also argue physical connectivity enhances the flow of ideas. Wendy Dant Chesser, President and CEO of One Southern Indiana, talking about the Ohio River Bridges project, noted how greater connectedness was not just about the immediate physical connections but also the potential for novel opportunities. In so doing, she said this bridge project would attract "*opportunities in many different categories*" (as quoted in Crowner 2018). Similarly, others have noted the importance of such connectivity to *"matching of employees and businesses, shared inputs, knowledge spill over, and overall economies of scale"* (EDRG 2014, p. 4). For us therefore, a remaining question is whether such benefits of greater connectedness can indeed be seen in the types of entrepreneurial ventures being founded. While recombination is a crucial step in many kinds of entrepreneurial activity (e.g., Bartel and Garud 2009; Chiles, Meyer and Hench 2004), its importance is particularly high for the founding of entrepreneurial ventures that are novel, knowledge-intensive, and aim for rapid growth by attracting outside funding. From the standpoint of internal organizational activity, recombination is a process of combining existing resources and business models in unique and novel ways. This can happen in two analytically distinct ways, although they are often observed together empirically.

The first involves startups engaging in recombination of skills, methods, technologies, business models and tacit knowledge to shake up the status quo within an industry. For example, Kaplan and Vakili (2015) find that while the sources of recombination are nuanced, recombination across more disparate sources are associated with greater economic value of ideas and knowledge. Powell and colleagues (1996) note the importance of contact between people across disparate approaches and perspectives, and even the reputation for bringing such groups together, as a driver of innovation within an industry. Davis and Eisenhardt (2011) find that not just resource availability but also the diversity and frequency of interaction across partners helps improve recombination in ways that enhance technological innovation. Lower frictions to coordination and interaction therefore become important beyond its impact on securing human capital or funding.

The second involves recombination to create entirely new products and services that sit in the interstitial gaps between industries, thereby generating novelty from boundary spanning. Here, recombination is measured as industry-spanning. From this vein, scholars have privileged boundary crossing, such as between industries as a source of novelty (e.g., Gruber, Harhoff and Hoisl 2013). For example, Lane and colleagues (2020) find that given overlapping interests, interactions between knowledge creators leads to greater innovation when they are from different rather than the same field.

However, geographic communities are often split across distinct microcosms of skills, knowledge, and cognitive lenses (Marquis and Battilana 2009). What happens then when such communities receive a jump in connectedness? If, as we argued, spatial connectedness provides greater opportunities for connectedness between people and resources, it would also suggest the possibility that such connections being made are not merely in terms of material resources. They also present greater potential opportunities for recombining value propositions and features across knowledge boundaries, be it measured as recombining skills, methods, models, and knowledge, or as industry spanning. Therefore, we expect that when overlaying spatial connectedness and spatial proximity, it would activate greater opportunities for recombination than previously realized, and present greater potential for spanning industries in entrepreneurial ventures. Hence, we hypothesize that:

Hypothesis 3a (H3a): Startups founded after the opening of newly built bridges in a geographic community are more likely to be recombinative in their organizational activities, compared to startups founded at other times.

Hypothesis 3b (H3b): Startups founded after the opening of newly built bridges in a geographic community are likely to span more industry categories, compared to startups founded at other times.

Bridge Heterogeneity in Connectivity

While we focus on spatial connectedness from new bridges, there is also heterogeneity in the kinds of bridges and their impact on spatial connectedness as a driver of startup activity. Beyond the empirical importance of such heterogeneity, they also help shed light on the nature of such connective processes underlying the hypotheses. For example, we propose the impact of bridges as being multiplicative, such as by fostering connectedness between people with ideas, and of ideas with the resources required to bring them to fruition. As a result, we expect their impacts to go beyond simple linear reductions in commuting distances alone. Bridges also differ in what kinds of features are being bridged, such as railway lines and highways that have a history of reinforcing segregation (Rothstein 2017), as opposed to natural barriers such as rivers, bays and valleys that are more organic separations of human capital and perspectives. Bridges also differ in the extent to which they add walkways versus just roadways. One can see the impact of added walkways being particularly important for connectedness in urban centers, and the encounters on them that may breed subsequent innovation (Jacobs 1961). We discuss these aspects further in a set of supplementary analysis, both to establish scope conditions as well as to illustrate the underlying processes.

DATA AND METHODS

Bridges in the United States

Bridges not only physically connect but are also triggers of social and economic outcomes (Law 1987;

Suchman 2000). Moreover, as opposed to other forms of infrastructure, bridges give us arguably one of the clearest signals of physical connectivity, even across physically proximate locales. For example, roads are not just used for enhancing connectivity but as a way to reduce detours and travel time (Fields et al. 2009), and airline and railways are often used to connect physically distant locales (Bernstein et al. 2016). As such, bridges present the clearest way to isolate the role of physical connectivity, above and beyond near-proximity and other factors that drive infrastructure development (e.g., traffic congestion).

The focal explanatory variables for our empirical study are features of the United States bridge system. A particularly useful aspect of the U.S. bridge system is that every bridge greater than 20 feet in length located on a public road and carrying vehicular traffic must be annually reported to the U.S. Department of Transportation (see 23 Code of Federal Regulations 650.403(a))[2]. For certain exceptional cases, inspections can be required in shorter intervals of up to 90 days, or longer intervals of up to 2 years (though each bridge should be reported upon annually). For more details, see the National Bridge Inspection Standards (US Department of Transportation 1988). As such, we are able to observe almost all bridges annually. This allows us to compile annual tallies of not only existing bridges, but also new bridges built, bridges reconstructed, and bridges that are in poor or worse condition with limited usability. Similar to other construction projects, new bridges predominantly follow what is known as a design-bid-build or an expedited design-build approach (Minchin Jr. et al. 2013; Shrestha, O'Connor and Gibson 2012). Usually, first a traffic, needs, and feasibility assessment is performed to ascertain whether a location needs a bridge. This is then followed by a more detailed engineering assessment to ascertain the technical needs for a bridge in the location (i.e., what types of reinforcement the bridge would need, does it need drainage channels, etc.). This is then followed with a series of alternative bridge designs with an associated cost and risk analysis. A project is then chosen; if there is a bid component, it is a competitive process where the design plan is often selected based on cost. The chosen project is then implemented and tests are done upon bridge completion to ensure it meets safety and structural standards. Depending on the complexity and scale of the

[2] https://www.gpo.gov/fdsys/pkg/CFR-2011-title23-vol1/pdf/CFR-2011-title23-vol1-part650-subpartC.pdf

project, prior studies indicate these projects can take on average anywhere between one and seven years (Berg et al. 2006; Wu et al. 2010).

Bridge funding depends on whether the bridge is on a federal-aid highway route or a non-federal highway route. Federal-aid highway routes are usually those on a federal interstate or that directly feed into an interstate. Non-federal-aid highway routes are usually those local routes not connected to the federal highway system. Other nuances in bridge construction and funding depend on the bridge's location, age, and/or type, which open up other avenues of funding and guidelines for project management, such as the Innovative Bridge Research and Construction program, the Bridge Discretionary Program, the National Historic Covered Bridge Preservation program, or the Bridges on Indian Reservation Roads (IRR) program, and so on (US Department of Transportation 1999, 2018). For those bridges on federal-aid highways, up to 80 percent of costs can be covered by the federal government, and for non-federal-aid highways, between 15 and 35 percent of costs can be covered by the federal government (see 23 Code of Federal Regulations 650.413). Local government agencies (or consortia of state, municipal, and county governments) cover the remaining costs. The specific mix of funding for each new bridge is relatively opaque and varies, but we control for total government revenue at the CBSA level (mostly from taxes) to account for local ability to pay for (number and capacity of) bridges.

To create the independent and control variables related to bridges we leverage annual records from the U.S. National Bridge Inventory (NBI) from 1992 to 2012 (N > 14.5 million total; N > 666,000 annually). We restrict the NBI data to a 21-year period of 1992 through 2012, as policy changes began limiting the number and types of reported bridges beginning in 2013. For longitudinal analysis, we annualized the recorded bridge inventory data and updated the panel using an official database of reported changes to structure numbers provided by the Federal Highway Administration as addenda to the NBI. Taken together, the bridge data from which independent and control variables are constructed for the (balanced) panel analysis of entrepreneurship rates, comes from 1,047,127 unique bridge-routes with data on state, county (matched to CBSA), structure number, condition, year built, and various markers of bridge type.

Besides a quantitative analysis of the entire bridge system, we also conducted qualitative work to ascertain the impact of such connectivity. Given infrastructure is often taken-for-granted (Halbwachs 1992, chapter 4), we prioritized archival data analysis but also supplemented our analysis through interviews with local urban planners, developers, and other community stakeholders. As seen by two indicative case vignettes of the Louisville and San Diego CBSAs in the Appendix, bridges were a source of connectivity that led to high-tech founding both throughout the city and even in close proximity to such construction. Moreover, while the economic impact of these bridges was recognized, the actually proximate trigger(s) for construction were often unrelated to economics. This strengthens confidence in our research design in that new bridge construction provides a largely exogenous boost to high-growth entrepreneurship.

Units of Observation

The units of observation are Core Based Statistical Areas (CBSAs) with over 50,000 population in the United States. These are areas that contain an urban center ('urban' by US standards given its wider dispersion of population compared to other developed nations) surrounded by less densely populated areas with which it is contiguous and has close economic ties. These areas were designated as "MSAs" in the past, but more recently, they have been classified in a unified manner as CBSAs (possibly to clarify that these are not all "metros" in the colloquial sense). In the aggregate, our sample comprises the place of residence of 85% of the United States' population[3]. Our sample of CBSAs includes the 50 states, but excludes the District of Columbia, military bases, and outlying territories of the US, such as the US Virgin Islands and Puerto Rico. This left us with 366 CBSAs out of 382 meeting the population cutoff based on the 2010 census. Areas that crossed the 50,000-population threshold in the 2010 census but were smaller in the 2000 or 1990 censuses are still retained in the sample for consistency. We excluded CBSAs that crossed the population threshold after 2010, based on intercensal estimates. These areas are observed annually for the period 1992 to 2012. The window of observation is restricted in this manner owing to constraints with the bridge data reporting regulations as discussed in the last paragraph of the previous subsection.

One may argue that physical connectivity should not matter for such a recent time period (1992-2012),

[3] https://web.archive.org/web/20161110102915/https://www.whitehouse.gov/sites/default/files/omb/bulletins/2015/15-01.pdf

especially given the rapid urbanization of the U.S. (Bounoua et al. 2018). We argue then if anything, finding an effect of bridges on new founding rates during such a recent period would be a conservative estimate.

Dependent Variables

The main dependent variable is a count variable: the number of new startups (high-growth, high-potential ventures that receive angel- or VC- funding) founded in a CBSA in a year. Besides being a more direct test of the core mechanism of our study – new arteries of spatial connectedness driving entrepreneurship - this also helps us exclude those ventures which may see a new bridge as an economic opportunity in and of itself (e.g., gas stations or convenience stores near a new bridge site). Founding data for startups (defined as firms that received any Angel or VC investment) were gathered from the Thomson Reuters VentureExpert or SDC "Platinum" dataset, with the last data pull in 2014 (since our sample is restricted to 1992-2012 due to bridge data constraints).[4]

We also use other dependent variables for testing organizational heterogeneity in the kinds of startups founded. For testing H2a (while controlling for startup founding rate), the dependent variable is founder entry rate. For gathering founder data, we merged the main dataset with CrunchBase information on founders. We calculated the total number of startup founders in a CBSA in a year using Crunchbase founder data for startups and aggregating unique founders by CBSA-year. This was normalized by the existing number of startups in the CBSA, to arrive at a founder entry rate, and to also retain consistency with the other DVs. However, the results are unchanged (and stronger in magnitude and significance) if we do not convert the counts of new founders into a rate. Ruef (2010) notes how the size of the founding team in itself is a complex multidimensional issue. However, the entry rate of founders in the CBSA is itself a directly relevant outcome given the proposed mechanisms underlying the impact of new arteries of spatial connectedness, such as new bridges opening up.

For the test of H2b, the dependent variable is the average number of early investors until the first round

[4] We also test for robustness to using all business founding as the DV but do not use it as our main sample since the impact of knowledge transfer/building from spatial connectedness is likely to be lower for such businesses.

or earlier. Of these, angels and other individuals comprise the majority, and are therefore largely local. It also includes some smaller seed/early VC funds. In the models shown, such seed investors are also included in calculating average number of early investors for the founded startups. Excluding them does not change the results, but we did not find a compelling reason to exclude them in the test of H2b, as long as they are early/seed stage investors.

For testing H3a and H3b, we again relied on Crunchbase data for textual evidence of recombination and the industry spanning nature of the average startup founded in a CBSA in a year. The dependent variable for H3a is the extent of recombinativeness as evidenced by the textual descriptions of the startups in the Crunchbase data. Before mining this textual data, we first excluded the very few Angel/VC funded startups that were in the domain of architecture, construction, general contractors, and real estate, to remove any doubt that the identified recombinators were building bridges between ideas and knowledge domains rather than involved in some capacity with the actual task of bridge construction or design. For these non-construction-related firms, we then mined textual descriptions to find out whether a startup has words indicating recombination. These included words (or grammatical variants or words) such as 'combining', 'bridging', 'spanning', 'straddling', 'fusion', 'crossing', and 'blending'. We identified a startup as recombinative if they had one or more of these words in their description. We then calculated the average incidence of such recombinative startups in a CBSA-year cohort of startups from the CrunchBase sample. Thus, higher levels of this DV indicate a greater proportion of startups founded in a CBSA-year being recombinative. For testing H3b, the DV is the average number of industry categories spanned by startups in a CBSA-year, based on Crunchbase classifications. This follows other studies that credit industry-crossing itself as a measure of novelty from recombination (e.g., Gruber et al. 2013).

Independent and Control variables

The focal independent variable is the number of new bridges built in a CBSA in a year. The building of new bridges in a CBSA is not a rare event in the period under study, partly due to the vast water-body studded land area of the US and partly due to slower government investments in infrastructure in recent decades. However, one should note that bridges are often built in multiples rather than one at a time, for two reasons. First, what the user sees as a "bridge" might include multiple structurally distinct components such as roadways (single or separate for either direction), railway paths, walk and bike paths either along the curb or as separate understructures, and occasionally distinct boulevards or "lids" offering spaces for walking and viewing. Second, once permitting and environmental assessments are done in a particular area for a bridge, it is often more convenient from a practical operational perspective to build multiple bridges as part of a bridge project.[5]

We use the Inverse Hyperbolic Sine (IHS) of this variable to account for the declining marginal impact of higher numbers of new bridges built in the same year. The IHS, apart from capturing the above, is also well defined at zero and does not require fudge factors such as are needed in log transformations. We also test alternative transformations of the independent variable (see Robustness Checks in Appendix).

We control for other bridge-related variables that might confound the relationship between new bridges and entrepreneurship rates. This includes the number of bridges that were reconstructed (i.e. existing bridges that underwent significant updating due to age or damage, to conform to new safety requirements, or to expand their size and/or add structures). We control for the log number of existing bridges in the CBSA, since new bridges will have less of a marginal effect when the CBSA is already crisscrossed by several other bridges. We control for the number of bridges in poor or worse condition—measured by the number of bridges where the substructure (structure carrying the bridge paths) was rated in the NBI as Poor or worse condition. The independent and control variables are lagged one year.

Apart from numbers, reconstruction status, and condition of bridges, we also controlled for several spatial and demographic features in the regression models. These included both average characteristics of

[5] A few CBSAs in rare years have very high number of bridges built. This is owing to unexpected events such as major disasters in the United States within our study period leading to irreparable and widespread structural damage on rare occasions, necessitating a massive array of new bridges a couple of years later (such as the Northridge Earthquake in Los Angeles and the surrounding CBSA, or the impact of Hurricane Katrina in New Orleans and the surrounding CBSA). Excluding this extreme-event-driven bridge building does not change the results—it in fact slightly strengthens the results since startup activity in these outlier instances does not track new bridge building too closely (note that we focus on angel- and VC-funded non-construction related startups as the dependent variable and not mom-and-pop stores and construction firms which might get a boost in such settings).

CBSAs as well as their distribution in smaller units within the area. Demographic and socioeconomic data such as household income, racial composition, employment and education levels are gathered from the decennial census of the Census Bureau and American Community Surveys interpolated on time for intervening years. Aggregate business activity data are gathered at the annual level from the County Business Patterns of the Census Bureau and aggregated to CBSAs. Summary statistics of control and independent variables are provided in Table 1.

<Insert Table 1 Here>

To account for baseline density dependence processes, we control for the number of existing startups in the CBSA in the previous year, and its square term. To further account for the possibility that larger economic centers might attract both more bridge building and more founding, we control for the number of all businesses (not just startups) in the CBSA in the previous year. We control for log of population of the CBSA, its population density, and the median household income of the CBSA. Since work experience in existing firms is often a precursor to starting new ventures (Sørensen and Fassiotto 2011), we controlled for the proportion employed in firms in the CBSA. A control variable for income inequality is also added, measured as the interquartile range of household income (i.e. 75th percentile household income minus 25th percentile household income). We control for racial/ethnic diversity, measured as the Simpson index of diversity based on the counts of Hispanic/Latino, and Non-Hispanic White, Black/African-American, Asian and Pacific Islander, Native American, and Other persons. We control for the proportion of college graduates in the CBSA and the proportion of the population below the poverty line.

We also controlled for the industry diversity of the CBSA, measured as the HHI (Herfindahl-Hirschman Index) calculated as one minus the sum of squares of proportions of different industry establishments in the CBSA. Industries were identified based on 4-digit SIC codes (till 1997) and 6-digit NAICS codes (after 1997). Since industry classifications have changed over the years from SIC to NAICS, and even within the respective systems new industries were added or reclassified at different times, we normalized (z-scored) the HHI index separately within the pre-1997 period (SIC) and the after 1997 period (NAICS). Since z-scored, these are then comparable between periods and usable as a single normalized z-score variable of industry diversity. Results are unchanged if we ignore the change in industry classification and just use a naive HHI index (or drop the variable altogether).

For calculating the variable measuring recent migrants, defined as the proportion of current residents who lived in a different place 5 years ago, we included people who moved in from a different CBSA, non-CBSA, state, or country. The variable measuring the degree of residential segregation is calculated as an Isolation Index of racial residential segregation (Massey and Denton 1988), with Non-Hispanic Black/African-American as the base category. The key reason for using the isolation index was that it offers a conceptual analog to the baseline representation of communities - the existence of distinct social worlds at the intersection of space and socioeconomic characteristics (Massey and Denton 1988; Massey and Denton 1993). The variable measuring the extent of local employment opportunities is calculated as 1 minus the proportion of employed workers 16+ years of age who are local residents but work outside it, representing a proportion of employed workers who had to seek employment outside the CBSA even though they live in the CBSA. We also controlled for other, relatively static features of a CBSA such as the proportion of water area (relative to total area) in the CBSA, and the level of government expenditure in billions of dollars in the CBSA (which can signal both economic health driving founding activity and new bridge building). Water area relative to total area was gathered from the decennial census and interpolated between the years; this is largely stable over years with a few exceptions where CBSAs with shrinking water area potentially represent sites of major environmental crises and/or climate change. Local government capital expenditure data was gathered and aggregated from the Annual Survey of State and Local Government Finances of the US Census Bureau.

Methods

To recap key points from the data section: We test our hypotheses using an annual panel of bridge-related and other variables for the 350+ CBSAs in the United States for the period 1991-2012 (the bounds being set by availability and reporting of the bridge data). Below, we discuss the models and methods we use for the tests of the hypotheses. We also show robustness to alternative specifications of the DV and alternative modeling choices in the Robustness Checks section.

For a test of the first hypothesis, the dependent variable is the count of startup founding in a CBSA in a year. Count variables such as founding typically have overdispersion, with the variance being much larger than the mean. For such settings the most apt specification is the negative binomial distribution (Cameron and Trivedi 2013), which has been widely used for predicting founding (Barron 1992).The negative binomial distribution offers a better baseline fit for predicting founding counts, and reduces issues of overdispersion inflating the observed effects. Specifically, we used a Multilevel/Mixed Effects Panel Negative Binomial model specification.[6] We used three levels of intercepts to account for baseline variation for States, CBSAs and Years. Apart from federal regulations that are common across all states, bridge building often entails a heavy involvement of state transportation agencies, particularly in civil engineering work (Suchman 2000), and different states can vary in both the modes of planning and execution of new bridge projects, as well as the extent of matching funding and attention available for bridge projects (Desai and Armanios 2018). Additionally, different states have differing emphases on new high-tech business creation as a policy goal (Armanios, Lanahan and Yu 2020). As a result, the effect of states is a major confound between the independent and dependent variables in the study. We therefore have state effects as the first level in our multilevel model. In a few cases, CBSAs are split between states; in those instances, we took the state indicator to be the one where the majority of the CBSA population resides.

CBSA indicators are the second level in our model, to account for variation in persistent factors across CBSAs such as extent of waterways and therefore need for bridges, as well as the underlying favorableness of the CBSA to new venture creation, in various unobserved ways. The third level in the models is the year of observation. Some periods might have more generous funding available or greater legislative focus on bridge infrastructure, while other periods might have severely tightened purse strings such as in recessionary periods. Similarly, some periods might be hot years for entrepreneurial activity while other

[6] Some analysts prefer a Poisson QMLE specification due to the 2-parameter form of the NB model (but Poisson doesn't account for overdispersion quite as well). We also tested using this Poisson specification with similar results.

years might see lower levels of entrepreneurship. As a result, the year effects are useful to have in a multilevel model for our proposed hypotheses. These multilevel/mixed effects negative binomial models are estimated via quasi maximum likelihood, which is a variant of ML estimation that uses a reduced form for partialing out persistently high levels of overdispersion for some States/CBSAs/Years over others. We report robust standard errors in parentheses. When discussing the results, we will also discuss the extent of variation taken out by each of the three levels in the mixed effects models. In the robustness checks section, we discuss the robustness of the results to various alternative modeling choices, either in terms of DV, model specification, or various ways of specifying the independent variable.

For the tests of hypotheses related to organizational features of the founded startups across CBSA-years (H2a,b, H3a,b) the dependent variables (as noted previously) are noncount outcomes. For these outcomes we used Mixed Effects linear panel models (with State, CBSA, and Year effects, for similar reasons as above). When predicting organizational features of the founded startups, we also control for the founding rate in those CBSA-years.

RESULTS

Control model

Model 1 in Table 2 is the control model predicting number of startups founded in a CBSA-Year. All right-hand side variables are lagged one year in predicting the founding rate. Among control variables, the pre-existing startup density in the CBSA is a positive and statistically significant predictor of founding rates while the second order term is negative and significant in predicting founding, as would be expected from organizational-ecology processes underlying founding. The coefficient on log population is positive and significant while that on population density is negative and significant—implying that larger population centers just have larger carrying capacity for startups except when they have high population density (for example, Silicon Valley is located in the San Jose-Sunnyvale-Santa Clara CBSA, which is a large but low-density population center). Fraction of the CBSA comprised of water bodies (decimal fraction) is positive and somewhat significant in predicting startups ; water body area is relatively stable, but presumably, places with shrinking water area are associated with environmental crises and/or climate change that are less likely to attract potential startup founders (and consequently see lower founding of VC- and angel-funded startups). Median household income has a negative relationship with founding rates, possibly due to greater opportunity costs when the median earner has a larger salary to forego.

The percentage of college graduates in the area, which is a control for the stock of local human capital, is a positive and significant determinant of founding. The level of poverty has a significant negative effect on founding, since our outcome focuses not on self-employment but founding with at least one employee other than the founder. The control for local government capital expenditure (on all kinds of amenities and infrastructure) is associated with higher numbers of startup founding. Note that the above effects are conditioned on the multilevel modeling strategy that partials out consistent/average differences by state, CBSA, and year (albeit parametrically drawn).

The bridge-related control variables are all not significant in predicting founding. These include the number of existing bridges in the CBSA, the number of bridges reconstructed or undergoing reconstruction, the number of bridges with poor-or-worse operational ratings in the substructure. These control variables appear to have no significant effects in the following year's founding rate in a CBSA, possibly having more diffuse effects or representing pre-existing artifacts that the geographic community has already adjusted to. The non-significant effects of bridge reconstruction are particularly notable, indicating that the results in the below paragraph are not driven by the economic boom from building alone, since reconstruction of bridges does not increase founding.

Main Models

Model 2 is the main model where the focal independent variable, log number of new bridges built in the CBSA in the previous year, is added. The effect of new bridges is positive and significant ($p<.01$) in predicting founding counts, providing support for H1. In magnitude terms, the building of one new bridge compared to none increases the number of startups by 16% on average.[7]

In Model 3, we predict the rate of founder entries into entrepreneurship in the CBSA on the same set of covariates as Model 2. While predicting the founder entry rate, we also add an additional control for the number of startups founded in the focal year (without this control, average early investor numbers might be confounded by founding rate itself). The coefficient on the new bridges variable is positive and significant at the $p<.05$ level, indicating support for H2a, that these connections allow for greater rate of entry of new startup founders in the CBSA in a year.[8]

Model 4 is a test of H2b, where we argue that by enhancing spatial connectedness, new bridges lead to more connections between people with ideas and those with resources. Therefore, one should see startups founded in such settings to have, on average, more early investors, such as predominantly Angels and FFF, which are mostly local sources of external financing and advice for new ventures. In Model 4, we predict the average number of early investors in the venture on the same set of covariates. The coefficient on the new bridge variable is positive and significant at the $p<.001$ level, indicating support for H2b.

In Models 5 and 6, we explore two different ways in which the above processes might increase not only greater volumes but also organizationally different startups—such as in their claimed levels of recombinative activity (even when porting ideas from other domains into their industry), and the extent to which the founded startups span industry categories. In Model 5, we predict the average recombinative-ness of newly founded startups in the CBSA as inferred by their use of recombinative words in their textual descriptions, as discussed in the Data and Methods section. We find the coefficient on the focal independent variable to be positive and significant at the $p<.05$ level, indicating support for H3a.

In Model 6, we predict the average number of industry categories spanned by newly founded startups.

[7] The calculation is as follows: asinh(1)=0.881, and the coefficient is 0.173. Given the negative binomial specification, the relative change in number of founding after one new bridge relative to none is given by exp(.173*0.881)/exp(.173*0) -1 = 0.16 or 16%. The relative effect on founding of building two new bridges compared to 1 is similarly exp(.173*asinh(2))/exp(.173*asinh(1))-1 =0.10 or 10%, which alludes to a marginally declining impact of additional new connectivity beyond the first new bridge.

[8] Note that similar (and larger in magnitude) results are obtained if we drop the control for startup rate when predicting size of investor group for the average newly founded startup (models available on request). Also, similar results are obtained with using alternative specifications, as we will discuss in the Robustness Checks section.

The emergence of new bridges has a positive significant relationship with the number of categories spanned by the average startup ($p<.001$), possibly indicating greater efforts at bridging industry boundaries rather than merely connecting the right people. Thus, H3b is supported. Beyond the particularities of the dependent variables themselves, these results indicate that bridges have an impact that is not merely economic but also organizational in the kinds of boundary-crossing and (metaphorical) bridging enabled by greater spatial connectedness, beyond proximity alone.

SUPPLEMENTARY ANALYSES

We further conducted several supplementary analyses to present scope conditions and help elucidate and support the mechanisms underlying the hypotheses. These include looking at the heterogeneity of newly founded startups, the heterogeneity of connectedness imposed by new bridges, and instrumental variable analyses to support the main effects.

Heterogeneity in Primary Industry of Newly-Founded Startups

The hypothesized processes of spatial connectedness aiding recombination are more likely for industries where such activity requires greater social rather than virtual contact. For example, startups in computer sciences and IT might benefit from greater spatial connectedness, but also such industries might involve a lot more virtual collaboration. Conversely, as we noted previously, access to knowledge in biotechnology has been argued as a key concern for innovation (Powell et al. 1996), because it often involves not only documented technical knowledge but also tacit knowledge about a range of activities such as failed trials, uncommercialized basic discoveries, and experience in bringing formalized knowledge in to rapid, changing contexts. Therefore, later studies note that spatial proximity to other organizations, especially public research organizations, provided added benefits beyond just network centrality (Whittington et al. 2009). Based on our study's reasoning, we expand beyond this prior work and note that if the posited mechanisms from spatial connectedness, above and beyond spatial proximity, were true, one would naturally expect differing impacts based on the primary industry of the founded firms. These are elaborated in models 7 and 8 of Table 3. In Model 7, we predicted the founding of biotechnology startups on the same set of covariates as Model 2. We find that the opening of newly built bridges has a positive significant impact on biotech founding rates. In comparison, Model 8 suggests that the impact of new bridges on founding rates in Computer science and IT is comparatively smaller in magnitude, albeit still positive and statistically significant.

Bridge Heterogeneity

While we focus on spatial connectedness from new bridges, there is also heterogeneity in the kinds of bridges and their impact on spatial connectedness as a driver of startup activity, as we previously detailed at end of the Theory & Hypothesis section. We proposed the impact of bridges as being multiplicative, such as by fostering connectedness between people and ideas, and of ideas with the resources required to bring them to fruition. As a result, we expect their impacts to go beyond simple linear reductions in detour distances alone, and potentially vary based on features being bridged, and with the kind of connections made possible. We discuss these aspects in detail below.

<u>Reduction in travel detour distances</u>

One important way newly built bridges are heterogeneous is the extent to which they reduce travel detour distances. If our results were entirely mediated by detour length, then perhaps what is captured is reduction in traffic as opposed to connectivity, the latter of which is what we argue as the mechanism driving the founding rates from new bridge construction. For each previous year, we calculated the change in average travel detour distances from the emergence of new bridge paths in a CBSA. We added this variable to the main specification, and this is shown as Model 9 in Table 3. We find that the change in average detour distance has a negative significant coefficient, indicating that declines in travel detour distances enhances founding. However, this variable appears to be only a weak partial mediator—the impact of the new bridges variable on founding remains positive and significant, and quite similar in magnitude compared to the unmediated model (Model 2). This suggests that the linear decline in travel distance (and by proxy, traffic decongestion) by itself does not account for the impact of new bridges. This is aligned with our core argument that new bridges have distinct effects on knowledge spillovers and contact between people, ideas, and resources that is possibly geometric and contingent on the local environment.

Bridges over natural vs manmade features

While we focus on spatial connectedness from new bridges, there are also differences in what they are bridging. There are instances of man-made infrastructural features that end up disrupting the communities they pass through. For example, railway lines in the United States were found to be used as policy devices that reinforce segregation, and many such 'dividers' are a few decades old (Ananat 2011; Rothstein 2017; Samila and Sorenson 2017). On the one hand, the segregating potential of such man-made divides—for segregating people with different resources, perspectives, and cultural capabilities (e.g., Clemens 1996)—is particularly dramatic (Ananat 2011; Samila and Sorenson 2017). New bridges that enhance spatial connectedness between such disparate social worlds are therefore likely to generate more recombinative opportunities, and potentially more organizational founding. On the other hand, when such bridges are over railway lines and highways (which were associated with often policy-aided racial and economic segregation in the United States), their direct impacts are likely on the racial composition and integration of such communities. Overcoming such massive social disruption requires solving the bigger problem of invisible social and institutional barriers, beyond the infrastructure dividing communities (Kirp 2000, chapter 3). Here then, spatial connectedness might have a weaker impact.

Conversely, large water bodies such as rivers and lakes (or even dry valleys) are natural boundaries that separate people who might otherwise be more proximate, often creating distinct social worlds. For example, San Francisco has always been known as a home of the rich and famous, even as far back as 1906 (Jacobs 1985, p. 145). Yet right across the bay to the east lay Oakland, a decidedly less affluent city. While physically close, the body of water in between introduces friction in the free flow of people and resources, and by the social segregation it often generates, reduces contact between populations that would otherwise be quite proximate (until the Bay Bridge was constructed in the 1930s). Geographic features such as river banks, valleys, and bays have existed for a long time and the human ecology around them has emerged organically, rather than being torn apart by instruments of policy such as new highways and railway lines. While not perfect, one would expect the opening of new bridges to be particularly valuable for bridging such organic barriers to connectedness, by alleviating barriers to connectedness that might be more invisible when analyzing spatial locations as continuous land masses. Additionally, among new bridges, those built over such natural barriers comprise over 80% of new bridges in the panel, compared to less than 20% built over manmade barriers such as railway lines and highways in the United States.

In Model 10 of Table 3, we replaced the new bridges variable with two variables, one for bridges over manmade barriers and one for bridges of natural barriers. We find that both bridges over manmade barriers and natural barriers have a positive impact (that approximately sums up to the total coefficient for new bridges). However, the magnitude impact of bridges over natural barriers (i.e, rivers, bays, valleys) is about twice that of bridges over manmade barriers (i.e., railway lines, highways and freeways).

Curb/Pavement Addition

A further way in which new bridges are heterogeneous is the extent to which they imply addition of new pavement/curb/bicycle paths over the baseline of roadways alone. Therefore, we predicted the total width (not length) of new pavement/curb added in a CBSA in a (previous) year on the number of new bridges built. In Model 11 of Table 3, we replaced the bridges variable with the predicted width of pavement/walkways added. The coefficient on this variable is positive and significant in predicting founding rates, suggesting that bridges impact founding rates potentially by the walkways or pavement that is added. In Model 12, we ran a similar model, except we also added the residual of this prediction along with the predicted value of pavement width on new bridges. The effect of predicted walkway width continues to be positive and significant and the residual is not significant, lending support to the idea that the impact of enhanced connectedness on startup founding is not just driven by enhancements in roadways transporting raw materials and finished goods. As per a rich tradition in urban planning (Jacobs 1961), such bicycle and pedestrian paths perhaps allow for serendipitous conversations that generate ideas amongst those who cross along these new channels.

In fact, in the San Diego CBSA, increased potential for contact was arguably a byproduct of the city's approach towards enhancing its innovative potential by attracting and connecting new generations of knowledge workers (Downtown San Diego Partnership and UC San Diego Extension Center for Research on the Regional Economy 2016). Urban developers and city planners that we interviewed attested to similar understandings, albeit with the lens of quality of social life rather than its entrepreneurial impact.

A particular project that seemed to reflect these efforts was the Harbor Drive Pedestrian Bridge, a key connection point between downtown and the city's harbor front. Shortly after it was built in 2011 until our last check in July 2020, via the San Diego Regional Bike and Pedestrian Counter,[9] there have been 17,516,312 pedestrians that have crossed the bridge, second most of any bridge in San Diego, at a daily average of 6,959 pedestrians, the highest daily average of any bridge in San Diego. While these were part of overall city efforts to enhance walkability and amenities to attract young talent, a byproduct of this is greater connectivity, and even the potential for serendipitous interactions as many previously disparate individuals walk or bike across the bridge. As one local blogger succinctly noted when discussing the bridge opening, "*Finally, We are Now Connected*."[10]

Instrumental variable models

In addition to the main models, we ran instrumental variables models where we used the extent of poor or worse bridge structures in a CBSA (over past years) as an instrument to the building of new bridges (as opposed to repairing old ones, which is done when the substructure is fine but the roads/pavement above need work). These models are discussed in the Appendix, and reported as Models 13(a,b) and 14(a,b) in Table 4 of the Appendix. These tests further bolster the case for a causal impact of new bridges on founding rates.

ROBUSTNESS CHECKS

We also conducted several robustness checks (placed in the Appendix), to check whether the findings hold for alternative functional forms of the independent variable, and under alternative choices of specification and covariates. We also discuss how these impacts on founding are not just limited to high growth startups,

[9] http://www.eco-public.com/ParcPublic/?id=681# (Accessed: July 17, 2020)
[10] http://sandiegovoiceforrealestate.com/post/2224449/finally--we-are-now-connected----- (Accessed: December 12, 2020)

but can also enhance the establishment of main-street businesses (albeit at a lower rate). In the Appendix, we also provide qualitative vignettes around the origination and siting of these bridges, as well as their economic impact on cross fertilization of ideas in geographic areas (which we have drawn on for quotes earlier in the paper).

DISCUSSION

This paper contributes to several theoretical domains while also connecting them to a set of practical questions of interest to scholars, practitioners, and policymakers alike. By connecting a focal element of physical infrastructure—bridges—to the broader process of entrepreneurship, we argue physical infrastructure elements are not only critical for enhanced quality of life; they are also crucibles of spatial connectedness that are distinct from mere proximity. What we find is that new bridges increase the founding of startups (H1), increase the entry rate of founders into entrepreneurship (H2a), and the resulting ventures have increased numbers of early-stage investors (H2b). Moreover, the resulting ventures are more likely to engage in recombination as claimed in their textual business descriptions (H3a), and also tend to span more preexisting industry categories (H3b).

We see this study as contributing to a greater dialog between sociomateriality and institutional theory. In a seminal review, Leonardi and Barley (2010) note that materiality is all too often conflated with determinism. In other words, simply because one focuses on the possibility afforded from physical attributes does not necessarily mean one has to argue such attributes drive behavior. Such attributes can simply allow for social behavior to link and evolve with material properties (Leonardi 2011). At the same time, Barley (2008) inquired why taken-for-granted understandings that are difficult to observe became the micro-basis for institutional theory, rather than patterns observed in actual individual behavior that either reinforce or change institutional orders. These arguments share strong resonance with the "alignment" view of sociomateriality, whereby how organization members interact around a new technology becomes an "occasion" for either reaffirming or changing the underlying social order (Barley 1986). We posit the reason for this disconnect between sociomateriality and institutional theory, despite the clear opportunities for their linkages, is their levels of analysis have not been adequately reconciled. Sociomateriality research is predominantly conducted inside the organization or around a single technological case whose intent is to carefully detail how organizational members interact with a technology and its social implications. Even when conducted within a single organization, institutional theory research is predominantly intended to understand social orderings that guide interactions arguably beyond any single organizational context (i.e., between or within a set of organizations). We feel our research provides an exciting opportunity to join more closely these two areas of research. In particular, we can conceive bridges as "occasions" for either reinforcing preexisting social orders or recognizing new ones. Existing bridges tend to reinforce existing social relations and therefore do not tend to lead to novel organizing. New bridges tend to reveal and create new social relations, which may more easily lead to novel organizing. Through leveraging physical attributes from a large more system-scale technology such as a bridge (as opposed to a more organizational-scale technology), we are able to raise the level of analysis from that typically taken in sociomateriality research. This allows us to more easily link its insights with institutional theory.

In doing so, our study advances the call for more organizational theory directed towards understanding engineering systems (Barley 2016). In particular, this stream incorporates organizational theory into our understanding of physical infrastructure (i.e., bridge systems) more specifically, and civil engineering, more generally. Desai and Armanios (2018) noted how physical infrastructure such as bridge systems often outlast the social systems that put them into place, so as social systems change, these physical systems become "relics" of the past system. Jones and Armanios (2020) argue that because physical infrastructure are relics, they allow biases of the social system that constructed them to persist; for instance then, racial minorities are associated with less access to such systems. This paper culminates this stream through showing the economic implications, namely that new bridges facilitate access to new innovation opportunities and thereby increase startup rates. We hope our study and this stream helps propel greater engagement between institutional theory and sociomateriality that to date, have not had adequate dialog.

In studying a hitherto unexplored component of the founding environment—physical connectivity—our paper further advances our understanding of the various nuances by which founding environments not only influence startup creation, but also their organizational characteristics. For example, work in organizational ecology has looked at the munificence of founding environments as a driver of the founded organizations' life chances (Carroll and Delacroix 1982; Carroll and Hannan 1989; Lomi and Larsen 1998). Similarly, prior studies on entrepreneurship have focused on the at-hand social rather than physical facets to these processes. For example, Baker and Nelson (2005) argue what makes recombination particularly powerful is that it often leverages resources whose prior meanings are taken-for-granted as useless and valueless (making "something out of nothing"). Thus, if such resources cannot be taken-for-granted, neither should their physical conduits. In extending the analytical lens from resources to the underlying connectedness between them, we provide insight into why places with similar volumes of resources might differ in their founding outcomes. This builds on an emerging literature that has focused on the interplay between entrepreneurs and places in driving founding (Cruz et al. 2018; Dutta 2019). That said, the impact on founding rates is heterogeneous. For instance, industries where face to face contact and tacit knowledge are more critical to founding (e.g. biotech) experience greater benefits than industries where it is less so (e.g., computer science and engineering), although the latter also see significant benefits from enhanced spatial connectedness. From another standpoint then, our study suggests that local physical frictions to contact might bound ecological parameters such as local carrying capacity, or category spanning.

In doing so, our study points to potential (physical) imprints in the founding environment. An extant literature since Stinchcombe (1965) has recognized the role of the founding environment in driving the adoption of certain organizational features (e.g., Marquis and Tilcsik 2013). We show another instance of how the connective features of the social environment constrains (or enables) the set of people, resources and capital that can be marshalled to found new organizations (Dutta 2017; Stinchcombe 1987, p. 188-190). We show that such imprints are not just limited by the resources of the local social environment but how well these resources are connected by the local physical environment. We find that enhanced connectedness influences the internal characteristics of the newly founded organizations such as the extent to which they engage in recombinative activities, or span industry categories. Future work ought to explore how such organizations fare over their lifetime, and how strong such physically induced imprints at founding remain as they grow and evolve. Some extant literature would suggest such imprints would persist, either through taken-for-granted norms & structures (e.g., Burton and Beckman 2007; Zucker 1977), persistence of underlying values and beliefs (Alexy et al. 2021; Eberhart and Armanios 2021), or by providing starting points for local search as the organization encounters new problems (Levinthal 2003).

Prior studies in institutional theory have long argued about the institutionalizing role of the mundane. These studies argue that institutional norms get reified and reinforced through negotiations and choices individuals make amongst even the most ordinary aspects of their lives (Giddens 1984; Lawrence 2008; Powell and Colyvas 2008). These processes are so powerful that their novel insertion or sudden absence can have a visceral and jarring effect on the individual (Garfinkel 1967). Yet, these studies have largely focused on the mundane patterning of *social* life without considering the role that physical space plays in facilitating these processes. To this latter point, we find that the built environment indeed influences social processes, such as entrepreneurship, through allowing for novel combinations of preexisting resources. We ought to pay attention to not only symbolism and aesthetics of bridges but also the capacity of such large-scale objects to be hubs of interpersonal and idea-related connections. For example, several people we interviewed noted how modern, attractive and imposing the Harbor Drive Pedestrian Bridge in San Diego was. Yet, once opened in 2011, we find that it is not just a symbol of a new downtown but also a pathway for the flow of ideas and recombination by connecting shoreline communities with various knowledge hubs.

Infrastructure reflects and entrenches the social systems at the time of its building and is remarkably persistent. Therefore, such infrastructure is difficult to move to reflect present-day social patterns and connectivity needs, hence the need for *new* rather than reconstructed infrastructure to spur novel founding. From an institutional perspective, bridge characteristics are strongly associated with the building standards and human ecology of their time. These characteristics persist as far out as 50-70 years after construction, well after these standards become outdated (Desai and Armanios 2018). Recent historical analysis shows the road networks of the Roman Empire at its zenith (117 CE) still track well with greater road density in 2010 (Dalgaard et al. 2018). In short, infrastructure – and its resulting footprint – is remarkably persistent, even as the societies around them change. Our archival analysis further confirmed these issues. In the

Louisville, KY CBSA, one of the cases that we explored in greater detail, engineers wanted to untangle the labyrinth of highways leading to a planned new bridge location. However, numerous businesses located along these highways over the years since their development. This became such an obstacle that engineers found even slightly moving this existing footprint to be prohibitively costly. As a bridge engineer noted:

> It moved the traffic, but as traffic built, the problems become more excessive and certainly the knowledge of roadway building and the safety aspects of that has improved over the years. So certainly there were aspects that if we had the same information back then, it would probably have been done differently than the original design (Crowner 2018)

Thus, there are not only constraints on expanding and modifying existing infrastructure from the technical and institutional side, but also from a social (and even engineering) perspective as well. More fundamentally in considering novel connections, the predominant way to both reflect current day social connectivity needs while breaking out of the embeddedness of existing infrastructure is to build an entirely new infrastructure (i.e., new bridge) at a different location.

Moreover, our study shows how physical infrastructure can serve as a lightning rod that sets off the tinder of existing distributions of people and resources in a community to foster entrepreneurship. Some scholars have argued that in spite of the rapid expansion of virtual connectivity, access remains unequal (DiMaggio et al. 2001; Hargittai 2002; Star and Bowker 2006). For example, internet providers see hotspots of poverty and racial segregation as low-priority locations, and are less likely to upgrade infrastructure in such areas (Galperin, Mariscal and Barrantes 2014). Future research on the impact of new bridges on entrepreneurship rates ought to look at whether prospective entrepreneurs and social entrepreneurs leverage physical connectivity on its own, or whether they combine it with other forms of access to resources, people and ideas in their repertoire. Our study adds a different track to the conversation on management and social welfare (e.g., Alvarez and Barney 2014; Jones et al. 2016; Walsh, Weber and Margolis 2003), by arguing that public-private interventions do not just have welfare benefits but also connectivity ones as well.

Finally, our study shows that exploring patterns of physical infrastructure can potentially help us better understand how more *serendipitous* innovation can potentially occur. Numerous studies note the importance of boundary spanning and recombination as means for more novel forms of innovation (e.g., Gruber et al. 2013; Kaplan and Vakili 2015). To build such cross-cutting opportunities, prior work notes that entrepreneurs either leverage past relationships (Gulati and Gargiulo 1999), especially weak ties (Burt 2004; Granovetter 1973), or they leverage status signals to build such ties when they do not possess such prior ties (Hallen 2008). In each of these instances, the entrepreneur anticipates, or at least has an inkling, as to how they will seek to develop such novel innovations. However, many of the most path-breaking innovations are unanticipated and a function of chance encounters; they can be serendipitous (Lane et al. 2020; Popper 1959), albeit within the various forms of social relations in which one is embedded (Ruef 2010). We argue that both approaches to innovation—serendipity and embeddedness of various kinds—ought to pay attention to physical connectivity as an understudied orthogonal dimension in such processes.

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TABLES

Table 1: Summary Statistics of Control and Independent Variables, followed by pairwise correlations

Sr.	Variable	Mean	SD	Min	Max	1	2	3	4
1	Number of new bridges built (IHS)	2.43	1.42	0.00	6.60				
2	Number of existing bridges (IHS)	7.12	0.97	0.00	10.18	0.64			
3	Number of reconstructed bridges (IHS)	0.10	0.41	0.00	4.16	0.18	0.25		
4	Num of bridges in structurally poor/worse condition (IHS)	3.59	1.43	0.00	8.21	0.51	0.66	0.17	
5	Number of (all) businesses in CBSA ('000)	14.33	34.46	0.52	478.18	0.38	0.57	0.25	0.29
6	Number of existing startups in CBSA (Startup density)	8.14	41.64	0.00	1019	0.17	0.21	0.03	0.08
7	Square of Startup density	1.8E3	2.9E4	0.00	1.04E6	0.04	0.07	0.00	0.00
8	Log population of CBSA	12.60	1.06	10.32	16.77	0.54	0.80	0.26	0.42
9	Population Density	0.16	0.23	0.01	2.50	0.34	0.56	0.23	0.28
10	Fraction of CBSA comprising water bodies	0.06	0.14	0.00	1.00	-0.01	0.02	0.01	0.01
11	Median household income $'000 (2010 $s)	41.93	9.88	16.49	94.42	-0.04	0.22	0.09	0.02
12	Income segregation (inter quartile range)	17.58	7.62	2.06	69.71	0.10	0.41	0.12	0.14
13	Racial diversity	0.34	0.16	0.03	0.72	0.08	0.21	0.05	-0.09
14	Residential segregation by race	0.25	0.20	0.00	0.79	0.28	0.37	0.13	0.38
15	Industry diversity of existing businesses (all kinds)	-0.01	0.99	-0.72	9.35	0.47	0.65	0.22	0.49
16	Percent college graduates	23.03	7.55	9.25	57.71	0.13	0.26	0.09	0.14
17	Percent households below poverty line	13.82	4.45	4.50	40.66	-0.14	-0.12	-0.08	-0.14
18	Percent employed in businesses with at least one employee	0.53	0.25	0.16	1.76	0.24	0.10	0.04	0.27
19	Percentage workers that are local to CBSA	90.93	7.66	46.60	99.52	0.22	0.23	0.04	0.16
20	Percentage migrants in population (arrived last 5 years)	0.23	0.13	0.00	1.00	-0.15	-0.33	-0.08	-0.27
21	Local government capital expenditure in CBSA	0.47	1.35	0.00	17.95	0.12	0.29	0.06	0.18

Sr.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	0.15															
7	0.05	0.90														
8	0.71	0.29	0.11													
9	0.92	0.17	0.08	0.76												
10	0.19	-0.01	-0.02	0.22	0.31											
11	0.28	0.27	0.18	0.38	0.36	0.14										
12	0.41	0.24	0.11	0.55	0.47	0.10	0.73									
13	0.30	0.17	0.11	0.41	0.32	0.09	0.21	0.43								
14	0.26	0.00	-0.04	0.37	0.32	0.18	-0.06	0.19	0.44							
15	0.56	0.14	0.01	0.59	0.45	0.05	0.14	0.29	0.19	0.43						
16	0.25	0.26	0.13	0.34	0.28	0.06	0.59	0.61	0.10	-0.07	0.20					
17	-0.13	-0.14	-0.07	-0.18	-0.17	-0.13	-0.45	-0.06	0.26	0.08	-0.11	-0.17				
18	0.03	0.04	0.02	0.03	0.03	0.00	-0.34	-0.26	-0.26	0.10	0.11	-0.05	-0.24			
19	0.05	0.02	-0.02	0.09	-0.05	-0.01	-0.25	-0.07	-0.03	0.09	0.23	0.04	0.16	0.15		
20	-0.17	-0.04	-0.01	-0.37	-0.25	-0.18	-0.15	-0.18	-0.08	-0.26	-0.15	0.14	0.10	0.01	0.01	
21	0.26	0.03	0.00	0.30	0.33	0.14	0.24	0.29	0.11	0.16	0.20	0.16	-0.07	-0.02	-0.04	-0.14

Table 2: Multilevel/Mixed-Effects Negative Binomial Models (State, CBSA, Year effects) predicting foundings (1,2) and similar M-E Linear Models predicting characteristics (3-6). Observations at CBSA-Year level. RHS variables are for the previous year. QML/ML Estimates, Two-Tailed tests. Robust SE in parentheses. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Model number and H's tested:	(1)	(2: *H1*)	(3: *H2a*)	(4: *H2b*)	(5: *H3a*)	(6: *H3b*)
DV:	Number of Startups founded	Number of Startups founded	Founder entry rate	Avg # early investors	Recombinative - ness	Industry-spanning
State Effects	Yes	Yes	Yes	Yes	Yes	Yes
CBSA Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of existing bridges	0.196	0.177	0.256	0.073	-0.002	0.007
(IHS)	(0.104)	(0.112)	(0.486)	(0.039)	(0.003)	(0.022)
Number of reconstructed bridges	-0.033	-0.037	-0.415	-0.025	0.002	-0.012
(IHS)	(0.050)	(0.047)	(0.291)	(0.021)	(0.005)	(0.021)
Number of bridges in structurally	-0.006	-0.019	-0.101	-0.037	-0.001	-0.003
poor/worse condition (IHS)	(0.051)	(0.050)	(0.272)	(0.023)	(0.001)	(0.011)
Number of (all) businesses in	-0.018	-0.019*	-0.057*	-0.002	-0.000	-0.000
CBSA ('000)	(0.010)	(0.010)	(0.025)	(0.002)	(0.000)	(0.002)
Number of existing startups in	0.019***	0.018***	-0.023	0.009***	0.001***	0.011***
CBSA (Startup density)	(0.002)	(0.002)	(0.033)	(0.002)	(0.000)	(0.003)
Square of Startup density	-0.000***	-0.000***	-0.000*	-0.000**	-0.000**	-0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population of CBSA	1.707***	1.554***	3.250***	0.288***	0.012**	0.196***
	(0.158)	(0.173)	(0.402)	(0.044)	(0.004)	(0.035)
Population Density	-4.859***	-4.705***	-2.835	-0.708*	-0.004	-0.562
	(1.184)	(1.170)	(3.560)	(0.313)	(0.033)	(0.320)
Fraction of CBSA comprising	1.461*	1.652*	4.909	0.419*	0.020	0.282
water bodies	(0.648)	(0.681)	(2.854)	(0.210)	(0.017)	(0.158)
Median household income $'000	-0.118***	-0.111***	-0.347***	-0.030***	-0.001	-0.011**
(2010 $s)	(0.009)	(0.009)	(0.052)	(0.005)	(0.000)	(0.004)
Income segregation (inter quartile	0.006	0.012	0.079	0.003	0.000	0.004
range)	(0.015)	(0.013)	(0.045)	(0.004)	(0.000)	(0.003)
Racial diversity	-0.328	-0.402	-1.231	-0.186	-0.022	-0.217*
	(0.919)	(0.907)	(2.221)	(0.216)	(0.011)	(0.093)
Residential segregation by race	0.318	0.252	-1.630	0.106	0.008	0.078
	(0.593)	(0.591)	(1.681)	(0.177)	(0.012)	(0.099)
Industry diversity of existing	-0.169	-0.161	-0.042	-0.034	0.000	-0.064*
businesses (all kinds)	(0.097)	(0.095)	(0.295)	(0.030)	(0.003)	(0.025)
Percent college graduates	0.156***	0.154***	0.346***	0.030***	0.001**	0.019***
	(0.010)	(0.010)	(0.037)	(0.004)	(0.000)	(0.004)
Percent households below poverty	-0.194***	-0.180***	-0.393***	-0.041***	-0.001*	-0.020***
line	(0.032)	(0.028)	(0.076)	(0.008)	(0.000)	(0.005)
Percent employed in businesses	-0.148	-0.057	0.606	-0.030	0.006	-0.163*
with at least one employee	(0.127)	(0.115)	(1.212)	(0.066)	(0.008)	(0.065)
Percentage workers that are local	-0.015	-0.017	-0.084**	-0.009**	-0.000	-0.004
to CBSA	(0.011)	(0.011)	(0.030)	(0.003)	(0.000)	(0.002)
Percentage migrants in population	-0.427	-0.672	0.839	-0.032	0.001	0.065
(arrived last 5 years)	(0.558)	(0.622)	(1.592)	(0.142)	(0.007)	(0.093)
Local government capital	0.132***	0.127***	0.163	0.016	-0.001	0.016*
expenditure in CBSA	(0.032)	(0.030)	(0.131)	(0.010)	(0.001)	(0.007)
Number of new bridges built		**0.173*****	**0.368***	**0.035*****	**0.004***	**0.047*****
(IHS)		**(0.030)**	**(0.148)**	**(0.009)**	**(0.002)**	**(0.010)**
Number of startups founded in			0.626	0.027	0.001	0.019
focal yr (control for models 3-6)[I]			(0.367)	(0.017)	(0.001)	(0.012)
Constant	-19.127***	-17.789***	-18.966***	-1.682***	-0.099*	-0.656
	(2.075)	(2.193)	(4.704)	(0.464)	(0.039)	(0.383)
Observations	7580	7580	7580	7580	7580	7580
Log pseudolikelihood	-4653	-4632	-9248	-29670	-7987	5948
Akaike Information Criterion	9354	9315	18551	59395	16027	-11843
Wald chi2 Statistic	3785***	3660***	7415***	57279***	8825***	20816***

[I] *we add this when predicting founded org characteristics to assuage empirical concerns, but results are unchanged without it.*

Table 3: Multilevel/Mixed-Effects Negative Binomial Models (State, CBSA, Year effects) predicting foundings. QML Estimates, Two-Tailed tests. Robust Standard Errors in parentheses. $^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

	(7)	(8)	(9)	(10)	(11)	(12)
Brief Comment on Model:	Biotech Startups	Computer Science & IT	Detour distance	Bridge type	Pavement addition	Pavement addition
Number of new bridges built	0.263***	0.164***	0.173***			
(IHS)	(0.059)	(0.043)	(0.030)			
Number of existing bridges	0.472	0.148	0.161	0.177	0.177	0.176
(IHS)	(0.334)	(0.121)	(0.109)	(0.109)	(0.112)	(0.112)
Number of reconstructed bridges	-0.053	-0.090	-0.039	-0.037	-0.037	-0.037
(IHS)	(0.086)	(0.067)	(0.047)	(0.047)	(0.047)	(0.046)
Number of bridges in structurally poor/worse	0.131	0.010	-0.015	-0.017	-0.019	-0.019
condition (IHS)	(0.132)	(0.059)	(0.049)	(0.051)	(0.050)	(0.050)
Number of (all) businesses in CBSA (‘000)	-0.024	-0.027*	-0.018	-0.020*	-0.019*	-0.019*
	(0.014)	(0.011)	(0.010)	(0.009)	(0.010)	(0.009)
Number of existing startups in CBSA (Startup	0.015**	0.020***	0.017***	0.019***	0.018***	0.018***
density)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Square of Startup density	-0.000*	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population of CBSA	1.167***	1.607***	1.573***	1.576***	1.554***	1.557***
	(0.338)	(0.215)	(0.176)	(0.165)	(0.173)	(0.175)
Population Density	-1.912	-3.865**	-4.686***	-4.550***	-4.705***	-4.722***
	(1.742)	(1.411)	(1.143)	(1.124)	(1.170)	(1.177)
Proportion of CBSA comprising water bodies	0.966	1.739*	1.641*	1.590*	1.652*	1.655*
	(0.790)	(0.736)	(0.675)	(0.664)	(0.681)	(0.681)
Median household income $’000 (2010 $s)	-0.108***	-0.123***	-0.118***	-0.113***	-0.111***	-0.111***
	(0.022)	(0.012)	(0.010)	(0.010)	(0.009)	(0.009)
Income segregation (inter quartile range)	0.017	0.006	0.015	0.012	0.012	0.012
	(0.022)	(0.017)	(0.013)	(0.013)	(0.013)	(0.013)
Racial diversity	0.146	-0.023	-0.477	-0.370	-0.402	-0.397
	(1.343)	(1.090)	(0.940)	(0.901)	(0.907)	(0.905)
Residential segregation by race	0.533	-0.417	0.209	0.218	0.252	0.250
	(1.004)	(0.660)	(0.603)	(0.584)	(0.591)	(0.590)
Industry diversity of existing businesses (all	-0.292	-0.021	-0.164	-0.163	-0.161	-0.161
kinds)	(0.152)	(0.087)	(0.097)	(0.095)	(0.095)	(0.096)
Percent college graduates	0.206***	0.173***	0.155***	0.154***	0.154***	0.154***
	(0.021)	(0.019)	(0.010)	(0.010)	(0.010)	(0.010)
Percent households below poverty line	-0.076	-0.208***	-0.181***	-0.181***	-0.180***	-0.180***
	(0.051)	(0.036)	(0.029)	(0.029)	(0.028)	(0.028)
Percent employed in businesses with at least one	-0.101	-0.225	-0.100	-0.092	-0.057	-0.059
employee	(0.381)	(0.146)	(0.114)	(0.115)	(0.115)	(0.115)
Percentage workers that are local to CBSA	-0.042	-0.019	-0.017	-0.017	-0.017	-0.017
	(0.021)	(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Percentage migrants in population (arrived last	0.188	-0.153	-0.591	-0.594	-0.672	-0.672
5 years)	(1.477)	(1.000)	(0.624)	(0.589)	(0.622)	(0.622)
Local government capital expenditure in CBSA	0.125	0.146**	0.135***	0.124***	0.127***	0.128***
	(0.084)	(0.045)	(0.032)	(0.030)	(0.030)	(0.031)
Change in average detour length			-0.026**			
			(0.008)			
# New bridges built over manmade barriers				0.062**		
(over railways/highways, IHS)				(0.022)		
# New bridges built over natural barriers (over				0.124***		
rivers/bays/valleys, IHS)				(0.029)		
Width of new curb/pavement added predicted					0.023***	0.023***
by new bridges					(0.004)	(0.004)
Residual from prediction of new curb/pavement						-0.000
by new bridges						(0.001)
Constant	-20.136***	-18.445***	-17.632***	-17.891***	-17.554***	-17.570***
	(3.366)	(2.910)	(2.238)	(2.130)	(2.203)	(2.221)
Observations	7580	7580	7580	7580	7580	7580
Log pseudolikelihood	-1046	-3352	-4611	-4638	-4632	-4632
Akaike Information Crit.	2140	6755	9274	9328	9315	9316
Wald chi2	5038***	3468***	7233***	3714***	3660***	4330***

APPENDIX

SUPPLEMENTARY ANALYSES (CONTD.)

Instrumental variable models

Instrumental variable methods are often used to aid in causal identification, particularly in cross-sectional data (Cameron and Trivedi 2005, section 4.8). Although we have longitudinal data, our number of units of observation is much larger than the time of observation, so IV methods can be a useful test of robustness of the link between new bridges and rates of entrepreneurship. Bridges often deteriorate, either due to weather, natural disasters, or general structural aging. Consistent with two of the coauthors' technical expertise in engineering aspects of bridges, in our dataset we find that bridges with deteriorated substructures (under-structures) are more likely to correlate with the emergence of entirely new bridges in subsequent years (either on the same site or a nearby site). Yet, deteriorated substructures do not by themselves correlate with the founding rate, as shown in the control and main models previously. Additionally, further lagged values of bridges with poor or worse substructures are unlikely to positively influence founding rates, except through their impact on spurring new bridges in the future.

Therefore, we first used a 2-stage Panel IV strategy that relies on poor or worse substructures from years past influencing new bridge creation (1st stage), with bridge creation subsequently positively influencing founding rates (2nd stage). The IV models are shown as the pair of models under Model 13. Stage 1 of this model (13a) predicts new bridge building in T-1 on the control variables plus lagged values of number of bridges with poor or worse substructures (lagged further, T-1, T-2, T-3 relative to new bridge), with random effects on CBSA. Among the control variables in the first stage model, the number of existing bridges reduces new bridge creation. The control for log number of existing establishments and that for startups are positive and significant in predicting new bridge creation: when CBSAs have a larger commercial base they are more likely to invest in new bridges. Among other controls more populated areas are more likely to build new bridges but denser areas have fewer. CBSAs with more water area are less likely to be bridged (presumably because larger water bodies like lakes are not usually bridged but narrower ones like rivers are). Racially diverse places are likely to find themselves as continued sites of bridge construction, especially to bridge manmade barriers following the various railway lines and highways that were designed to cut through such communities in the 60's and 70's (Rothstein 2017). Household income negatively predicts new bridges controlling for other factors, as is evident in the legacy of affluent communities in the US unwilling to have enhanced flows of outsiders into it (Winner 1980). On the other hand poverty rate also reduces bridge building, so poorer communities are ignored in that. Together this appears to be driven by two tails—highly affluent communities want to remain secluded inspite of ability to fund local contributions to infrastructure, while high poverty communities also have fewer bridges owing to less attention or poor local governments.

Stage 1 also shows the influence of instruments on new bridge creation, of which only the number of poor or worse substructures in period T-3 is positive and statistically significant ($p<.01$) in fostering new bridge building. This conforms to the typical average times in new bridge creation (Berg et al 2006, Wu et al 2010).

Stage 2 of the IV model is reported as Model 13, predicting the foundings in period T on the control variables as well as the estimate of the independent variable from the first stage (instruments are excluded). The Sanderson-Windmeijer multivariate F test of excluded instruments is statistically significant rejecting the null that instruments ought to be included in the second stage ($F(3, 7137) = 30.34$, $p<.001$)), satisfying the excludability condition. The model F statistic is also higher than the cutoffs proposed by Stock and colleagues (2002) (i.e., F-statistic values typically greater than 10) suggesting that we don't have a weak instruments problem (same conclusion from Stock and Yogo's 2005 cutoffs as well). The second stage effect of the new bridges estimate is positive and significant, indicating the lagged values of poor or worse substructures in the CBSA positively influence foundings through their effects on new bridge creation. The estimates in the IV specification are higher than the single stage main models with negative binomial mixed effects. The Sargan-Hansen statistic (overidentification test of all instruments) for Model 13b is 5.516 ($p=.063$) indicates that there is not significant overidentification, but potentially close to being overidentified.

So next, we ran a modified IV model, keeping only the T-3 number of poor or worse sub-structures, and dropping the additional instruments with lower lags. This model is reported (both stages) as Model 14 in Table 3. The IV first stage specification (Model 14a) is similar to the previous iteration, except only one instrument is used: the T-3 lagged value of the variable representing poor or worse substructures in the CBSA. The effect of the instrument on the independent variable is positive and significant at the $p<.001$ level in the Stage 1 (Model 14a). In Stage 2 (Model 14b), the dependent variable is predicted on the instrumented estimate of new bridges in the previous year, and shows a positive significant ($p<.05$) effect on the founding rate. As in the previous second stage model, the model statistics indicate that excludability condition is satisfied and the null that the equation is weakly identified can be rejected in a one-tailed test. The Sargan-Hansen test of overidentifying restrictions (instruments uncorrelated with the error term, and instruments are correctly excluded from the second stage) indicates that IV is exactly identified to the extent that the conditions in the parentheses are satisfied. While neither of these tests uniquely substantiates the chosen IV strategy, together they imply that the IV results can be reasonably construed as an identification of the effect of new bridges on the founding rate in CBSAs, in that the observed effects of new bridges on foundings are unlikely to be driven by unobservable factors alone.[1]

ROBUSTNESS CHECKS

Alternative functional forms of the independent variable

We used an inverse hyperbolic sine transformation of the number of new bridges in a CBSA in a year to parameterize the baseline that the marginal impact of a new bridge will be greater for the first new bridge compared to the second new bridge in the CBSA in the same year, and so on, while allowing for the zero level to be parameterized without fudge factors. Features similar to the IHS transformation can be obtained by using a natural log transformation with 1 added. We therefore replicated Model 2 from the main table (table 2) while using the ln(x+1) transformation of the #new bridges in a CBSA in a year. This is reported as Model 15 in Table 4. The coefficient on this alternative form of the independent variable is similar in direction and significance, albeit somewhat higher in magnitude.

[1] However for more accurate magnitude estimates of impact of the independent variable on foundings, we would suggest the reader to rely on the main models. For example, Kennedy (2008, p. 167) notes how the instrumented independent variable captures only the part of the variation in the independent variable that is driven by instrument. An exception is if the instrument fully explains most of the variation in the independent variable (which it never does in real data). Hence we have retained the mixed effects negative binomial models as the main one to predict foundings.

Next, we ran a model ignoring the additional (declining marginal) impact of new bridges on foundings, by using a dummy variable for a new bridge being built in a CBSA in the past year. This is shown as Model 16 in Table 4. The effect of this alternative form of the variable is also positive and significant in predicting foundings. Together these lend confidence that the results are not driven by the choice of the functional form of the independent variable alone.

Other Alternative Modeling Choices

Below we discuss other tests of robustness to specification choices.

<u>Possible overspecification of base effects</u>

One possible concern might be that when predicting founding rate we also include a control variable for number of existing startups in the CBSA in the previous year and its square term, together to account for density dependence process that might underlie foundings, such as studied by organizational ecology scholars. In some quarters, this might be seen as inflating the observed effect on the DV. In unreported models (available on request), we replicated Table 2 while excluding the controls for the base of existing startups in the CBSA. The results are similar in significance and direction (albeit larger in magnitude).

<u>Autoregressive specification</u>

While we use mixed effects models as the main models (effects on state, CBSA and year), and show robustness to other modeling choices as discussed previously, there is sometimes a lingering concern around the generative process possibly driving both the dependent and the independent variable on a continuing basis. Thus in Appendix Table 5, we re-ran the models from Table 2 with a (first order) autoregressive specification, using a negative binomial model (A1-A2) and linear regression model (A3-A6) with the (relevant) lagged dependent variables on the right hand side for all models. The results are largely unchanged in direction and significance (albeit slightly smaller in some models).

The autoregressive specification accounts for lagged DVs and thus opens up some other modeling possibilities, one of which was seeing how the effects of new bridges dissipate with distance. One modeling choice was around using CBSAs with population>50,000 (as designated by the 2010 US Census, also see first footnote) as units of observation, observed annually. These aren't all large units-in fact the average size of a CBSA in the sample is 2.68 square miles (land plus water, standard deviation of 3.01). One question is whether one would see similar results if we were to take an arbitrary radius around the potential new bridges to be built in the future and see before and after comparisons. Since we cannot gather controls for these arbitrary boundaries, an autoregressive specification allows us to still reasonably test for impact of foundings in arbitrary boundaries by using lagged foundings within the boundary on the RHS along with the CBSA-level controls. To do this we chose two reasonable radii. First, we identified all foundings by year within a 1-mile radius of new bridges in the CBSA (starting before they were built within the panel window).[2] Next, we re-ran the main model (with the above autoregressive specification) with 1mile radius founding rate as the DV (model not shown, available on request). We find that the effect of the new bridges variable is still positive and significant (beta .054, p=.047), albeit smaller in magnitude than the CBSA level effect. Similarly we repeated the above procedure for a 5-mile radius. However the effect of opening of newly built bridges has a positive but not significant when considering the 5 mile radius (beta .049, p=.082). Together these results seem to suggest that new bridges have radial effects that decline with space, but the true effects possibly follow patterns of human and economic geography represented by CBSAs rather than simple as-the-crow-flies effects over space.

Additional model with control for *both* local govt. capital expenditure and revenues

In the main models we control for local Government capital expenditure (e.g. capital spending such as on buildings, roads/highways, airports, public transit, and so on) in CBSA to account for factors that might drive both greater ability to contribute to infrastructure and foster entrepreneurial activity. We also have mixed effects on state, CBSA and year (and several controls) that capture many of the geographic and temporal variation in how governments spend their money. However, local government revenues (such as from taxes) might appear to be still a source of additional variation in the extent to which new bridges emerge. However capital expenditure is highly correlated (over .9) with the local area government revenues, and adding it in the main model leads to multicollinearity between revenue and capital expenditure. We nonetheless reran the main models from Table 2 with both govt revenue and capital expenses as controls—these models are reported as Table 6 in the Appendix (Models B1-B6). The coefficients on local govt.

[2] Using the formula for area of a circle (pi*r^2), a 1 mile radius leads to a circular area of 3.1416 square miles

revenue and capital expenditure are opposite in sign and similar in absolute values, indicating the multicollinearity to be expected with correlations of over 0.9 between these two variables. More importantly, the effects of new bridges are similar in magnitude and standard errors in these models. In unreported models available on request we also separated the government capital spending items into its subcomponents (as listed before) with no change in results.

Other robustness tests

One concern might emerge that, as Aldrich and Ruef (2018) have lamented, too much attention is paid to Angel and VC-backed startups, to the exclusion of what is often called 'main street' entrepreneurship, typically local businesses with limited growth aspirations. While the importance of knowledge transfer and recombination is lower in such ventures, they are still somewhat important in terms of gaining tacit knowledge and resources even when founding less-innovative ventures. We gathered such founding data at the CBSA level annually from the Business Dynamics Dataset of the Census Bureau. We predicted the founding rate of such business establishments in CBSA-years as the DV (Models unreported, available on request). The opening of newly built bridges also has a positive significant effect on the founding rate of all businesses, although the effect size is less than a third of that for startups. Thus greater spatial connectedness helps not just the knowledge intensive foundings such as of Angel- and VC-backed startups, but also does so for business foundings in general.

APPENDIX Table 4: Two-stage Panel IV Models (GLS est.), and Panel ME NB Models (QML est.). Two-Tailed tests.

	(13a) Stage 1 of Panel IV	(13b) Stage 2 of Panel IV	(14a) Stage 1 of Panel IV	(14b) Stage 2 of Panel IV	(15) Log(+1) Indep. Variable	(16) Dummy Indep. Variable
Number of existing bridges	0.486***	-0.874*	0.489***	-0.842*	0.179	0.189
(IHS)	(0.046)	(0.361)	(0.046)	(0.351)	(0.111)	(0.107)
Number of reconstructed bridges	0.033	-0.035	0.033	-0.034	-0.037	-0.031
(IHS)	(0.030)	(0.124)	(0.030)	(0.124)	(0.047)	(0.049)
Number of (all) businesses in CBSA (‘000)	0.007***	-0.010*	0.007***	-0.009	-0.019*	-0.018
	(0.002)	(0.005)	(0.002)	(0.005)	(0.010)	(0.010)
Number of existing startups in CBSA	0.006***	0.131***	0.006***	0.131***	0.018***	0.019***
(Startup density)	(0.001)	(0.004)	(0.001)	(0.004)	(0.002)	(0.002)
Square of Startup density	-0.000***	0.000***	-0.000***	0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population of CBSA	0.478***	-0.304	0.480***	-0.295	1.555***	1.686***
	(0.051)	(0.181)	(0.051)	(0.177)	(0.172)	(0.161)
Population Density	-1.251***	1.933*	-1.260***	1.894*	-4.663***	-4.936***
	(0.305)	(0.842)	(0.306)	(0.832)	(1.161)	(1.195)
Proportion of CBSA comprising water	-0.449*	0.179	-0.457*	0.169	1.642*	1.526*
bodies	(0.179)	(0.417)	(0.179)	(0.415)	(0.678)	(0.664)
Median household income $’000 (2010 $s)	-0.053***	0.001	-0.053***	-0.001	-0.111***	-0.116***
	(0.004)	(0.022)	(0.004)	(0.021)	(0.009)	(0.009)
Income segregation (inter quartile range)	-0.026***	-0.024	-0.026***	-0.024	0.012	0.007
	(0.004)	(0.015)	(0.004)	(0.015)	(0.013)	(0.015)
Racial diversity	0.194	1.236**	0.182	1.243**	-0.404	-0.346
	(0.194)	(0.441)	(0.193)	(0.440)	(0.903)	(0.932)
Residential segregation by race	0.319*	-0.684	0.334*	-0.671	0.244	0.332
	(0.151)	(0.393)	(0.150)	(0.389)	(0.589)	(0.604)
Industry diversity of existing businesses (all	-0.068*	0.033	-0.068*	0.031	-0.161	-0.162
kinds)	(0.033)	(0.080)	(0.033)	(0.079)	(0.095)	(0.097)
Percent college graduates	0.025***	0.002	0.025***	0.003	0.154***	0.156***
	(0.004)	(0.014)	(0.004)	(0.013)	(0.010)	(0.010)
Percent households below poverty line	-0.070***	0.018	-0.070***	0.015	-0.180***	-0.189***
	(0.006)	(0.028)	(0.006)	(0.027)	(0.028)	(0.032)
Percent employed in businesses with at least	-0.356***	0.856***	-0.348***	0.856***	-0.060	-0.117
one employee	(0.065)	(0.252)	(0.065)	(0.251)	(0.114)	(0.125)
Percentage workers that are local to CBSA	-0.001	-0.014	-0.001	-0.014	-0.017	-0.015
	(0.003)	(0.007)	(0.003)	(0.007)	(0.011)	(0.011)
Percentage migrants in population (arrived	0.378*	-0.876	0.359*	-0.860	-0.650	-0.590
last 5 years)	(0.178)	(0.503)	(0.178)	(0.499)	(0.614)	(0.598)
Local government capital expenditure in	0.009	0.052	0.010	0.052	0.127***	0.129***
CBSA	(0.015)	(0.039)	(0.015)	(0.039)	(0.030)	(0.033)
Predicted number of new bridges built (IHS)		0.971*		0.933*		
from Stage 1 of IV models		(0.432)		(0.418)		
Number of bridges in structurally poor or					-0.019	-0.012
worse condition (IHS)					(0.050)	(0.051)
…#poor or worse structures (IHS) in	0.019					
T-1 (relative to new bridges)	(0.032)					
…#poor or worse structures (IHS) in	0.018					
T-2 (relative to new bridges)	(0.040)					
…#poor or worse structures (IHS) in	0.098**		0.131***			
T-3 (relative to new bridges)	(0.031)		(0.016)			
Number of new bridges built (natural log					0.192***	
(x+1) transform)					(0.034)	
Dummy variable for any new bridges built						0.572***
in CBSA						(0.169)
Constant	-4.390***	8.290***	-4.428***	8.157***	-17.757***	-19.514***
	(0.582)	(2.504)	(0.584)	(2.464)	(2.187)	(2.106)
Observations	7160	7160	7160	7160	7580	7580
Chi2 Statistic	3143***	17647***	3123***	17748***	3547***	4899***

APPENDIX: Table 5: Models with Autoregressive specification (with Lagged DVs for all models) predicting foundings (NB) and characteristics (linear) in CBSAs. Note that the lagged DV varies by what DV is being predicted, but their coefficients have been placed in the same row to fit into one page. Observations at CBSA-Year level. RHS variables for prev. year. ML Estimates, Two-Tailed tests. Robust SE in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001

	(A1) Number of Startups founded	(A2) Number of Startups founded	(A3) Founder entry rate	(A4) Avg # early investors	(A5) Recombinative-ness	(A6) Industry-spanning
Respective Lagged Dependent	0.023**	0.022**	0.089***	0.227***	0.055*	0.214***
Variable (for all models)	(0.007)	(0.007)	(0.015)	(0.021)	(0.028)	(0.022)
Number of existing bridges	-0.023	-0.098	-0.183	0.002	-0.003	-0.022
(IHS)	(0.066)	(0.073)	(0.307)	(0.022)	(0.002)	(0.018)
Number of reconstructed bridges	-0.047	-0.050	-0.674*	-0.049*	0.002	-0.017
(IHS)	(0.048)	(0.048)	(0.300)	(0.023)	(0.004)	(0.021)
Number of bridges in structurally	0.030	0.022	0.090	-0.009	-0.001	0.002
poor/worse condition (IHS)	(0.027)	(0.027)	(0.143)	(0.010)	(0.001)	(0.009)
Number of (all) businesses in CBSA	-0.041***	-0.042***	-0.067***	-0.004***	-0.000	-0.002*
('000)	(0.003)	(0.003)	(0.013)	(0.001)	(0.000)	(0.001)
Number of existing startups in CBSA	0.024***	0.024***	0.042***	0.009***	0.001***	0.011***
(Startup density)	(0.001)	(0.001)	(0.008)	(0.001)	(0.000)	(0.001)
Square of Startup density	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population of CBSA	1.805***	1.758***	3.047***	0.238***	0.012***	0.158***
	(0.079)	(0.079)	(0.344)	(0.025)	(0.003)	(0.022)
Population Density	-1.227***	-1.089***	0.176	-0.190	-0.001	-0.142
	(0.284)	(0.284)	(1.963)	(0.141)	(0.026)	(0.150)
Proportion of CBSA comprising	0.839***	0.902***	4.003**	0.259**	0.017	0.170
water bodies	(0.158)	(0.161)	(1.464)	(0.091)	(0.012)	(0.100)
Median household income $'000	-0.091***	-0.087***	-0.292***	-0.020***	-0.001*	-0.008***
(2010 $s)	(0.007)	(0.007)	(0.033)	(0.002)	(0.000)	(0.002)
Income segregation (inter quartile	0.013	0.015	0.059	0.006*	0.000	0.005*
range)	(0.008)	(0.008)	(0.033)	(0.002)	(0.000)	(0.002)
Racial diversity	-0.250	-0.306	0.287	0.022	-0.019	-0.108
	(0.291)	(0.295)	(1.342)	(0.103)	(0.011)	(0.070)
Residential segregation by race	-0.007	-0.089	-2.727**	-0.085	0.006	-0.021
	(0.194)	(0.196)	(1.032)	(0.073)	(0.010)	(0.059)
Industry diversity of existing	-0.002	0.011	0.116	-0.003	0.000	-0.027
businesses (all kinds)	(0.026)	(0.026)	(0.228)	(0.016)	(0.003)	(0.015)
Percent college graduates	0.123***	0.121***	0.299***	0.021***	0.001***	0.013***
	(0.006)	(0.006)	(0.034)	(0.002)	(0.000)	(0.002)
Percent households below poverty	-0.135***	-0.126***	-0.296***	-0.025***	-0.001**	-0.012***
line	(0.013)	(0.013)	(0.050)	(0.003)	(0.000)	(0.002)
Percent employed in businesses with	0.195	0.192	1.831*	0.142**	0.007	-0.048
at least one employee	(0.122)	(0.122)	(0.820)	(0.053)	(0.008)	(0.042)
Percentage workers that are local to	-0.031***	-0.032***	-0.082***	-0.006***	-0.000	-0.003**
CBSA	(0.004)	(0.004)	(0.021)	(0.001)	(0.000)	(0.001)
Percentage migrants in population	0.294	0.063	0.817	0.094	0.001	0.081
(arrived last 5 years)	(0.447)	(0.452)	(1.227)	(0.082)	(0.008)	(0.054)
Local government capital	0.017	0.018	0.114	0.002	-0.001	0.005
expenditure in CBSA	(0.016)	(0.016)	(0.124)	(0.009)	(0.001)	(0.008)
Number of new bridges built		**0.118***	**0.311***	**0.025**	**0.003**	**0.037***
(IHS)		**(0.031)**	**(0.131)**	**(0.009)**	**(0.001)**	**(0.007)**
Num. of startups founded in focal			0.220***	0.014**	0.000	0.012*
year (control for models A3-A6)			(0.037)	(0.005)	(0.001)	(0.005)
Constant	-18.851***	-18.054***	-17.921***	-1.596***	-0.091*	-0.460
	(1.008)	(1.006)	(4.179)	(0.309)	(0.039)	(0.261)
Observations	7580	7580	7580	7580	7580	7580
Log pseudolikelihood	-4932	-4923	-29832	-9329	5950	-8061
Akaike Information Criterion	9910	9894	59713	18707	-11852	16171
Chi2 (A1-2) and F-stat (A3-6)	4416***	4447***	79.7***	130.5***	13.4***	71.8***

APPENDIX: Table 6: Table 2 replicated with controls for *both* local govt. expenditure and revenue. Same model specifications as Table 2. Two-Tailed tests. Robust Standard Errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001

	(B1) Number of Startups founded	(B2) Number of Startups founded	(B3) Founder entry rate	(B4) Avg# early investors	(B5) Recombinative-ness	(B6) Industry-spanning
State Effects	Yes	Yes	Yes	Yes	Yes	Yes
CBSA Effects	Yes	Yes	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Number of existing bridges	0.198	0.180	0.251	0.073	-0.002	0.007
(IHS)	(0.103)	(0.110)	(0.485)	(0.039)	(0.003)	(0.022)
Number of reconstructed bridges	-0.031	-0.035	-0.404	-0.024	0.002	-0.011
(IHS)	(0.051)	(0.048)	(0.294)	(0.021)	(0.005)	(0.021)
Number of bridges in structurally	-0.005	-0.018	-0.091	-0.037	-0.001	-0.002
poor/worse condition (IHS)	(0.050)	(0.050)	(0.271)	(0.023)	(0.001)	(0.011)
Number of (all) businesses in CBSA	-0.018	-0.019^{*}	-0.059^{*}	-0.002	-0.000	-0.000
(‘000)	(0.009)	(0.009)	(0.025)	(0.002)	(0.000)	(0.002)
Number of existing startups in	0.019^{***}	0.018^{***}	-0.023	0.009^{***}	0.001^{***}	0.011^{***}
CBSA (Startup density)	(0.002)	(0.002)	(0.033)	(0.002)	(0.000)	(0.003)
Square of Startup density	-0.000^{***}	-0.000^{***}	-0.000^{*}	-0.000^{**}	-0.000^{**}	-0.000^{*}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Log population of CBSA	1.707^{***}	1.555^{***}	3.263^{***}	0.289^{***}	0.012^{**}	0.197^{***}
	(0.159)	(0.175)	(0.403)	(0.044)	(0.004)	(0.035)
Population Density	-4.814^{***}	-4.656^{***}	-2.595	-0.696^{*}	-0.003	-0.543
	(1.192)	(1.179)	(3.536)	(0.313)	(0.033)	(0.319)
Proportion of CBSA comprising	1.468^{*}	1.659^{*}	4.891	0.418^{*}	0.020	0.279
water bodies	(0.633)	(0.664)	(2.838)	(0.209)	(0.017)	(0.156)
Median household income $’000	-0.119^{***}	-0.112^{***}	-0.349^{***}	-0.030^{***}	-0.001	-0.012^{**}
(2010 $s)	(0.010)	(0.010)	(0.052)	(0.005)	(0.000)	(0.004)
Income segregation (inter quartile	0.005	0.011	0.079	0.003	0.000	0.004
range)	(0.014)	(0.013)	(0.045)	(0.004)	(0.000)	(0.003)
Racial diversity	-0.356	-0.443	-1.159	-0.181	-0.022	-0.211^{*}
	(0.901)	(0.889)	(2.217)	(0.216)	(0.011)	(0.093)
Residential segregation by race	0.373	0.314	-1.695	0.103	0.008	0.074
	(0.600)	(0.599)	(1.686)	(0.177)	(0.012)	(0.099)
Industry diversity of existing	-0.174	-0.166	-0.037	-0.034	0.000	-0.064^{*}
businesses (all kinds)	(0.100)	(0.099)	(0.294)	(0.029)	(0.003)	(0.025)
Percent college graduates	0.157^{***}	0.156^{***}	0.347^{***}	0.030^{***}	0.001^{**}	0.019^{***}
	(0.009)	(0.009)	(0.037)	(0.004)	(0.000)	(0.004)
Percent households below poverty	-0.196^{***}	-0.181^{***}	-0.396^{***}	-0.041^{***}	-0.001^{*}	-0.020^{***}
line	(0.032)	(0.029)	(0.076)	(0.008)	(0.000)	(0.005)
Percent employed in businesses with	-0.183	-0.093	0.560	-0.032	0.006	-0.168^{**}
at least one employee	(0.125)	(0.113)	(1.212)	(0.066)	(0.008)	(0.065)
Percentage workers that are local to	-0.016	-0.019	-0.085^{**}	-0.009^{**}	-0.000	-0.004^{*}
CBSA	(0.011)	(0.011)	(0.030)	(0.003)	(0.000)	(0.002)
Percentage migrants in population	-0.438	-0.679	0.840	-0.032	0.001	0.064
(arrived last 5 years)	(0.572)	(0.640)	(1.600)	(0.142)	(0.007)	(0.094)
Local government capital	1.242^{**}	1.241^{**}	3.845	0.183	0.005	0.334
expenditure in CBSA	(0.427)	(0.440)	(3.827)	(0.113)	(0.011)	(0.173)
Local government revenues in	-1.138^{**}	-1.143^{*}	-3.684	-0.167	-0.006	-0.318
CBSA	(0.428)	(0.447)	(3.753)	(0.110)	(0.011)	(0.170)
Number of new bridges built		**0.172^{***}**	**0.364^{*}**	**0.035^{***}**	**0.004^{*}**	**0.047^{***}**
(IHS)		**(0.030)**	**(0.149)**	**(0.009)**	**(0.002)**	**(0.010)**
Num. of startups founded in focal			0.625	0.027	0.001	0.019
year (control for models A3-A6)			(0.366)	(0.017)	(0.001)	(0.012)
Constant	-18.988^{***}	-17.648^{***}	-18.963^{***}	-1.683^{***}	-0.099^{*}	-0.658
	(2.110)	(2.229)	(4.698)	(0.463)	(0.039)	(0.385)
Observations	7580	7580	7580	7580	7580	7580
Log pseudolikelihood	-4641	-4620	-9248	-29669	-7984	5948
Akaike Information Criterion	9333	9293	18552	59394	16024	-11841
Wald chi2 Statistic	4047***	4101***	7790***	60621***	8609***	21830***

QUALITATIVE APENDIX: Case Vignettes

Vignettes Overview and Approach

Akin to a referee at a sporting event, infrastructure is often taken for granted (Halbwachs 1992, ch. 4); when it works, no one pays attention to it, so only when it fails are people salient to it. This presents a well-documented challenge for qualitative data gathering of infrastructure systems as they are often not as salient and front-of-mind to stakeholders. Therefore, their connections to actual decision-making becomes invisible or even opaque to the respondent (Star 1999). To account for these issues, our approach was to prioritize archival materials. These archival materials included but were not limited to news articles, economic impact studies, local, state, and national transportation administrative documents, documentaries, legal documents, videos, construction development proposals before and after bridge completion, amongst many others. We also interviewed 8 community stakeholders around new bridge building such as city planners, local civic organizations, neighborhood associations, and the leader of a proximal university extension with current expansion plans. These interviews helped add nuance to the insights obtained from the archival materials. Details of the professional roles of each interviewee, date of interview and length are provided in table below.

Interviewee's Professional Role	Interview Date	Interview Length
City Planner	9/1/2020	40 minutes
Communications for City Planning	8/18/2020	30 minutes
Engineer and Developer (joint interview)	8/26/2020	54 minutes
Dean of a Prominent University's Extension	9/1/2020	49 minutes
President, Residents Association	8/13/2020	36 minutes
President, Residents Association and Architect (joint interview)	8/19/2020	25 minutes

What struck us from our qualitative data gathering is the similarity around how these projects progressed, even as the geographic and urban contexts for these projects were highly distinct. In our analysis, we particularly focus on the Ohio River Bridges Project in the Louisville, KY CBSA, and the Harbor Drive Pedestrian Bridge project in San Diego, CA CBSA. In both instances, the exact confluence of events that finally triggered bridge construction and placement were often not just economic in nature. They usually predicated a mixture of traffic, funding, environmental, historical, and even proximate infrastructure concerns (e.g., to act on railroad infrastructure, a bridge first had to be built). This suggests that the resulting impacts were largely uninfluenced and thus external to the control of those who sought to support entrepreneurship, let alone those individuals who sought a desirable location for their entrepreneurial ambitions. This gives us confidence in the relative exogeneity of these projects to entrepreneurs and/or entrepreneurial supporters (apart from static considerations that we partial out in our modeling approach such as state regulations, CBSA outlook, and annual macroeconomic conditions). While some of the benefits are distributed across an entire metro area, we also see some benefits that are quite localized to the bridge link.

These projects were also planned or built in sets that involved multiple bridges and multimodal forms of transportation (e.g., driving, bicycling, and walking). In other words, these bridges were often part of a multi-structure project. When interviewing bridge officials in Pennsylvania, one example they provided is bridge lifting to allow mass transportation such as buses to more easily go underneath a bridge. Often, many bridges are along one highway path; so for this to make sense, you would need to lift several bridges at once. Yet, while these projects are situated in a larger urban plan and the benefits are distributed across a metro area, we found at least some of the entrepreneurial fruits of such newfound connectivity are borne not just across the entire area but also quite near these projects. This suggests newfound high-tech opportunity can be quite localized and this perhaps explains why sidewalk lengths (see Supplementary Analyses in manuscript) have such an influence on these projects because many of the hot spots of activity that arise seem, at least in part, in close proximity to these bridges.

Ohio River Bridges Project – Louisville, KY

Overview

The Ohio River Bridges Project established multiple bridge links that connect the Louisville Metropolitan area (an older label for CBSAs over 50,000 in population). The Louisville metropolitan area (LMA) comprises Jefferson, Oldham, and Bullitt counties in Kentucky, and Floyd and Clark Counties in Southern Indiana. The first link was the Downtown Crossing, the Abraham Lincoln Bridge, that connects downtown Louisville with Jeffersonville, Indiana (in Clark County, IN) and opened in 2015. This ran parallel to the John F. Kennedy Bridge that was also rehabilitated as part of the project. The second link was the East End Crossing, the Lewis and Clark Bridge, that connects Prospect, Kentucky (in Jefferson and Oldham counties, KY) with Utica, Indiana (in Clark County, IN) and opened in 2016, which also has a pedestrian lane (Indiana Department of Transportation 2020). The entirety of the project totaled approximately $2.5bn (Shafer 2006).

History

Ever since the very first LMA transportation in 1969, there was recognition that there was a need to cross the Ohio river to better connect the area. For example, one of the recommendations of this plan was an "*extension of I-265 through Clark County [Indiana] with a crossing of the Ohio River at Utica [as] an extremely important additions to the freeway system* (Federal Highway Administration, Indiana Department of Transportation and Kentucky Transportation Cabinet 2001, p. 1.1)."

A confluence of factors drove several delays in the process. First, there was natural administrative hurdles. These LMA bridge constructions not just involved two different state governments (Indiana and Kentucky), but also several necessary federal reporting and environmental impact assessment requirements. Therefore, there was inevitable administrative friction due to the number of different stakeholders involved.

Second, there were significant environmental and historical concerns. Regarding the environmental concerns, the concern was (1) the project's greenhouse and ultra-fine particle emissions during construction, (2) stormwater run-off as well as road de-icing salts on creek in the project area, (3) disposal of tunnel spoil (e.g., materiel displaced from tunnel construction), and (4) impacts of new bridge pier constructions within a water body (2014). Moreover, there was numerous historical properties in the path of these proposed bridges. These had to be circumvented either through tunnels underneath the properties or by constructing pathways around these properties. Due to these complex environmental and historical issues, a settlement on the issues was not reached until 2013 (WLKY 2013). Only then could construction begin.

Third, a financial shortfall emerged that necessitated the need to establish tolling that was met with local resistance. The issue was that early estimates were projected at $2.5 billion. However, the project cost estimated increased to $4.1 billion. Moreover, the projection was that only $1.9 billion would be available in state and federal funding based on past funding history in both Indiana and Kentucky. This led to a $2.2 billion gap that had to be filled. With some cost-saving design measures, $1.2 billion in savings could be achieved, but that still left a $1 billion gap. Thus, the project officials felt they needed to cover the gap through tolling (Federal Highway Administration, Indiana Department of Transportation and Kentucky Transportation Cabinet 2012). In public forums on the issue, an especially vocal group were those community and city officials representing those who live outside Louisville but come into the city for work. These groups felt this would be equivalent to a tax that was asymmetrically shouldered by their communities (2013; Mann 2013). Moreover, others felt tolling would just divert traffic to other existing bridges that did not require tolls (Renn 2013, 2018). Despite resistance and recognition that this could disadvantage low income communities, the final decision was to toll as other alternatives such as raising state taxes appeared even less palatable and the shortfall had to be covered (WDRB 2013a, b), though a gas tax was used to shoulder part of the costs (Allyn 2013).

Overall then, a series of administrative, historical, environmental, and financial concerns all had to be settled before construction could even begin. These all suggest that the exact installation date was therefore exogenous to anticipated economic benefits.

Economic Impact

While a confluence of local financial, environmental, administrative, and historical factors had to be resolved around the bridge, the perceived subsequent economic impact of the bridge(s) amongst stakeholders was undisputed. Several economic impact assessments were conducted, all of which suggested that these bridges would significantly attract new business activity, even right next to these bridges. In 2012, the Economic Development Research Group projected that these bridges would generate an average of 17,796 jobs per year for 30 years and, during that 30 year period, generate about $78bn in economic output (EDRG 2012). In 2014, the same group updated those projections to 15,556 jobs per year and about $86.7bn in economic output (EDRG 2014). Wendy Dant Chesser, the One Southern Indiana, President and CEO summarized this consensus around the positive economic development that would arise from these bridges:

> When we think about what we can do as a region, as a group of communities, working together, this bridges project is the best example of showing not just ourselves but showing the world that this is a community that can make things happen (Crowner 2018).

In these reports, a key factor driving entrepreneurial activity was enhanced connectivity from these bridges. For example, the economic impact reports noted it as a key driver of economic growth. This anticipated productivity was not just increased accessibility to customers across metropolitan areas but also via better "*matching of employees and businesses, shared inputs, knowledge spillover, and overall economies of scale* (EDRG 2014, p. 4)." As Chesser also notes,

> There were already people in transportation avoiding this area because of the bottlenecks….We also knew that we had some potential for really tying our region together that would attract economic development opportunities in many different categories (Crowner 2018).

One example of particular interest is that of the River Ridge Commerce Center. The newly constructed Lewis and Clark Bridge became the nearest bridge to the area (5.3 miles – 9 mins drive – see Figure A below). Subsequently, Amazon constructed a 1 million square foot warehouse and distribution center in the area, and "*the planned new bridge figured prominently in Amazon's decision to locate at the site* (EDRG 2014, p. 20)." Moreover, given River Ridge is the "*first Indiana interchange from the new Lewis and Clark Bridge"* and *"to capitalize on this proximity*", the Commerce Center executed a 300-acre office park to attract more new tech businesses to come to the area (River Ridge Development Authority 2019, p. 4). An explicit aim of River Ridge was to "*foster a culture of entrepreneurship and encourage a relationship between startup and large businesses* (SIRDP 2015, p. 121)." In 2017, just one year after the bridge was built, River Ridge had already attracted 50 businesses employing nearly 9,000 workers (Hoy 2018). This does not include the overall plan to develop similar technology center and entrepreneurial hubs across Southern Indiana to directly take advantage of these new bridge projects. The following quote typifies such sentiments around the bridge:

> For many, the Ohio River functions as a physical and psychological barrier that separates Southern Indian form the rest of the Louisville region. With two new highway crossings under construction and the Big Four pedestrian bridge now open, Southern Indiana is more accessible than ever before. A renewed focus on the River … can transform the Ohio River into a unique destination and regional asset (SIRDP 2015, p. 53).

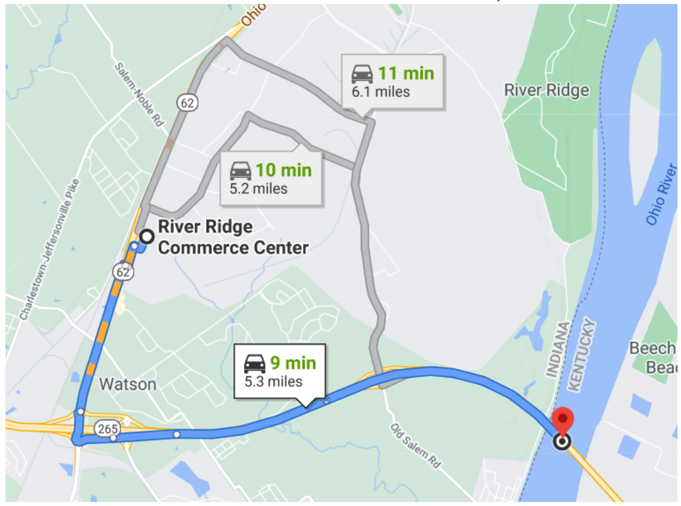

Figure A: Distance from Lewis & Clark Bridge (East End – Red Marker and River Ridge Commerce Center)

Harbor Drive Pedestrian Bridge Project – San Diego, CA

Overview

The Harbor Drive Pedestrian Bridge was a pedestrian bridge designed to connect Harbor Drive and Park Boulevard to enhance access to San Diego's waterfront, the convention center, Petco park, and the Gaslamp Quarter. The bridge was completed in 2011, and it ended up costing $26.8 million, though it was projected to cost just under $13 million (San Diego Reader 2011). As with the Louisville bridges, this pedestrian bridge was also to be coupled with other construction, namely a railroad crossing for vehicles that was supposed to immediately follow the construction of the pedestrian bridge. However as will be discussed later, this has experienced delays, but has just received some new funds that has allowed construction to start with an anticipated opening for 2022 (Grove 2019).

History

As with the Louisville bridges, there was long awareness that there was need for a "Park to Bay Link" between Balboa Park (known originally as "City Park") and the San Diego Bay (Balboa Park 2020). As early as 1908, the noted architect for the city, John Nolen, stated in his plan:

> The people of San Diego will do well if they recognize to-day that the two great central recreation features of the city, now and always, are the City Park of 1,400 acres, and the Bay Front, and that the value of both will be increased many-fold if a suitable connecting link, parkway, or boulevard, can be developed, bringing them into direct and pleasant relation (Nolen 1908, p. 40).

This has been part of a general strategy to increase connectivity between neighborhoods, and even reconnect those previously disconnected. For example, in the 2006 San Diego Community Plan (amended in 2012 and 2013), one of its eight guiding principles were (bold in original document):

> **A place connected to its context and to San Diego Bay**. The Plan seeks to connect downtown's neighborhoods to the waterfront with new streets and view corridors, re-establish Balboa Park's relationship to downtown, and integrate downtown with the surrounding neighborhoods. It also fosters better linkages within downtown (Dyett & Bhatia Urban and Regional Planners and Centre City Development Corporation 2013, p. 1-3).

The plan then reports numerous new bridge connections and freeway "lids" designed to reconnect previously disconnected neighborhoods such as those along I-5 (Dyett & Bhatia Urban and Regional Planners and Centre City Development Corporation 2013, p. 5-24, 5-25).

However, interestingly, the final push that led to the creation of the Harbor Drive Pedestrian Bridge and its vehicular counterpart that would complete the long-awaited Bay-to-Park link was not these long known connectivity needs. Two exogenous issues drove both the final push for this bridge, as well as subsequent delays that occurred.

First, the emergent need for the bridge arose from a new diagonal street, Park Boulevard, that relocated the railroad crossing. The California Public Utilities Commission (CPUC) and railroads worried that this new crossing would pose undue hazard to pedestrians who may ignore warning signals and cross the train tracks regardless (California Public Utilities Commission 2003; Showley 2014). Thus, the pedestrian overpass was part of a set of negotiated safety precautions between the CPUC and the City of San Diego that had to be built prior to an at-grade vehicular crossing. As one city planner familiar with the project noted, and was also shared by other stakeholders we interviewed,

> The pedestrian bridge was a key component of the ballpark district. And so with construction being plopped in the middle of that grid pattern, a new street was created, Park Boulevard, that was a diagonal. And the diagonal would cross the railroad tracks and connect to Harbor Drive and the waterfront, much as Eighth Avenue used to do. Eighth Avenue was part of the grid system. Because Eighth Avenue was being closed for the ballpark construction and Park Boulevard opened up, it actually relocated the crossing about 40-50 feet to the east.[3] And because of that, the California Public Utilities Commission, you know, found that it was a new crossing, which they really don't like here. They don't like rail corridors being crossed by new vehicular, and especially pedestrian, crossings. So long story short, they basically said if you are going to reconnect this new street to Harbor Drive, you can't have pedestrian access across the tracks. Therefore, the bridge came into being, and took many years, but the bridge was finally designed and constructed and completed in 2011. And the California PUCs said that until the bridge was open, the city could not start construction on the Park Boulevard crossing.

Secondly, right after the pedestrian bridge was completed and the vehicular crossing was to start, redevelopment was terminated in California with the California Supreme Court's decision in *California Redevelopment Association vs. Matosantos* in 2012. Prior to this ruling, cities had significantly more discretion to use their local tax revenues to fund infrastructure projects, and such discretion was heavily curtailed after this court ruling (Lefcoe 2012). As the head of a local residents association that we interviewed noted,

> What that allowed us to do is say you got a lot and it is a 1,000 square feet and it's taxed at a $1,000. Now you build 10 condos on it, or a 100 condos on it, and now it's taxed at $100,000 instead of a $1,000. That $90,000 difference stayed in downtown and was reinvested into stuff, so we were able to build parks… and then the governor blew it up.

This immediately put a halt to the at-grade vehicular crossing that was supposed to accompany the pedestrian bridge as alternative funding sources had to be negotiated that would have been previously covered through redevelopment. As the aforementioned city planner noted,

> Although the bridge opened in 2011, in 2012, redevelopment ended in California. So that threw all funding, everything else, into a great disarray and it is has taken many many years to get funding back, to get the state to approve their portion of the funding, and actually it is being funded now by a special state legislation that was passed last year to provide funding for the project.

While the pedestrian bridge helped enhance connectivity, and thereby could have contributed to economic impact in the area, the most immediate impetus for the pedestrian bridge, as well as the delays on the vehicular crossing, were not related to economic impact potential. For the pedestrian bridge, it was the need to address pedestrian safety measures as a result of the redrawn crossing due to other construction. For the delays on the vehicular crossing, it was the termination of redevelopment that necessitated protracted negotiations to identify alternative funding sources. Like in the Louisville case, this suggests that the exact installation date of the bridge was largely exogenous to anticipated economic impacts.

[3] For exact figure, according the CPUC comment on the project, they note the exact displacement to be 70 feet to the southeast of Eighth Avenue (California Public Utilities Commission 2003).

Economic Impact

While both Louisville and San Diego saw their new bridge connections as vital to their enhanced connectivity, the mechanism by which this was seen as generating economic impact in each city was different. As discussed in Louisville, the idea was that bridges would generate direct economic impact in terms of new businesses and production that came from enhanced connectivity new bridges would facilitate. In San Diego, the implicit idea was that increased bridge connections would enhance lifestyle (e.g., make commutes easier, as well as bicycling and walking to the waterfront and its amenities), and this would attract the young talent needed to jumpstart the economy. As one report notes:

> Comfortable living in smaller spaces such as apartments and condominiums, these millennials are looking for neighborhoods that are walkable and with access to amenities around the clock, seven days a week (Downtown San Diego Partnership and UC San Diego Extension Center for Research on the Regional Economy 2016, p. 20)…Urbanized communities like downtown San Diego are becoming increasingly desirable as people demand a variety of mobility options. With these trends in mind, downtown San Diego has committed to a vision and lifestyle where active transportation options, specifically walking and bicycling, are comfortable, safe and fun, and easily combined with public transportation to get in and out of downtown with ease (p. 38).

These increased mobility and interaction options were seen as vital to competing for and attracting young talent that can jumpstart the local economy. As two developers noted in our interviews,

> Both of us had experience in doing transformational projects, and we decided we would team up and see if we could do something downtown that would be of a scale and nature that could be transformational for downtown San Diego…We kinda looked around and we saw what was happening in the rest of the world, which was marked by high degree of competition for young highly educated people, and recognition on the part of cities that creating a great city was the most fundamental important economic development tool that a city had to try to attract individuals that would drive their economy. This was a really interesting trend where young people were picking where they wanted to live before they picked what they wanted to do, or who they wanted to work with. The implications of that were profound because it suggested that the top 1% was highly selective in terms where they wanted to go, and it was the top 1% that lots of high tech companies were chasing after, so tech companies were deciding they needed to go where the talent wanted to be…Our thesis was if downtown San Diego wants to get into the game, we better start thinking about what kind of downtown we are going to have and how's that going be rich in the kind of amenities that are going to be relevant to the people who are going to drive our economy for the next 30-50 years.

The Harbor Drive Pedestrian Bridge directly seems to enhance walkability to amenities that are along the Harbor. Shortly after it was built in 2011 and up until the present (as last checked in July 2020 via the San Diego Regional Bike and Pedestrian Counter[4]), there have been 17,516,312 pedestrians that have crossed the bridge, 2nd most of any bridge in San Diego, at a daily average of 6,959 pedestrians, which is the highest daily average of any bridge in San Diego.

Such trends also seemed to generate local business foundings, some of which were quite proximate to the bridge. When we looked at the documented downtown development project status logs,[5] we see a notable increase after the pedestrian bridge was completed. If we look at all planned, pending, under review, under construction, or completed projects along Harbor Drive (4-5 min drive, 20-30 min walk from the bridge), we see two new projects between 2004 and 2011, when the nearby Petco Park Stadium (home of the San Padres baseball team) was completed and before the completion of the pedestrian bridge. However, after the completion of the pedestrian bridge in 2011, we see 9 new projects. Interestingly of these 9 projects, four of them involve the Manchester Pacific Gateway area which has been almost entirely acquired by a biotech company to create a new waterfront life science campus – the San Diego Research Development District (RaDD) (Grove 2020), potentially generating knowledge spillovers that have been studied extensively in strategy and entrepreneurship pertaining to this sector (Powell, Koput and Smith-

[4] http://www.eco-public.com/ParcPublic/?id=681#
[5] https://www.sandiego.gov/planning/community/profiles/downtown/project-status-logs

Doerr 1996; Zucker, Darby and Brewer 1998). Also as per the city's overall strategy of implicitly using bridges to make amenities more accessible, the belief is that, "*The RaDD will attract top tenants and talent that will be drawn to this premier work-live-play campus with remarkable access to transit, housing, dining, and top amenities* (2020)." Thus, while other amenities such as the local stadium could have had some effect on local development, the bridge also seems to have also had a substantial impact.

In short, while in San Diego and Louisville the economic impact ends were similar, the means by which to do it were conceived differently. In Louisville, the hope was these new bridges would directly improve flows of goods and services that lead to new businesses. In San Diego, the implicit hope was these new bridges would enhance walkability, transit, and bicycling so as to improve access to lifestyle services (e.g., proximity and greater access to the waterfront, restaurants, and different neighborhood cultures). In turn, this would attract young talent who prioritize such amenities, thereby jumpstarting entrepreneurial activity in the local economy.

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